Faculty of Engineering

Czech University of Life Sciences Prague

Conference Proceedings

3rd International Conference TAE 2007

Trends in Agricultural Engineering 2007

12 - 14 September, 2007

Prague, Czech Republic

ČESKÁ ZEMĚDĚLSKÁ UNIVERZITA V PRAZE

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Dear friends and colleagues

It is my privilege and big pleasure to invite you to participate in the 3rd International Conference Trends in Agricultural Engineering 2007 to be held in Prague this September.

I would like to remember here the successful previous conferences. The first of them was organised in the year 1994 and there 107 participants took part. The second one was organised in the year 1999 and there 126 participants took part. I believe that our conference will be the successful continuation of the previous conferences and you will use the opportunity to exchange new experiences, ideas and scientific results in the so complicated complex of scientific discipline.

Thirteen years of the conferences on the trends in agricultural engineering represent also the years of changes in this discipline. At the beginning of this period the main domain of the discipline consists mainly in improving of the agricultural machinery, development of automation and robotics. Now, the main role consists in detection of the product quality and in developing of the agricultural technologies more precise and friendly related to environment.

I am looking forward to meeting you and offer an interesting scientific programme and an attractive programme of social cultural activities in Prague. This is also feeling of all my colleagues in Local Organisation Committee that are ready to prepare the best conference conditions for you.

Martin Libra
Chairman of the Scientific Board

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RECENT ADVANCES IN PRECISION FARMING - SENSORS AND TRACEABILITY

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This paper reviews recent developments in sensors and traceability systems for use in precision agriculture in the arable sector principally from work conducted by Cranfield University. It considers a number of applications relating to issues of soil and crop variability for wheat and onions. The results from wheat studies give valuable data on profitability and environmental quality, and the onion work to crop quality (size). Reference is made to recent developments in the application of ground based crop sensors, "on the go" monitoring of bale quality, the determination of subsoil strength and telematics. Issues and developments in traceability to ensure crop quality are reported.

Introduction

This paper reviews recent developments in the application of precision agriculture in arable cropping using a number of case studies. These include: 1. the application of sensor technology to determine the variation in crop performance for wheat, 2. the control of onion size, 3. the weight and moisture content of large rectangular bales, 4. sensing subsoil compaction, 5. the application of telematics, 6. the use of RFID tags and the related architecture for the development of traceability systems to ensure crop quality and 7. the development of standards for system integration between key stakeholders in the food chain. Of necessity a significant amount of the material referred to below can also be found in the recently published paper by Godwin (2007).

Soil and crop variability

Nitrogen management for wheat

The results of a research program to develop management guidelines for cereals grown in the UK were reported by Godwin et al, (2003). This demonstrated that it was possible to improve the economic return by approximately £22/ha from a combination of additional yield and reduction in overall nitrogen input. A protocol was developed to manage the crop in real time by sensing the crop canopy status using aerial digital images, determining the normalised differential vegetation index (NDVI) which was spatially correlated to the number of shoots or green area index (GAI). Nitrogen was then applied at three times in the season depending on whether the canopy was on, above or below target in line with the Wheat Growth Guide (HCGA, 1998). The principles were established where the NDVI could be determined from either aerial, satellite or ground based systems. The authors chose to use airborne systems for the research project because at that time satellite data was not sufficiently reliable (due to the limited number of flights and cloud/weather conditions) and terrestrial systems were time consuming and expensive (Godwin et al, 2003).

The work reported by Godwin et al (2003) on cereal crops for the variable application of nitrogen showed some savings in regard to the difference between the nitrogen that was applied and that removed in the grain (and straw). Where the residual nitrogen for a series of different seed rates from strip experiments where one half of the strip was managed with a uniform application and the other spatially applied according to the crop status. Overall if a field had equal proportions of each seed rate then the cumulative residual nitrogen for the spatially varied application would be 74 kg/ha rather than 112 kg/ha for the uniform application i.e. an overall reduction in residual nitrogen of 1/3.

Since then satellite services have improved with a greater frequency of over flights at costs similar to those suggested by Godwin et al., (2003) for aerial images. As a result, Griffin (2007) reported on a commercial study where fields on a series of 10 farms were split into two halves; one half received a uniform application of nitrogen and the other a spatially variable amount applied using the principles recommended by Godwin et al, (2003). The results of this study are very similar to the earlier study, with 9 out of the 10 fields returning a positive benefit from the spatially variable application of nitrogen with an average benefit of £24/ha obtained from increasing crop yield and a reduction in fertiliser use as given in Godwin et al, (2003).

Alternative ground based sensing systems have also entered the market; these are proving to be particularly valuable in areas where weather conditions are problematic like the conditions in Northern Ireland where there are insufficient cloud free days for aerial and satellite imaging. A study by Morris (2006) in Northern Ireland has shown that use of Crop Circle manufactured by Holland Scientific (http://www.hollandscientific.com and http://www.soilessentials.com/) has a valuable application. His results indicated that the active sensor, which has its own light source, will operate effectively under both cloudy and night time conditions. He also conducted a simple experiment to determine the maximum distance between successive passes of the sensor. This was undertaken by scanning a field at 4 m centres, estimating the NDVI and then deleting intermediate passes. Analysis of this data showed that the pattern for the variation in the field starts to degrade at about 12 m wide pass widths, although this is a rather subjective analysis it has sufficient resolution to practically guide in field decisions. This result shows that fitting a sensor on either side of a spray boom at 12m centres will be an economically practical proposition making spatially variable fertiliser application possible in areas with poor weather conditions.

Studies by Havránková et al, (2007a, b) have compared the results of both Crop Circle and Field Scan (which does not have a light source) and obtained similar calibration sensitivities when relating their sensitivity to both plant numbers and the amount of nitrogen per unit area. The results of field studies in the UK where the fertiliser in alternate tramlines was applied from data collected by both techniques in comparison to a uniform agronomic recommendation are given by Havránková et al, (2007a, b). These results show that both sensors reduced the overall application of nitrogen by 15 kg/ha with no loss in wheat production. This reduces both the potential for the direct environmental effect of surplus nitrogen and the environmental cost of the fertilizer production process.

Onion size and quality

Studies in Bedfordshire by Maguire et al, (2003) showed the potential to improve the uniformity of onion sizes to meet the size quality standards set by the supermarkets, where ideally the size should be a near uniform 50-60 mm diameter. A grower had identified that in a number of his fields there was a significant variation in onion size, where onions grown on sandy soils were smaller than average and those grown on clay soils were larger. This was due to variations in soil texture and water holding capacity of the soil. Preliminary agronomic investigations had identified the optimal seed rates for each soil type as shown in Figure 1. The requirement was to provide a seed space controller that would increase the spacing for sandy soils and decrease the spacing for the clay soils. This was achieved by adapting the seed spacing of a precision drill using a planter controller operating from a terminal in the tractor cab. The seed rate was varied from 370,450 to 543,620 seeds per ha when traversing from the lighter sandy loam to the heavier clay soils. The Fieldstar terminal was provided with an application map based upon the soil texture/water holding capacity of the fields. Electromagnetic induction techniques were used to determine the variation in field conditions.

The results of this development significantly reduced the variation in onion size range; unfortunately no grade size analysis was conducted but the grower reported a significantly greater proportion (approximately 30% extra) of the crop being sold into the premium target market. This is an excellent example of where the principles of precision agriculture influenced the simple quality indicator of crop size.

Sensing the weight/moisture content of hay and straw bales

It is valuable for both contractors and farmers to know the number, weight and moisture content of both hay and straw bales. The moisture content is of particular importance in determining the longer term quality and potential storage fire risk. Maguire et al, (2007) have shown, for fields in Bedfordshire, that the mass of individual bales can be determined by recording the tension force in the chains supporting the bale chute by the use of two proprietary tension dynamometers, one of which is

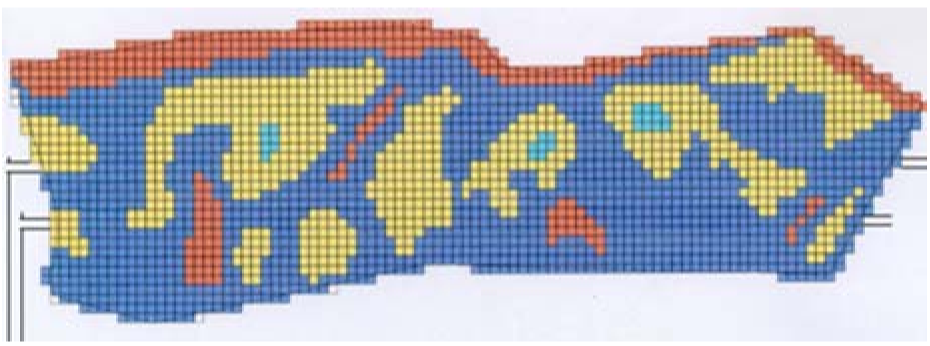

Figure 1. Seed rate application map, as influence by soil type. Red 543,620 seeds/ha, blue 494,200 seeds/ha, yellow 444,780 seeds/ha and light blue 370,450 seeds/ha. Grid size 10m. After: Maguire et al, 2003

shown in Figure 2, and an inclinometer to record the angle of the chute.

The most critical issue is to obtain a true indication of the tension force at the point of cant as the bale tips over the rear roller which is independent of signal noise. A typical output is shown in Figure 3 where a filter was used to smooth the data. The results of this work showed that the overall error in 255 bales was 0.03%, with 86% of all individual bales within +/- 5%. The work also showed that it was possible to produce yield maps from the data, but there are limitations to their accuracy due to the problem in apportioning yield to particular field locations, especially when a range of swath tedding and gathering operations have been conducted.

Parallel work indicated that the use of a device manufactured by Harvest-tec (http://www.harvesttec.com) that records the electrical resistance between two star wheels which penetrate and rotate along the upper surface of the bale, can determine the moisture content to within +/- 2% of the absolute moisture content. This would enable any suspect bales to be easily identified to ensure management action to minimise the storage risks. Both of these developments could be crucial to the wider uptake of the management of bio-energy crops in the next 10 years.

Figure 2. Proprietary tension dynamometer fitted to the chains supporting the bale chute. After: Maguire et al, (2007)

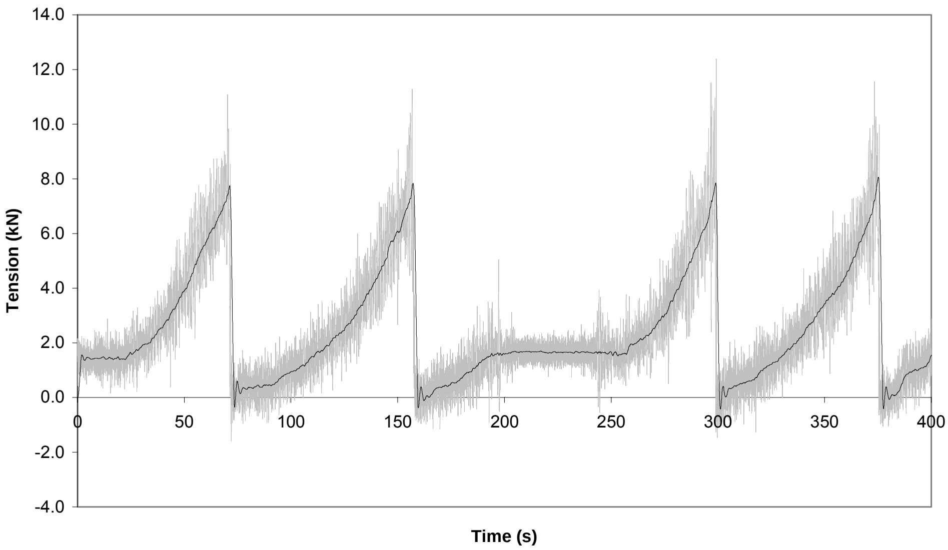

Figure 3. Tension dynamometer output for four bales, showing peak tensions at the point of cant. After: Maguire et al, (2007)

Soil Strength Monitoring

One of the most significant soil parameters affecting root growth is soil compaction. It is therefore important to be able to determine the presence of compacted layers, their depth, thickness and spatial location without the necessity of digging a large number of holes in the field with either a spade or backhoe. Previous investigations have identified soil compaction by different methods such as: using ground penetrating radar (GPR), acoustic systems, vertical and horizontal penetrometers and instrumented wings mounted on the faces of tines. Linking the output from these sensors to global positioning systems would give an indication of the spatial patent of the variation. The aim of a study by Sharifi et al, (2007) was to evaluate the performance of a soil compaction profile sensor in both controlled laboratory and field conditions. The sensor consisted of a series of instrumented flaps (similar to that described by Verschoore et al, 2003); a flap is defined as the sensing element which comprises one half of a pointed leading edge to the leg of a tine to which strain gauges are placed on the rear face of the flap. Studies measured the effect of compaction on the changes in the soil resistance acting upon a flap face in a soil bin laboratory and under field conditions. The results indicated that the sensor was sensitive to differences in soil strength at different depths in soils. The soil compaction profile sensor was tested on a number of fields to determine the changes in soil strength below the wheelings of a pea harvester operating at different tyre inflation pressures as shown in Figure 4.

Telematics

The past few years has seen a significant rise in the use of diagnostic systems for fault detection in the service of farm machines following the practices used in the automotive industry. In the recent past, Claas (www.claas.com) has taken this one stage further with the introduction of a "Telematics"system which uses an on board data logger to record information from the CAN BUS at 15 second intervals. This information is stored on a PCMCIA card and every 15 minutes this is transferred via mobile telephone modem to the internet, where it is stored by a secure sever which can be accessed and analysed by the farmer, service engineer and manufacturer.

The output of this system can provide information on:

1. the operational performance of the machine, which is valuable in benchmarking output against potential to maximize productivity,
2. the location of the machine such that the farmer and drivers of the tractor/trailers and trucks for crop transport, the factory and the service engineers know the location of the combine harvester. This can be linked to Google Earth such that annotated aerial photographs can be given to drivers unfamiliar with the field locations,

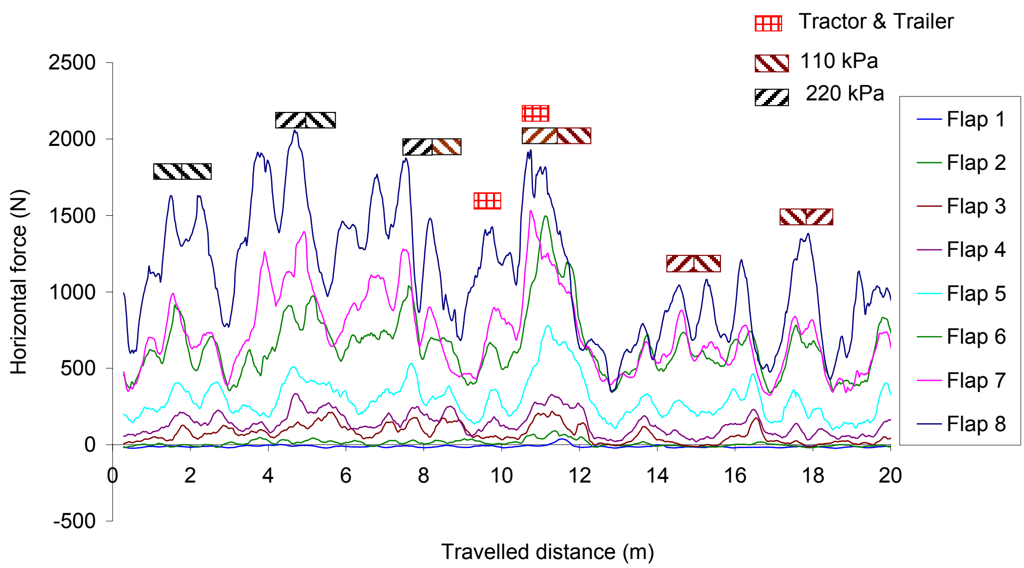

Figure 4. Changes in the horizontal force on each of the flaps (1 at 0-50mm to 8 at 350-400 mm deep) drawn at 90 degrees to the direction of travel of a pea harvester operating at tyre inflation pressures of 110 and 220kPa. The effect of the passage of a tractor and trailer is also shown. After: Sharifi et al, (2007)

3. the status of the harvester, to be automatically communicated to the trailer/truck,
4. the results of a remote diagnostic check, such that service engineers can be alerted to reduce the down time and carry the correct spare parts.

This system shows the future direction when fewer staff are employed, machine capacity grows and the cost of down time becomes prohibitive in terms of operational efficiency, cost and ultimately crop quality. This may not be critical for grain quality, but it does provide the potential to maintain quality for crops such as “garden peas” and other time dependant vegetable crops.

Traceability

Recent food scares such as those where: 1. non-genetically modified maize for human consumption was contaminated with genetically modified material designated for animal consumption and 2, the contamination of spinach with *e-coli* in California indicate that product tracking and traceability should be a major research focus, particularly to provide the tools on-farm to initiate the process.

The work of Watts et al, (2003), and Watts (2004) clearly identified in on-farm studies that Radio Frequency IDentifer (RFID) methods were superior to bar codes in the field identification of agrochemicals and that this information could link to the approved product data bases for agrochemicals and pesticides held within the farm/tractor/sprayer computer systems. Further studies by Peets et al, (2007) have developed the structure of the RFID label data and they have developed a more sophisticated architecture which links the field application rate recommendations of the agronomist, to the precise identification of the agrochemical using national agrochemical databases and the measured application of agrochemicals to on-farm data bases, as shown in Figure 5. This also accommodates details on the country of registration, registration number, container size, specific gravity of the agrochemical and a digital signature to verify the integrity of the data and provide further security.

To achieve these aims special monitoring equipment is needed where agrochemicals are taken into the sprayer. Watts (2004) suggested that this be undertaken gravimetrically to accommodate the wide range of agrochemical packaging from a few grams to 300 kg. Current work at Cranfield University at Silsoe is developing the hardware and software systems to integrate this to the CAN BUS system mounted on the tractor/sprayer.

It has been recognised that there are many stakeholders in the development, implementation and acceptance of traceability systems. To this end Gasparin et al, (2007) have conducted a series of semi-structured interviews with representatives of all concerned ranging from: farmers and growers, agrochemical companies, software and hardware providers, food and environmental agencies, food retailers and supermarkets. The key findings of this are that all are in favour of such developments as they may provide enhanced food standards, environmental management and commercial market advantage. Key issues are that the systems be cost effective, avoid the labour required for manual entry of data and that the supermarkets only need to work with a limited amount of data, but need access to further details only as and when required. Currently the economic criteria for these systems are being developed. These look very favourable as much of the required technology is already available on the tractor/sprayer and harvester for other purposes.

In the longer term the traceability concepts may well provide the technological support for automated carbon trading between businesses and have international significance with the

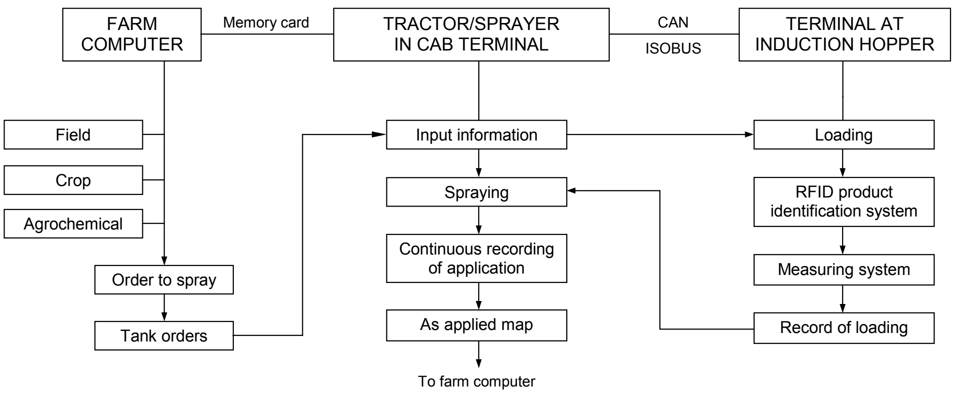

Figure 5. Outline of a data flow chart for a farm traceability system. After: Peets et al, (2007)

development of issues effecting global warming and energy scarcity. These issues are well documented in the Stern Report (http://www.hm-treasury.gov.uk/media/8AC/F7/Executive_Summary.pdf).

Conclusions

The past two decades have seen significant progress in the application of the principles of precision agriculture to improve the production quality of a whole range of crops. The successful applications now are resulting from the need to solve real problems rather than the earlier applications which were undertaken because the technology was available. However, without those earlier pioneering studies the more recent applications may never have been possible and current focus is on the improvement to crop and environmental quality rather than total yield. The requirements will be no less stringent as technology is required to help compensate for the increased competition for arable land for the production of bio-fuels in addition to food crops. The developments in traceability systems could well have value in the recording of carbon trading initiatives as environmental quality issues become increasingly important.

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NON-DESTRUCTIVE AND DESTRUCTIVE METHODS FOR QUALITY EVALUATION OF SOFT AGRICULTURAL PRODUCTS BY ACOUSTIC VIBRATION

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Non-destructive method with a laser Doppler vibrometer (LDV) was applied to evaluate maturity of soft agricultural products after harvest. Vibration of fruit or vegetables forced to vibrate by an acoustic frequency was monitored by LDV. Elastic modulus (μ) was calculated by an equation (Cooke 1972), $\mu \cong m^{2/3} \times \rho^{1/3} \times f_2^2$, where m is mass of product, ρ is its density, and f_2 is the second resonant frequency. Analysis of softening process of individual fruit or vegetable by the non-destructive method disclosed that some exhibited a biphasic decrease in elastic modulus after harvest, which was not detected by a conventional, destructive puncture method. A portable device for measuring μ of fruit in the field by the non-destructive vibration technique was developed. The μ decreased when melon fruit increased its diameter during cultivation, and was minimum at 15:00 within a day in a greenhouse.

A destructive method for qualifying the texture of fresh commodities was developed. A probe was inserted into the tissue of apple, pear, persimmon, or blanched bunching onion and its acoustical vibration was detected by a piezoelectric sensor. A half-octave multi-filter was used to analyze the texture signals in the frequency domain between 0 to 25600Hz. The texture index (signal amplitude density) was computed by summing up the amplitude (V) and dividing by the data number.

Introduction

A primary objective of studies on postharvest handling of agricultural products has been to sustain the efficient delivery of high quality and fresh commodities to consumers. In most sorting lines of the products, size, shape, color, and absence of exterior blemish are the major criteria for screening. Recently infrared sorting has been used to select fruit or vegetables by sugar or acid content, but fruits with even high sugar and appropriate acidity are not accepted if they have too soft or hard texture. Precise determination of fruit firmness by a non-destructive method is a sort of promising evaluation technique of fruit quality, since most of immature fruit is harder than that of mature fruit and the firmness of mature fruit is harder than that of unacceptable over-ripe or putrid fruit. Muramatsu et al. (1997) first applied a laser Doppler vibrometer (LDV) to the measurement of fruit firmness, demonstrating its advantage over the conventional device, such as an accelerometer. Fruit was placed on a stage of vibration generator that served as the source of a sine waves imposed on the fruit. The vibration transmitted through the sample was detected at the top surface of the fruit by the LDV and analyzed by fast Fourier transformation (FFT). Cooke (1972) has proposed a theoretical firmness index,

$$\text{Firmness index} = f_2 \times m^{2/3} \times \rho^{1/3} \times CR$$

where f_2 is the second-lowest resonant frequency, m the mass of a fruit, ρ the density of a fruit, and CR the conversion ratio that depends on the fruit. Terasaki et al. (2001a) demonstrated that the second lowest resonant frequency was a ${}_0S_2$ mode by electronic speckle pattern interferometry, confirming that the elastic modulus of fruit can be calculated by the above equation. Recently Kuroki et al. (2006) developed a portable device for measuring an elasticity index of fruit in the field based on the theory of vibration technique.

Texture of food is one of the most important criteria for selection by consumers, because crispness of lettuce, celery or cucumber reflects their freshness, and soft and tender textures of fruits are also suitable feature of some fruits. For organoleptic evaluation of food, a microphone was often used to monitor the crushing or masticating sound of food emitted from the mouth (De Belie et al. 2002). The microphone method, however, holds some drawbacks in analyzing the sound, because some of the sound quality within the mouth may not be transmitted to the microphone; e.g., high frequency sound is lost through the jaw bones, and some food in the mouth that is wet with saliva may not transmit an acoustic sound (Duizer 2001). Novel technique for acoustic measurement of crispness of food was recently developed (Sakurai et al. 2005a, b). Piezoelectric sensor was sandwiched between a probe and a piston. The probe was inserted into food at a constant speed and the acoustical vibration of the probe was directly detected by the piezoelectric sensor. This device satisfies the three aspects of human organs to sense the texture of food; first, tooth is a probe, second, nerves under the tooth is a piezoelectric sensor, third, sense by brain is the calculation of the voltage change emitted from the piezoelectric sensor by computer.

Materials and methods

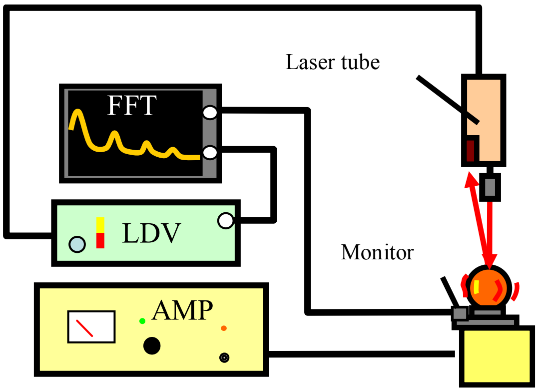

Fig. 1 LDV system for measuring vibrating object

Figure 1 shows the laser Doppler vibrometer (LV-1720, Ono Sokki Co. Ltd., Yokohama, Japan) measurement system. Fruit was subjected to sinusoidal excitation. The response signal at the top of the fruit measured by LDV was analyzed by a FFT program (Spectra Plus, Sound Technology, USA).

Figure 2 shows an illustration of the developed portable device for the measurement of the elasticity of melon fruit in the field. It is 1.5 kg weight and consists of a hammer to produce vibration and a piezoelectric sensor to detect damped oscillations on the opposite side of the fruit. A melon was placed between the hammer and the sensor on the equatorial plane, and the fruit vibration and diameter were simultaneously measured. The resonant frequencies of the fruit were obtained after FFT of the acquired vibration ignals.

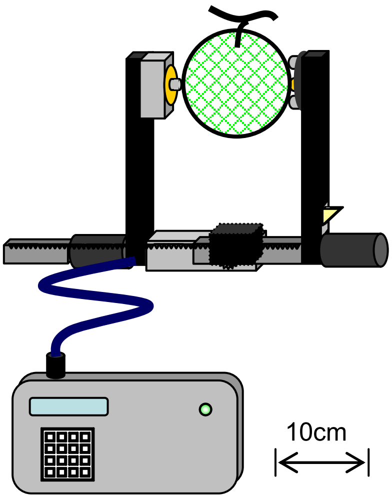

Fig. 2 Illustration of a newly developed portable device for measuring the elasticity index of melon fruit with a vibration technique.


Fig. 3 Photograph of AMC system for measurement of texture index.

Fig. 3 shows the acoustical measurement system of food texture (AMC, Applied Vibro Acoustics, Ltd., Hiroshima, Japan). Low viscosity silicon oil was delivered by a conveying pump into a brass cylinder to drive a probe down. The probe was a stainless steel screw with a conical tip with an angle of 30°. A piezoelectric sensor was sandwiched between probe and piston. The vibration signals obtained with the piezoelectric sensor were put into PC and acquired with a program developed using LabVIEW (National Instruments Corp. Ltd., Austin, TX, USA). Data sampling rate was 80 kHz. Data were then analyzed in the frequency domain. We developed a half-octave multi-filter to perform this analysis. The multi-filter covered up to 25.6 kHz that is nearly full audio frequency range. Using filtered voltage data, we qualified food texture using an algorithm developed by Taniwak et al. (2006a). The texture index (TI) value was determined according to the amplitude density of the obtained signals, as

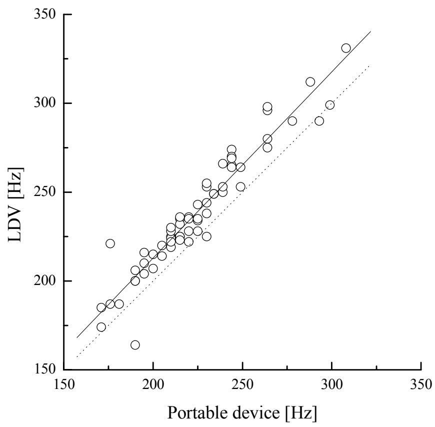

Fig. 4 Correlation of the f_2 obtained with a portable device and LDV (Kuroki et al. 2006).

$$\text{Texture index (TI)} = \Sigma\ |Vi|\ /\ T$$

where $|Vi|$ is the absolute amplitude of each data point in volts and T is the data length in seconds.

The TI reflects the level of sound generated per second when a sample is masticated by the probe.

Results

The LDV method allows a non-destructive and non-contact measurement of the elasticity index of fruit. This method applied to estimate the elasticity indices from the detected second resonant frequency of various kind of soft agricultural products, such as apple (Muramatsu et al. 1997), kiwifruit (Muramatsu et al. 1999, Terasaki et al., 2001a, 2001b), pear (Murayama et al. 2006, Terasaki et al. 2006), melon (Blahobec et al. 2007a), and potato (Blahovec et al. 2007b). However, the apparatus of the LDV method is complex, large, and inappropriate for practical use in a cultivation field. To measure the elasticity index of the fruit cultivated in the field, we developed a portable device to measure the second resonant frequency of fruit. First the reliability of the device was tested using the same melon and the data of different melons were compared with those of LDV method. When the same melon was measured 10 times, the mean of the second lowest resonant frequency (f_2) was 180.4 Hz and its coefficient of variation was 0.5%. This result demonstrated that the new portable device provided reproducible measurements of f_2. Next, we compared f_2 measured with a portable device with that by LDV (Fig. 4). The f_2 with the portable device was 14.1 Hz lower than that measured by LDV. Correlation coefficient was 0.95, which was significant at the 1% level. The results showed that the portable device was able to measure the elasticity index of fruit accurately, although the value was consistently smaller than that of LDV. As Muramatsu et al. (1997) pointed out, the direct contact between the fruit surface and the vibration detector may restrict the free vibration of fruit, resulting in the lower f_2.

When elasticity index of melon fruit grown in a greenhouse was continually measured within a day, great diurnal change in the elasticity index was found (Fig. 5). We measured two varieties of melon, ‘Earl’s Seine’ and ‘Venetia’. Both melon exhibited lowest elasticity index at 15:00 and highest at 6:00. Diurnal fluctuations of elasticity were 27% for ‘Earl’s Seine’ and 24% for ‘Venetia’. There was a possibility that ambient temperature in a greenhouse affected the elasticity, because the temperature was highest at 15:00 and lowest at 6:00. Next, we measured the elasticity of melon at different temperatures (6 to 29°C) in laboratory (Fig. 6). No or little temperature dependency on the elasticity index of the harvested fruit was observed over a wide range of temperature, which does not account for the large fluctuation of elasticity indices in the greenhouse. These results suggested that the melon fruit in the greenhouse was soft at the middle of afternoon and hard early in the morning. In the afternoon, transpiration from leaves is maximal. When water is actively evaporated from the leaf stomata, water in the fruit receives negative pressure. This water status (dehydration from the fruit) probably leads to the decrease in elasticity index of melon fruit at 15:00. Transpiration was minimal in the night. Therefore, during the night enough water may be delivered into the fruit from the ground, resulting in the highest turgidity of fruit found at 6:00.

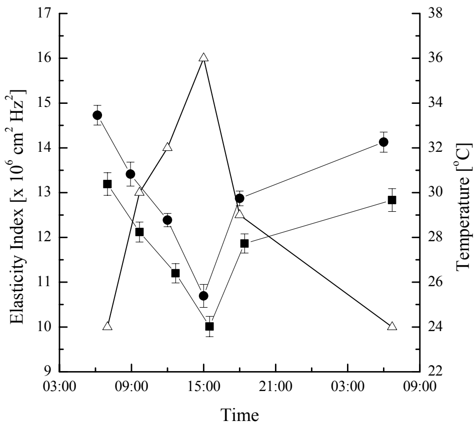

Fig. 5 Diurnal changes in the elasticity index of the melon fruit and temperature in the greenhouse. The filled circle and rectangle indicate the elasticity index of ‘Earl’s Seine’ (n=36) and ‘Venetia’(n=26), respectively. The open triangle indicates the temperature. The vertical bars indicate SE (Kuroki et al. 2006).

The portable device was able to measure the elasticity of filed-grown fruit. The data may serve as the estimation of watering program and harvest time. The similar vibration technique is now applied to tomato, grape, and peach grown in the field.

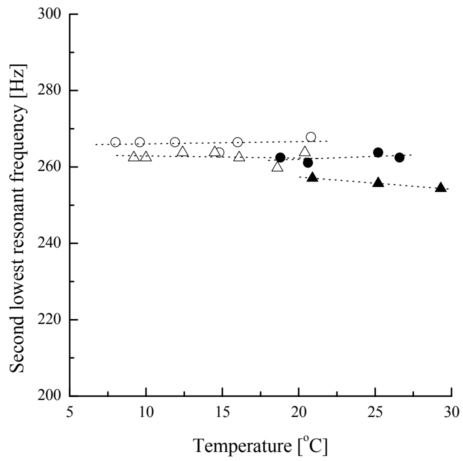

Fig. 6 Relationship between fruit temperature and the elaxticity index. Circle and triangle symbols show the

measurement of two individual fruit. The data with filled symbols were measured one day later than those with open ones (Kuroki et al. 2006).

Acoustic measurement of crispness using a piezoelectric sensor was first applied to cucumber and persimmon (Sakurai et al. 2005a, 2005b). In the study they used FFT to estimate their crispness. However, the signals obtained by the piezoelectric sensor were not periodic, but pulse or non-periodical that are not appropriate for FFT analysis. Therefore, multi-filter was introduced to evaluate crispness index (Taniwaki et al. 2006a). The device was also modified at piston and cylinder part. The brass cylinder, instead of glass-made, with low-viscosity silicone oil, allowed smooth movement of the aluminum piston when the probe was driven. This feature minimized the noise caused by the piston movement. The inherent resonance of the probe was set above 20 kHz not to interfere the data obtained by sample mastication. The probe speed was 22 mm/s, which was within a range of actual mastication speed (Roudaut et al. 2002). The obtained spectrum of apple, persimmon, and pear were compared. This method was also applied to texture of blanched bunching onion (Taniwaki et al. 2006b). The probe with a knife edge was inserted to several onion leaves. When the probe penetrated into each leaf, the characteristic voltage signals were obtained especially at a 0-50Hz band (Fig. 7). The peaks seem to correspond to the position of each leaf and inner tissue. The response of piezoelectric sensor at low frequency may reflect the direct stress received by the probe. TI at low frequency band was higher at the inner leaf than at the outer one and TI at high frequency band was higher at the outer leaf than at the inner leaf, suggesting that the outer leaf of bunching onion is crispier than the inner leaf (data not shown). Fig. 8 shows the comparison of TI among apple, persimmon, and pear (Taniwaki et al. 2006a). TI of apple was always higher than those of persimmon and pear over the full range of bands. Characteristic peak was found at 2240-3200Hz band for apple, which was also found for persimmon. TI of pear that reached an appropriate soft texture was lower than that of apple or persimmon, especially from 50 to 200Hz. No characteristic peak at 2240-3200Hz was found for pear.

Discussion

There are several measuring systems to evaluate soft agricultural products, such as puncture test, stress-relaxation test, and vibration method. Stress relaxation test estimates viscosity modulus as well as elastic modulus (Kojima et al. 1991, Sakurai and Nevins 1992, 1993), but the method is destructive. Terasaki et al. (2001) claimed that the vibration method affords viscous modulus in addition to elastic modulus, but estimation of viscous properties based on the resonant peak width is practically not ready. New theory for estimation of viscous properties of fruit or vegetable by resonant method is awaited

Texture of fruit or vegetable, at least partly, was able to express numerically by a destructive vibration method. However, there is no guarantee for relationship between calculated TI and organoleptic test. Allotting specific half-octave band to some mouth feeling or crispness received by human sense or brain is necessary.

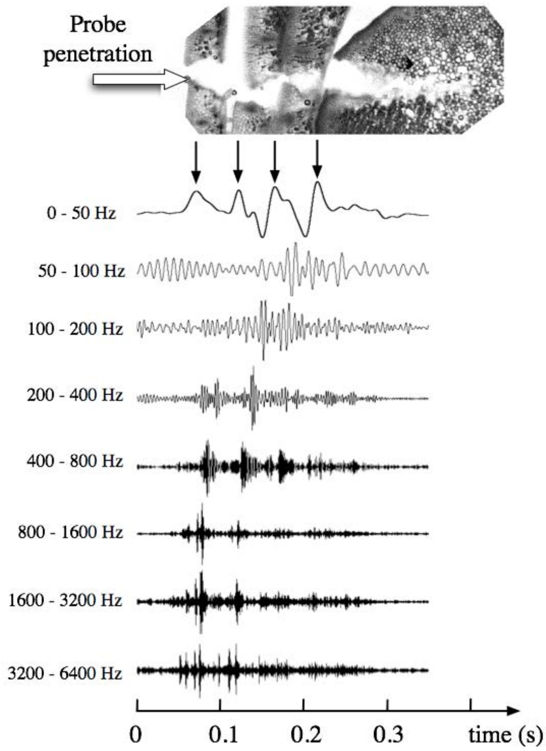

Fig. 7 Photograph of cross section of bunching onion (above) and changes in voltage at multi-filter bands (below). Horizontal arrow shows the direction of probe insertion. First, second, third leaf and inner tissue position correspond to the peak of 0-50 Hz band (Taniwaki et al. 2006b).

Conclusions

Non-destructive measuring system of fruit firmness affords a versatile section method for maturity of fruit and vegetables. Monitoring of a portable device of fruit firmness measurement helps watering program and decision of harvest time. Texture of soft agricultural products can be measured by an acoustic vibration technique using a non-FFT method. The device obtains a full auditory range of sound emitted from the sample without any interference of human mouth form, bones and wetness by saliva.

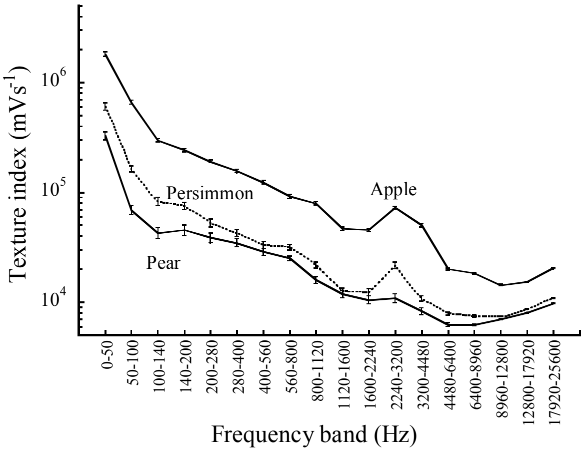

Fig. 8 Comparison of TI among apple, persimmon and pear. Abscissa represents frequency bands of multi-half octave filter (Taniwak et al. 2006a).

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THE UNITY OF THE TOTAL DIRECTION OF THE AGRARIAN-ENGINEERING PROGRESS AND SELF-ORGANIZING OF THE NATURE

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The analysis of the positions of the self-organizing synergism the non-balance thermodynamics and the track record of the nonlinear systems as well as the Russian scientists investigations on the technetium shows that history development technologies and technique and the basic stages evolutions of the nature have a total direction. It is revealed that regularities of the technical formations shaping is identical empirical revealed laws of the shaping biological formations in the technetium. The total scientific explanation of this phenomena is possible on the base of the principle energy extrement of the self-organizing and progressive evolution (PEES PE). This principle merges the second beginning of the thermodynamics (VNTD) in the manner of mirror symmetrical and opposite him on the essence - the survival law. The joint analysis is required of the technical formations considered in the agrarian ecological and engineering investigations. Herewith the technical formations are considered as the elements of the holistic ecological closing agrarian system (AETS). It will allow to shorten the expenses of the energy on the production of the agricultural product and negative influence agrarian technologies on the nature. The Total progressive Direction of the agrarian-engineering researches in the XXI century must coincide with the progressive Direction of the nature evolutions.

Introduction

The analysis of the positions of the self-organizing synergism the non-balance thermodynamics and the track record of the nonlinear systems as well as the Russian scientists investigations on the technetium shows that history development technologies and technique and the basic stages evolutions of the nature have a total direction. It is revealed that regularities of the technical formations shaping is identical empirical revealed laws of the shaping biological formations in the technetium [1]. The total scientific explanation of this phenomena is possible on the base of the principle energy extrement of the self-organizing and progressive evolution (PEES PE). This principle merges the second beginning of the thermodynamics (VNTD) in the manner of mirror symmetrical and opposite him on the essence - the survival law. The joint analysis is required of the technical formations considered in the agrarian ecological and engineering investigations. Herewith the technical formations are considered as the elements of the holistic ecological closing agrarian system (AETS). It will allow to shorten the expenses of the energy on the production of the agricultural product and negative influence agrarian technologies on the nature. The total progressive direction of the agrarian-engineering researches in the XXI century must coincide with the progressive direction of the nature evolution.

The Condition Problem

The results of the technical formation studies executed basically by school prof. B.I. Kudrin are stated in [1-3]. At first this scientist has motivated the unity to general direction of the history development technology, technology and evolutions of the nature [1]. We shall bring the bright expression of B.I. Kudrin's position [1, s. 22]: «Using ideas and notions of the biological evolution for description of all phenomena and resting in the trivial fact: nesting, the consequent product by physical reality of the biological realities (the dead - alive), hereinafter - a realities technical, information and, finally, (so far), realities social… the Nesting reflects the evolution of the planets and allows to consider surrounding as united developing". In the ditto time the problem of the contradictions between the biological evolution and the evolution of the nature on VNTD remained to be unsolved before motivation PEES PE [4]. As is well known, the evolution of the alive nature is directed to improvement of the development of the structures and the organism functions and their community then the evolution of the nature on VNTD is directed diametrically opposite - to the destruction of the structures, the energy degrade, ubiquitous and unceasing growing of the entropy. We shall consider the consequent naturally scientific motivation of the principle PEES PE, in accordance with which occurs the progressive direction of the evolution of the whole nature.

The Motivation of the PEES PE

The symmetry of the nature is the most main characteristic of the self-organizing nature on all levels of her organizations: from the smallest particles (the photons, electrons) to cosmic mega object (the planets, stars). The main laws of the nature must reflect this characteristic. Indirect proof of the confession by world scientific public to symmetries of the laws of the nature at the beginning initially second half XX century is uncommonly speed awarding to Nobel prize (1956) to the american physicists Li and Jang for opening of the breach of the mirror symmetry in the radioactive disintegrations. In consequence these physicist and L. Landau were revealed that this appearing asymmetry turned out to be the special type of the mirror symmetry.

The short consideration of the symmetries problem in the laws of the main sections of the modern physicists and its relationship with other existing problem of the science is of interest. The symmetry is reflected in the third law Newton In the classical mechanics in the evident type: "The action has always the equal and opposite reluctance" or otherwise: "The interaction between two bodies is equal and is made for opposite sides". In accordance with the Nyotte's theorem the main laws of the mechanical engineers conservation are symmetrical to the space and time homogeneity. The Puankare-Misry's return theorem displays the mirror dynamic symmetry of the essentially. The principle in coordination the VNTD with track record of the rest sections physicists is revealed not accidentally on the base of this theorem.

In the classical thermodynamics the VNTD demonstrates the evident asymmetry of the main natural processes that disagrees to reality. The attempt to prove the legality of the VNTD is made in [5, 6]. However, for this proof were used not phenomena of the nature but results of the activity of the person. The error of this attempt even obvious from the invalid initial position. Exactly because of the VNTD unnatural asymmetric it has conditioned the appearance of the row of the problems in physics not only, but also in biology - in theory of the biological evolution. Named and row of the other problems of the science given the VNTD asymmetry, were revealed as far back as XIX century. They have conditioned two catastrophes in physics: misgiving to heat death of the Land and the Universe and "ultraviolet catastrophe" - impossibility to motivate coming from the VNTD analytical dependency of the spectral sharing the radiation absolutely black body. They have conditioned two catastrophes in physicist: misgiving to heat death of the Land and Universe and "ultraviolet catastrophe" - impossibility to motivate coming from the VNTD analytical dependency of the spectral sharing the radiation absolutely black body. The first - remained not solved correct before recent time. The decision second - by M.PLANK in 1900 became possible only due to opening quantum characteristic radiations and quantum of the action - Plank's constant - which turned out to be not connected with the VNTD.

The opening principle of the least action by Mopertiyui in 1740 introduced its asymmetry of the nature. The transformation of this principle by L. Eyler in 1744 in the principle of the extreme action has restored the belief about symmetries of the laws of the nature. In accordance with extreme principle action can be as minimum - an economical energy, so and maximum - a lavish energy, not economical energy. In XVIII age there was not beliefs about self-organizing that did not allow revealing in what condition action is an economical energy but in what - and lavish energy. Again a principle of the extreme action was motivated by G.S. Landsberg in 50-th years XX century at considering of the Ferma's principle [7], which in the same way either as principle of the least action, could be considered as sign asymmetry laws of the nature.

The making of the principle of the extreme action from the Ferma's principles and from the least action is indicative of vicinity of essence of the lasts. not accidentally The creators of the classical thermodynamics Klauzius and Bolicman as well as Gelimgolic tried to make the VNTD from the principle of the least action [8] probably understanding certain relationship to their essence and it is not enough convincing motivation the VNTD. The principle of the least action herewith was obviously used in dug the axioms. The VNTD and value to entropy were subjected to in this period critic. Answering this critic, colleague L. Bolicman - De Cudr has voiced the part of important axiom, which is brought beside Brod in [9, s. 324-325]: "Second beginning as well as the first is taken only from experience. This the most faithful from all known us experienced laws - wrote De Cudr - he more faithful than death, since death - only special event second begin". This faithful and very strong comparison is part of the important axiom. For the full discovery its demand question: that necessary the death should take place, and was shown the VNTD? The answer unambiguous: at least one life.

The Relationship between life and death is the most important axiom of the nature presenting itself dynamic at the time the mirror symmetry. She is around the world directly observed and the exceptions except in religious teachings except in all other area of expertise has not. The duplication by fissions of the hutch is sometimes considering the immortality, but this can be disputed possible considering maternal hutch as vanished at fission.

This axiom is indicative of logical needing to reveal and take into account the law opposite on its essence The VNTD - a law, named law of the survival (ZV). The full wording and clear consideration of the axiom to lives and deaths so obvious for all find in scientific publication us not to manage.

The enough full consideration of the position about lives and deaths is kept basically philosophical labour F. Engels "Dialectics of the nature". In section of this labour, named "Biology", position "Life and death" is central [10, s. 259]: "Already and now do not consider scientific that physiology, which does not consider the death as essential element to lives, which does not understand that negation to lives essentially is kept in most lives so life always imaginative in correlation with its necessary result, concluding in its fetus, - smertiyu. Live - signifies to die". The quoting happens to in this labour from Gegel [cit. on 10, s. 305]: "Life, as such, carries fetus of the deaths" in itself.

On the base of this axiom possible to motivate the theorem on discovery the ZV and the PEES PE. Briefly we shall consider the theorem confirming mirror dynamic symmetry the VNTD and revealed the law - the ZV. If on the open balance system with spontaneous process of the destruction of the structures and growing to entropy in accordance with VNTD, act external power and to she enters the available free energy, that first or last under their influence in accordance with revealed by law - the ZV opposite on essence the VNTD self-organizing structures appear in system spontaneous which will develop growing to entropy in system to fall then its entropy will decrease but free energy to increase (be accumulated) in system. As a result such evolution the balanced system complied in determined time period the VNTD can change in self-organizing (unbalanced) system residing in consent with the ZV and not complying with the VNTD. Inevitably address. Only under its presence is possible the progressive evolution.

The considered axiom is in the agreement with the Puankare-Misry theorem of the return, from which not accidentally follows the problem of the principle in coordination VNTD with track record of the main sections physicists. She is also in the agreement with theorem of the quantum theory of the field (SRT-theorem) proved by Lyuders (1952-1954) and V. Pauli (1955). In accordance with this theorem of the equation to quantum theory of the field is invariant comparatively SRT transformations. They do not change its type if simultaneously produce three transformations: charge interfacing - a change the inverse particles (S), spatial inversion - a mirror image - (R) and address of time - a change the sign with "+" on "- " (T). In accordance with SRT-theorem if in nature occurs certain process then with the same probability in her can occur also inverse process in which particles are replaced corresponding to opposite particle projections their back has an opposite sign but initial and final conditions of the exchanged process the places [11].

Not accidentally this theorem executes specifically important role in quantum electric speaker, about than witness, for instance, references to it in many places of the scholastic course of this section physicists [11; s. 68, 71, 307, 317, 351]. Coming from consideration of the particles of the inverse particles and of the truly neutral particles as well as their relationship with the theorem - the SRT, not is accidentally noted in [11, s. 68] following: " appropriately emphasize that though stated here the discourses and introduce the natural development usual quantum mechanical engineers and classical theory to relativity but got such by the results leave for their frames as on the form (ψ -an operators, containing simultaneously operators of the birth and deleting the particles), so and essentially (the particles and the antiparticles). ***These results it is impossible so consider as purely logical need. They contain in itself new physical principles the criterion to correctness which can be only experience***" (the cursive of the authors). We shall pay attention to word from quoting "containing simultaneously operators of the birth and deleting the particles". They, obviously, not understandable for their authors we shall pay attention to word from quoting "containing simultaneously operators of the birth and deleting the particles". They, obviously, not understandable for their authors, but clear display the axiom of the lives and deaths. This quoting is indicative of important, not yet realized dug the theorems - SRT and considered axioms in building of the quantum theory.

One of the complex undecided problems to theories of the biological evolution (Darwin's, syntetic) - a divergence on many orders of importance of the real velocity to evolutions with importance of this value calculated on origin mutation and their selection theoretically. The real velocity to evolutions on 7-8 orders goes quicker than accounting. This is persuasively shown calculation, on base of the theories to probability, in work E. K. Tarasov [12, s. 7-8]. Hereunder dock-is healled that principle of the casual origin to genetic information, provided Darwin's theory, not well-to-do. The decision of this problem turned out to be possible on base of the principle Le Shatelie [13].

The elementary mechanism of the manifestation ZV in speedup of the origin to biological information most comfortable reveal on macro level, coming from principle Le Shatelie. In accordance with this principle the influence of the external ambience to self-organizing system causes in her change, which bring about weakening of this action. The system constantly directly adapts is adapted to change the external ambience. The elementary mechanism of the manifestation ZV in speedup of the origin to biological information most comfortable reveal on macro level, coming from principle Le Shatelie. In accordance with this principle, the influence of the external ambience to self-organizing system causes in her change, which bring about weakening of this action. The system constantly directly adapts, is adapted to change the external ambience. In alive nature this adjustment increases in the event of extreme external environments.

The schematic relationship of the history development extreme principle with ZV, PEES PE, as well as axiom to lives and deaths is shown on Fig. 1.

Any directed change the external environments occur in the manner of the fluctuations having as the positive direction so and opposite negative one. Herewith the directed fluctuation reaction of the self-organizing system occurs in accordance with the Le Shatelie principle on influence of the external ambience. These processes occur on all the levels of the nature organizations: from the elementary particles atom molecules before organism, population, ecological systems and cosmic objects. The high velocity to progressive direction to evolution of the self-organizing nature speedup of the development improvements to its information on measure philogenetic developments of the self-organizing systems are conditioned exactly these phenomena. These positions confirm the results of the analysis not only considered but other main problems to modern theory to biological evolution on base of the principle Le Shatelie provided in [13].

In accordance with the ZV the whole self-organizing nature, particularly living is economized. The progressive evolutional development of the alive self-organizing nature, increase its economy occurs by means of the improvement information controlling systems. The progressive development of the alive self-organizing nature increase its economy occurs by means of improvement information controlling systems and structured organization providing efficient operation organism and their community. In accordance with principle Le Shatelie directed adaptive oscillatory selection economical mechanism and structures occurs on all hierarchical level of the organizations of the development of the system.

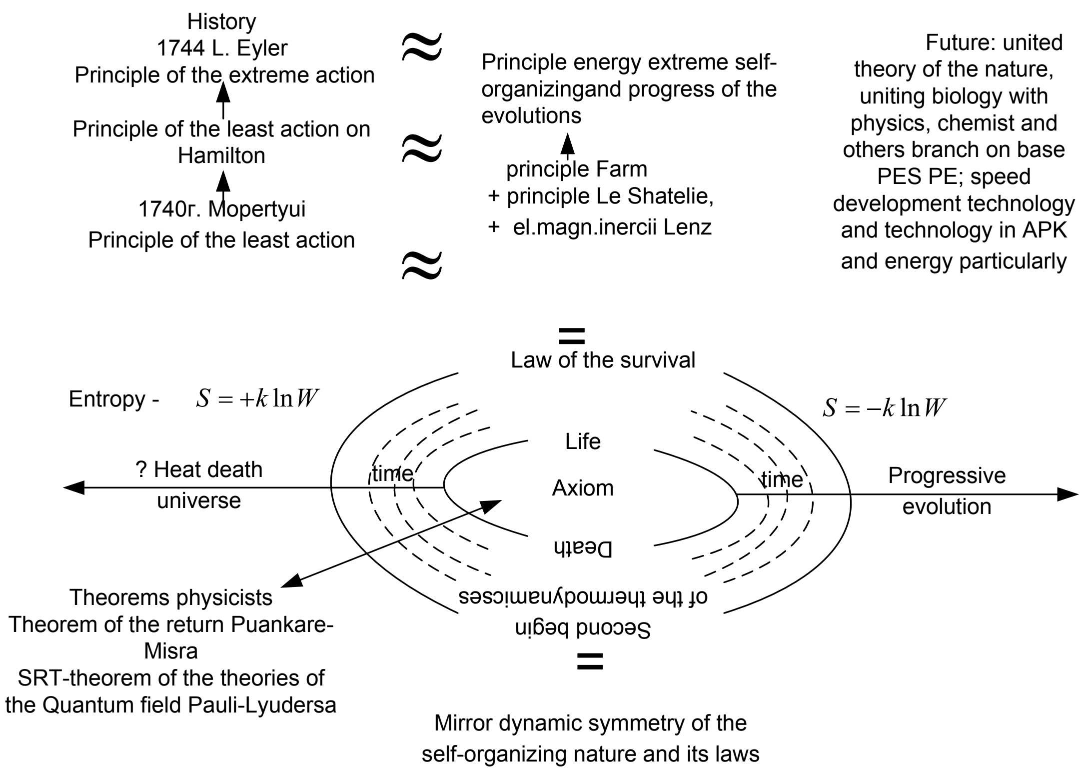

Fig.1. To the motivation relationship of the physic-chemical principle with the ZV and the PEES PE (explanations in text)

The modern dates on study of the genetic organism structures confirm this position having very big importance for decision of the considered problem to theories to evolutions. If receive a visit at correspondence to with modern data that gene of the person consists of the 30 thousand gene the gene mouse forms 90 % of the person gene . Only 1% of the gene mouse differs from the corresponding structures of the person gene. These dates are installed empirical. They allow coming to the following conclusion. Since time of the divergence of the ways to evolutions of the person and mouse the person gene initial having more complex and progressive structure increased for considered period on 10 % more then. For this period by gene mouse increased on 1 % only. Is it thereof seen that genetic information structures of the person changed for this period tenfold quicker.

In accordance with these dates as this possible was expect and coming from principle Le Shatelie genetic information structures of the person as more complex self-organizing system at the beginning initially evolved tenfold quicker than like structures mouse - at the beginning initially obviously more complex system. In this one more indirect acknowledgement to realities of existence ZV its general directing dug in progressive development of the evolutions of the nature in speed development of the information genetic structures. The ZV is realized by means of different natural mechanisms mechanisms of the economy. To their count; calculate; list pertain the phenomenal principles, used in physics and chemistry as reference positions: the least action Ferma, Le Shatelie and, as it is shown in [14], the Lenz law of the electromagnetic inertia.

The evolyucionny progress in accordance with the ZV and PEES PE is reached by price of the high expenses to energy. As according to the principle Le Shatelie in the course of time the progressive evolution speeds up, that "evolution action" of nature is necessary to measure in the same unit, as value of the action in accordance with principle of the least action (J*s). There is base to consider that on base of the principle Le Shatelie possible to calculate the velocity to progressive evolution in these units, which, regrettably, hitherto did not fall into the general system of the physical units.

The coincidence empirical modern dates on identifications gene mammals with the forecast on base of the principle Le Shatelie confirms the determinism of the evolutions processes and the general efficient Direction all its stages as well as simultaneously demonstrates the high cognitive possibility of the use physic-chemical principle. We shall note that in accordance with principle Le Shatelie origin and selection of the progressive information occurs in determined measure goal-directed. This is indicative of need and possibility of revision of the determination to information on Kastleru.

The founder communication theory Shannon not without bases noted that: "Much seldom manages to open simultaneously several secrets of the nature one and same key. The building our several artificially created welfares can collapse easy . As soon as at one beautiful day it will turn out to be that with the help of several magic words like information, entropy, redundancy it is impossible solve all undecided problems" [15, s. 12-13]. This position as it is impossible better characterizes the ZV and PEES PE role in progressive development of the modern science. Possible to confirm that with their opening really collapsed former "several artificially created welfare" physicists, founded on former belief about VNTD about excessively exaggerated dug entropy in physical миропонимании, in theories of information - a communication theory. The ZV has performed the key role in understanding the economy of the self-organizing nature and simultaneously must execute this role in quantitative estimation quality to biological information.

Conclusion

1. In accordance with principle energy extreme self-organizing and progressive evolution general progressive direction of all the nature evolutions stage have a direction spare resource and energy. This principle necessary to take into account at motivation of the optimum agrarian technical systems.
2. Reasonable to use the exergy analysis and try to take into account biological (genetic) information at the motivation of the optimum agrarian technical systems.
3. The motivation of the choice of the borders separate agrarian technical systems is important.
4. For choice the efficient agrarian technical systems from the number existing ones has important significance an analysis of the conditions of their development, developments and результативности use on base of the principle energy extreme self-organizing and progressive evolution exergy analysis and other revealed regularities agrarian technical systems.

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FROM AGRICULTURAL WASTE MANAGEMENT TO ENERGY PRODUCTION; CIRCULAR ECONOMY AND CO_2 TRADING IN AGRICULTURE

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Biomass is the organic matter in trees, agricultural crops and other living plant materials. The end product of photosynthesis is carbohydrates which is organic compounds of biomass. Organic compounds of biomass is used as renewable energy source (Anonymous, 2007a).

The usage of energy from agricultural waste, also another biomass, reduces the concentration of CO_2 in the atmosphere. The energy from biomass is in natural CO_2 cycling, because the biomass uses the CO_2 in the atmosphere through photosynthesis. Consequently the usage of biomass does not contribute to the risk of global climate change.

Utilization of agricultural wastes for energy production means an income for agricultural sector. The farmers can sell the biomass directly after harvesting or use these for energy production. The produced energy can be sold or used in farms themselves. The fermented organic materials can also be used in the plant production.

Keywords: Waste management, energy production, circular economy

Agricultural Waste management

Material flow management (MFM) is called the logical use of the materials and energy in production.

The goals are achieved by ecological and economical areas and by observing social aspects. In addition, MFM is the most important factor for circular economy and sustainable development.

The management of agricultural wastes in distribution of scarce resources is an important factor in the economics. The task of the management of material flow becomes relevant for agriculture with the beginnings of the industrial production. There are some developments in the operational material flow management in last years. But the term "material flow management" is still unknown for the farmers. Actually in practice, the tasks of material flow management in agricultural production are material economics and logistics, as well as environmental management.

Material flow management in agriculture is conventional structure of the supply and disposal economy principle. In the sense of the normative lastingness requirement on the organic portions of the material flow systems, a special meaning attain material flow management. Efficient handling systems in agriculture require an exact knowledge of the genesis and logistics of materials, the potential and technical options for the optimization of material flow, and also the availability. This knowledge is available in the context of the refuse economy. Logistical, technical and financial parameters of our refuse economy systems are outstanding.

The classical refuse economy already represents a simple form of material flow systems in agriculture. The input materials in agricultural production are soil, fertilizer, seed, plant protection agent and fuel. The output materials in agricultural production are yield product and residual substances. The yield product can be sold or used but agricultural wastes can not be sold. It actually contains disposal and never used in production and is not valuable product for agricultural enterprise. Therefore the classical waste management is not sustainable. Regional, ecological, social aspects are not evaluated in this perspective.

Today, a material flow management can be organized in farms or materials can be sold to another plant as an input material. Waste management in the agricultural sector developed fast in world-wide. There were no any legal regulations in Germany until 1972 for refuse disposal (Heck and Bemmann, 2002). Today there are multiplicities, adapted regulations in the refuse disposal. After these regulations, the residual substances are eliminated in all sectors, and also in agricultural sector, by related actors. An example for the material flow management in a farm is shown below (Figure 1).

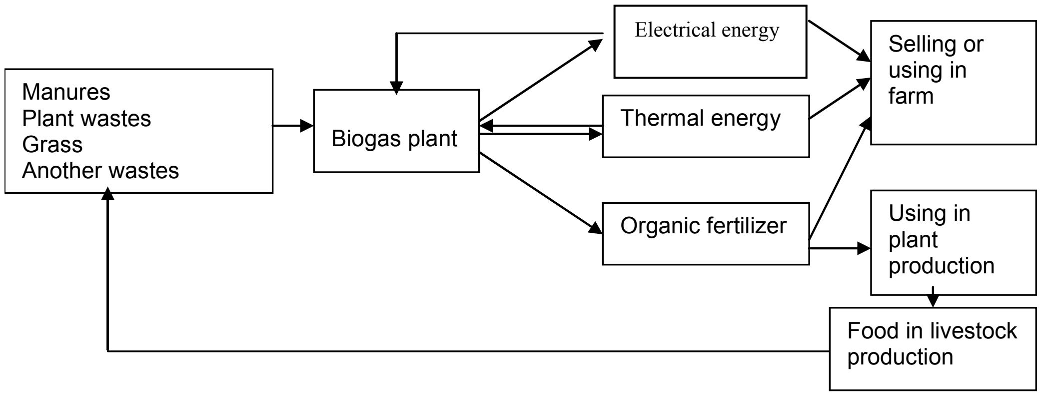

Figure 1: Material flow management in agriculture

Waste mountains were occured because of waste composed after agricultural production. Dirtiness as a result of usage fossil energy sources intensively in agricultural production started to threat people lifes in the world. The decreasement in raw material reserves moved to agenda of primarily scientists then entire people with developing communication tools and consciousness of civilian society.

The new agenda composed in the World were discussed in Earth Summit organized by United Nations on Environment and Development (UNCED) in 1992 in Rio de Janeiro and "sustainable development" principle were occured first time in Rio decleration. This principle is defined as balancing the fulfillment of human needs with the protection of the natural environment so that these needs can be met not only in the present, but in the indefinite future. The production and life philosophy in the World were rearranged according to this term.

The scientists and civilian society establishments were conducting intensive works on planning of source usage in production, waste management, developing nature sensitive systems, re-organisation of life. These studies ascertained the necessity of planning of material flows according to the new principles in all systems. In this scope, a new working area come into agenda of the World as "Material Flow Management".

The agricultural production were started to re-planning according to the sustanable development with material flow management aproach. The material flow management evaluates the material and energy usage as a whole and targets to decrease environmental effects to the lowest value without concession of production method, high efficiency, quality production and life princibles. In this mangement

Energy usage, waste and raw material management wer replanned according to the sustainbility princible in this management process. The following strategies were adopted as a result of conducted studies;

Energy management strategy
- Energy saving
- Efficient use of energy
- Usage of renewable energy sources

Waste management strategy
- Decreasement of waste production
- Re-use
- Re-cycle

The wastes composed after agricultural production and usage of agricultural products seems as an important problem. By steering the organic agricultural wastes composed as a result of intensive production to again in production, this problem is tried to be solved.

The balance of life cycle based on reuse of waste. The rupture of this chain is a result of environmental problems in these days. Mineral fertilizing, intensive medicine usage, insensible soil usage as long as many years, are continuing to be a big problem in some countries where environmental problems are not discussed.

The wastes composed after livestock production has the big share. The most common method is storage at unchecked conditions. Storaged wastes on land cause CO_2 and CH_4 gas production. In addition to these gasses composed anaerob fermentation at the storage stage, nitrate cumulation is also another environmental problem. Leaving agricultural wastes in produced areas is also one of the source of greenhouse gases. The gases composed as a result of anaerob fermentation releases directly to the atmosphere.

Biogas and compost are utilizable production technologies. The aim of biogas production both energy and fertilizer production. Only organic fertilizer production mentioned in composting. But both of them named as waste and aimless destroyed or stored away are the re-evaluation applications of wastes. That is necessary to consider these technologies which can be used both storage or usage of agricultural wastes and increasement of farmers income and usage of the term "industry".

By spreading of biogas production, wastes composed after agricultural production will became a raw material in industrial production. In addition, organic fertilizer composed after fermentation will be used as input material in agricultural production. The farmers activating joined in this cycle will become a partner of this amenity.

Manure, plant and other wastes can be used in biogas production. In the biogas fermentation, organic fertilizer, electrical and thermal energy produced from organic wastes. This energy can be sold or used by farmer. Organic fertilizer can be used in food production for livestock. The residual substances in the livestock production can also be used for gas production. That is a good example of material flow management in one of in agricultural enterprise.

New working areas are generated by material flow management perspective. Occupation companies can connect in the form of material flow management companies for economical and social goals.

The system of the occupation company can be substantially improved in combination with a material flow management strategy (Heck and Bemmann, 2002).

Agricultural Waste and Energy production

Usage of local energy sources as well as agricultural residuals, steps apart from the discussed advantages of supply security, to the environmental compatibility by CO_2 neutral burns so that can be void long routes of transportation from the production to the use. The utilization of agricultural residuals in agriculture has different advantages. The residuals are burned either irregularly or simply stored. Both methods cause a large environmental pollution. However, all of these residual substances contain energy. They can be used with different methods for power production. These methods serve also procuration security, increase of economy of agricultural production and environmental compatibility. These energy-related political goals are shown in Table 1

Power production from agricultural residual substances in enterprise has following advantages.

a) high energy efficiency
b) optimum energy and waste management
c) energy supply in own enterprise
d) clean environment in farms

The farmers are actually energy users they pay much more money for energy and total production costs constitute large portions of energy costs. If the energy costs are reduced, the production costs could be degraded in the agricultural production. The decentralized one on local available resources developed power supply creates new jobs. The biogenous energy sources create five times more jobs than conventional fuels, like natural gas and oil. Use of the regenerativ energies consist of local jobs within the range development, building, operating and to maintenance. It concerns with its jobs all qualification levels .(Heck and Bemmann, 2002).

Table 1 Political goals and strategy during the use of agricultural waste materials for the power production (Heck and Bemmann, 2002)*.

	Procuration security	Economy	Environmental compatibility
Strategies	✓ strengthen and develop native resources ✓ reduce import risks ✓ use more economical and rational energy ✓ provide technical security of power mains	✓ Create economical and efficient energy supply for industry and consumers ✓ secure energy production standards ✓ increase export potentials of energy producers ✓ Create energy producers from agricultural production ✓ Meet energy industry in agriculture ✓ Increase farmers income	✓ replace polluting energy sources with environmental energy sources ✓ usage energy in logical and economical ✓ Reduce environmental pollution by storage of agricultural and animal wastes

- added to the original table by author.

Methods of energy production from agricultural waste

Biodiesel

Biodiesel is produced from biological sources (such as vegetable oils), which can be used in diesel-engine vehicles. It is thus distinguished from the vegetable oils or waste oils. Biodiesel is biodegradable and non-toxic, and typically produces about 60% less net carbon dioxide emissions than petroleum-based diesel (Anonymous, 2007b)**.**The farmer can produce the biodiesel for internal requirement in small plants. The farmer can have cheap and pollution free energy via biodiesel process. That is very important for the farmers. They can also degrade production costs.

Bioethanol

Bioethanol fuel is produced by sugar fermentation process, although it can also be manufactured by the chemical process of reacting ethylene with steam. The main sources of sugar required to produce ethanol come from fuel or energy crops. These crops are corn, maize and wheat crops, waste straw, willow and popular trees, sawdust, reed canary grass, cord grasses, jerusalem artichoke, myscanthus and sorghum plants.

Table 2: Biodiesel end ethanol production in European Union in 2004 (tons)(Anonymous, 2006d).

Country	Biodiesel	Ethanol	Country	Biodiesel	Ethanol
France	348 000	80 887	Denmark	70 000	
Sweden	1 400	56 529	Netherlands		11 146
Germany	1035 000	20 000	Italy	320 000	
Finland		3 768	Greece	0	
Poland	0	38 270	United Kingdom	9 000	
Spain	13 000	202 354	Slovakia	15 000	
Austria	57 000		Latwia	0	9 800
Czech Republic	60 000		TOTAL EU	1933 400	422 754

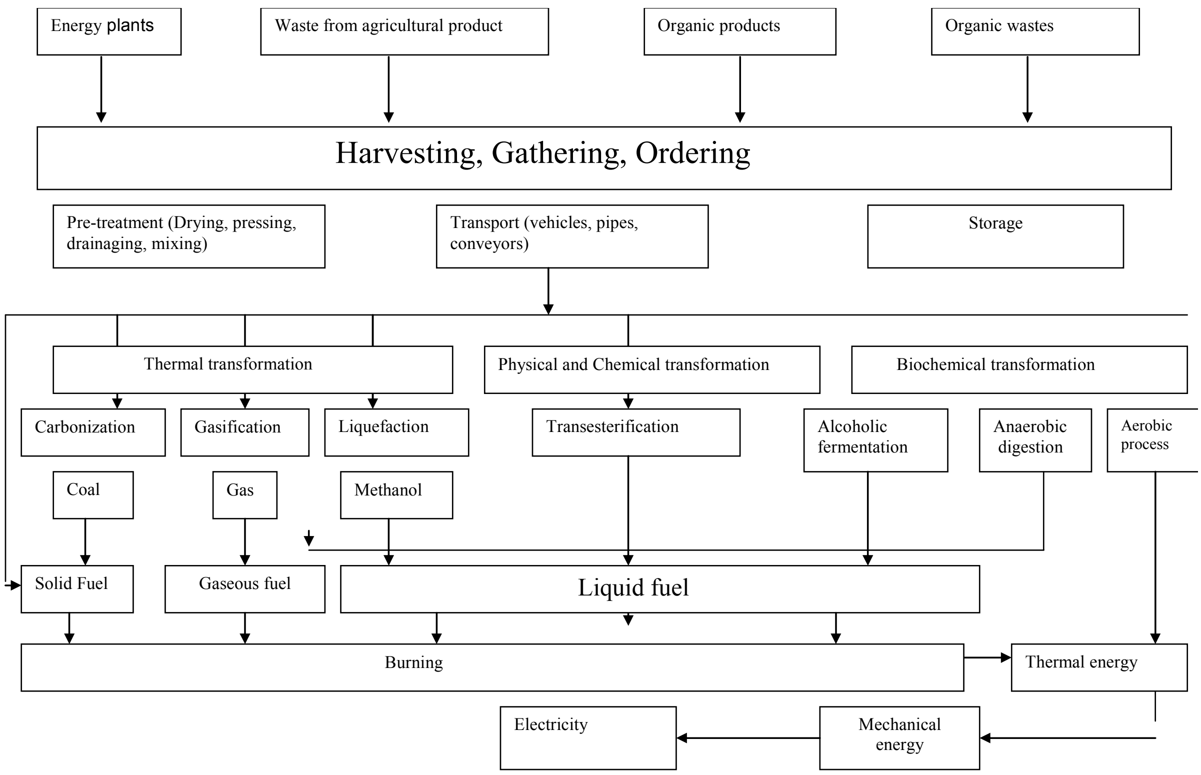

Figure 2: Methods of energy production from agricultural waste (Heck and Bemmann, 2002)

Anaerobic Digestion

Anaerobic digestion can help to dispose of all wastes and to control odor of livestock production. This is a logical method for disposal of waste management, that is why electrical and thermal energy and biofertilizer is produced. Nonetheless harmful microorganisms are eliminated through anaerobic fermentation. CO_2 and methane emissions can be reduced by biogas production So that the farmers should be motivated to use this technology.

As a fermenting substrate for biogasification only one organic waste is enough. They do not have to contain harmful materials. Beside liquid manure and bio waste, the other residual substances such as biowaste, grass cut, wastes from the vegetable production, intestine contents, fish wastes, liquid manure, wastes from the milk industry, energy plants (corn, potatoes, field beans, feeding carrots), wastes from the beverage industry, sewage sludge can be used in fermentation of biogas. We must consider, however, the following points.

Table 3: Biogas production from different organic wastes (Kuhn, 1995)

Material	DM (%)	ODM (%)	$N_{tot.}$ (%)	NH_4-N^+ (% -N_{top})	P_2O_5 (% KM)	K_2O (% KM)	Mg (% KM)	Biogas (l/kg.ODM)
Cattle manure	6-11	68-85	2,6	39-60	0,5-3,3	5,5-10	0.3-0,7	200-260
Pig manure	2,5-9,7	60-85	6-18	50-92	2-10	3-7,5	0,6-1,5	260-450
Chicken manure	10-29	75-77	2,3-6	69-70	2,3-6,2	1,2-3,5	0,4	200-400
Sheep manure	25-30	80	3	35	1,2-1,7	2,7-4,8		400-500
Horse manure	28	75	2,1		1	1,8		300-400
Grass silage	26-82	67-98	3,5-6,9	6,9-19,8	0.38-0.76			500
Grass	86-93	83-93	2,0-2,1	5,7-12,4	0,19-0,33			
Clover	20	80	2,8		0,7	3		400-500
Cereal straw	85-90	85-89	0,5		0,2-0,4	11-2,3		300-600
Corn straw	86	72	1,2		0,5	1,7		600-700
Beet leaf	15-18	78-80	2,0-2,5		0,5-1,1	4,0-4,7	0,72	400-500
Potato leaf	25	79	1,5		0,5	2,9		500-600
Apple pulp	2-3,7	94-95			0,73			300
Potato pulp	12-15	90	5-13		0,9	6,4		330
Wheat pulp	3-5	96-98	6-9,9		3,6-6,0		0,4-0,7	
Molasses	10,5	71,2						
Grape pulp	40-50	80-95	1,5-3,0		0,8-1,7	3,4-5,4	0,15	
Waste from malt industry	21-15	66-95	4,0-5,0		1,5	1,2		800
Waste from milk industry	4,3-6,5	80-92	0,7-1,5	20,3	0,8-1,8			
Vegetable waste	5-20	76-90	3-5		0,8	1,1		400
Aromatic plants	53	55	2,3		1,2	1,1		
Cacao glumes	95	91	2,5		1	2,8		
Waste from oil plants	92	97	1,4		0,3	1,2		
Waste of raps	88	93	5,6		2,5	1,6		
Biowaste	40-75	30-70	0,5-2,7	7	0,2-0,8	0,3-0,8		200-600
Animal flour			8-12		2-5	0,3-0,5		
Blood flour	90	80	12	0,6	1	0,6		
Food wastes	9-37	74-98	0,6-5,0	1,5-22	0,3-1,5	0,3-1,2	0,04-0,18	500-700

DM: Dry matter; ODM: Organic dry matter

a) The origin of the materials is to be specified clearly,
b) We must know the quantities and qualities of the material in planning stage,
c) Temporal availability and prices of material,
d) The waste category should be known before utilization,
e) Special requirements at processing stage should be known
f) Characteristics (Specific gravity, dry substance content, organic dry substance content, nutrient content, gas productivity) should be known (Heck and Bemmann, 2002).

Table 4: Electricity production from biogas in the European Union in 2004 and 2005 (in GWh) (Anonymous, 2007d)

Country	2004	2005	Country	2004	2005
France	444,0	460,0	Netherlands	282,0	286,0
Sweden	61,6	53,4	Hungary	23,0	25,0
Germany	4414	5564,0	Italy	1170,3	1313,1
Finland	21,7	21,7	Greece	179,0	179,0
Poland	155,0	175,1	United Kingdom	4383	4690,0
Spain	824,7	879,4	Belgium	231,9	236,9
Austria	57,7	57,7	Slovenia	30,3	32,2
Portugal	14,6	34,4	Slovakia	2,0	2,0
Czech Republic	138,8	160,9	Ireland	101,0	122,0
Denmark	265,0	274,0	Luxembourg	20,3	27,1
			TOTAL EU	**12819,9**	**14593,9**

Gasification

Gasification converts biomass into a combustible gas by thermo chemical process. Produced gas contains carbon monoxide, hydrogen, water vapor, carbon dioxide, tar vapor and ash particles. Gas quality depends on raw materials and process conditions.

Gasification process divided into two-stages. Heat vaporizes the volatile components of biomass in the absence of air at temperatures ranging from 450° to 600° C (842° to 1112° F) in the first stage, which called pyrolysis. Vapor of pyrolysis process consists of carbon monoxide, hydrogen, methane, volatile tars, carbon dioxide and water. The residue, about 10 % to 25 %t of the original fuel mass, is charcoal. The second stage of gasification is char conversion which occurs at temperatures of 700° to 1200° C (1292° to 2192° F).

Produced gas contains 70 % to 80 % of the energy originally present in the biomass feedstock. The gas can be burned directly for space heating or drying or burned in a boiler to produce steam. The gas can be converted into methanol, a liquid fuel. Electric power can be produce by combining a gasifier with a gas turbine or fuel cell (Anonymous, 2007a).

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MEASUREMENT OF SOIL COMPACTION IN LABORATORY CONDITIONS

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This paper is focused on determination of soil deformation under loading of pressure in laboratory condition. For experimental measurement of soil deformation a special measuring method and equipment was developed. Tested soil was placed in the glass cylinder in 5 layers. Volume of each layer was 10 cm^3 and soil humidity during the measurement was change in the range 0 to 24 percentages. During the measurement the loading force and pressure was constant 1 bar. Loading time was various as follow 2, 4 and 60 second. Distances of individual layers of soil were measured before and after loading of the soil by pressure. Soil deformation was determinate as are different between this distances mentioned about. The soil deformation was measured for three various types of soil. It was obtain that soil deformation selective three types of soil is expressive dependent on soil humidity in the range from 5,5 to 17 percentage.

Key words: soil deformation, glass cylinder, soil layer, soil humidity, soil type.

1 Introduction

Nowadays a soil compaction is as a result of a negative influence of tractors and other agricultural machines on the soil. For this reason it is necessary to determine relation ship between loading of soil by pressure and soil deformation. Experimental measurement must be accomplished to fulfill the goal mentioned above. These measurements may be accomplished in the laboratory and also in the field conditions. From the point of view of theoretical analyses laboratory measurements are preferred. However for laboratory measurements special measuring method and equipment must by developed.

Thus laboratory measurement allows objective comparison of obtained results due to constant measuring conditions. Consequently measurement of soil compaction presented in this paper was accomplished in laboratory conditions by using specially measuring method and equipment which was developed at the Department of Vehicle and Heat Devices of Agricultural University in Nitra.

2 Material and Method

2.1 Measuring device

Measuring device shown in Fig.1 consist of classical scale balance 5 which is fixed by arm 9 and is carried by supporting strut 2. Pattern of soil is placed in the laboratory glass cylinder 4 and deformed by pressure piston 3 after lock-off fixes arm 9. By moving of loading weight 6 deformation force of pressure piston is adjusted. The value of deformation force may by adjusted in range from 10 to 200 N in dependence on number of additional weights 7 placed in the right side of arm 5.

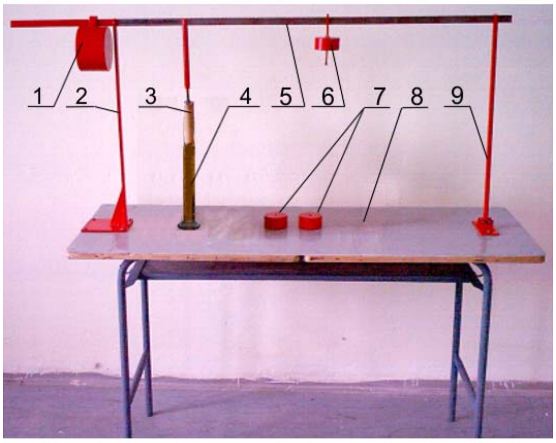

Figure 1 Measuring device - 1 - balancing weight, 2 - supporting strut, 3 - pressure piston, 4 - glass cylinder, 5 - scale balance, 6 - moving weight, 7 - additional weight, 8 - measuring table, 9 - fixing arm

For the individual measurement the action time of pressure piston on the soil was to 2, 4 and 60 seconds and for each measurement the contact pressure was 1 bar. The individual measurement was accomplished at soil humidity 0; 5,5; 13; 17 and 24 volume percentages.

2.2 Measuring glass cylinder

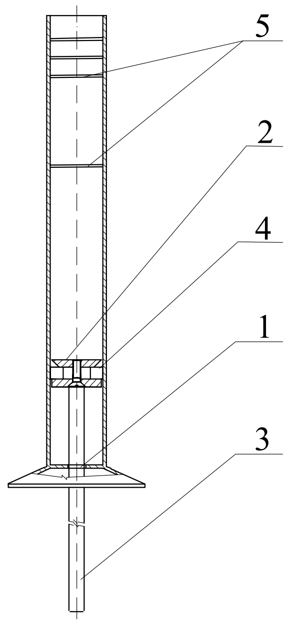

Figure 2 Laboratory glass cylinder adapted for measuring of soil deformation
1- hole, 2 - plunger, 3 - delivery rod, 4 - gasket, 5 - foils

Measuring glass cylinder is shown in Fig. 2 and his volume is 350 cm3. For the soil compaction measurement this glass cylinder was adapted. In the bottom of the measuring cylinder was hole 1 which allows removing of pressured soil out off the cylinder in the end of measurement. For discharging of pressured soil out off from measuring cylinder a discharging piston 2 was used. This piston consists of two steel circular plates and between the two plates a textile gasket 4 is placed. Before each measurement the measuring cylinder is filled with five layers of soil and during the filling aluminium foil 5 is placed between individual layers. Volume of each soil layers is 10 cm3 and distance between surface of the top layer and the top of cylinder is 190 mm. Before loading of the soil by pressure piston the distance between each layers and the top rim of the glass cylinder was measured and recorded in the table. The measuring cylinder filled by this procedure is prepared for the next measurement. After finishing of loading of the soil the individual distances mentioned above was measured again and also recorded in table.

2.3 Characteristic of the soil types which was used for experimental measurement

For laboratory measurement were selected three characteristic types of soil from western part of Slovakia. These types of soil are characterized by soil type and soil class as shown in Table 1. Basic characteristics of the selections soil types are shown in Table from 2 to 4.

Table 1 Paedologistycal ordering according to soil type and soil class

Soil type	Soil class	Locality
Sandy soil	Sandy	Moravský Ján
Black soil	Sandy loam	Komjatice
Brown soil	Loamy	Choča

Table 2 Soil reaction and indexes Cox a Hm

Soil type	pH		%		% $CaCo_3$
	H_2O	KCl	Cox	Hm	
Sandy soil	6,12	5,48	0,72	1,24	0
Black soil	7,51	6,93	1,79	3,08	1,40
Brown soil	6,71	5,35	1,91	3,29	0,44

Table 3 Grain class in %

Soil type	Grain, mm				
	2 – 0,25	0,25 – 0,05	0,05 – 0,01	0,01 – 0,001	< 0,001
Sandy soil	29,26	20,92	30,16	9,32	10,34
Black soil	1,43	25,70	43,56	17,33	11,98
Brown soil	1,04	16,45	44,04	18,05	20,42

Table 4 Sorption – index of sorption ability

Soil type	Sorption, $mmole.kg^{-1}$			Base saturation V, %
	Hydrolytic Acidity H	Sum of exchange kation S	Total capacity T = S+H	
Sandy soil	8,2	35,16	43,36	81,08
Black soil	4,9	245	249,9	98,03
Brown soil	21,2	159,8	181,0	88,3

3 Results and discussion

Measured results are described in Fig. 3 for selective soil types. Average values of deformation are displayed dependently on the soil humidity. As shown in Fig. 3 the greatest values of deformation was obtained in the range of humidity from 5,5 to 17 percentages. It was obtained different deformation for selective types of soil in the same humidity. For example in the humidity 5,5 percentages the greatest average deformation about 30 mm was obtained for Sandy soil. But in the same humidity 5,5 percentages the least average deformation was obtained for Black soil. On the contrary in the humidity 13 percentages the greatest deformation about 25 mm was obtained for Black soil and the least average deformation 10 mm was obtain Sandy soil. For all selective soil types the least of average deformation was smaller than 5 mm in humidity 24 percentages. Also lowest value of deformation was obtained in humidity 0 percentage for all selective soil types.

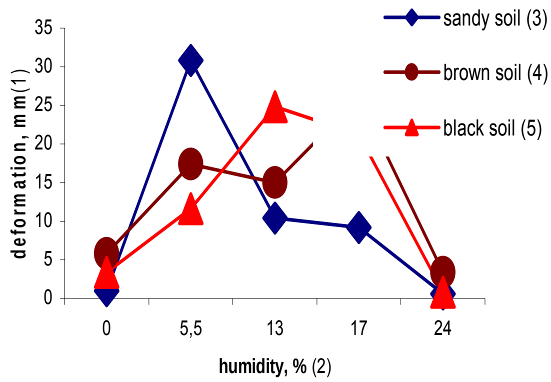

Figure 3 Displayed of influence humidity on deformation of soil by using different soil types

On the basic of obtained results by using of laboratory measuring method we can stay that soil humidity in range from 5,5 to 17 percentages has expressive influence on the soil deformation for three selective types of soil. The total deformation of individual soil layers is shown in Table 5 and 6.

Table 5 Values of vertically deformation of soil in glass cylinder after two seconds action

soil type	layer in deep mm	humidity				
		w_1 (0%)	w_2 (5,5 %)	w_3 (13 %)	w_4 (17 %)	w_5 (24 %)
sandy soil	ground	2	38	21	16	3
	20	2	37	11	15	0
	40	1	31	10	7	0
	60	0	30	8	7	0
	110	0	18	2	1	0
brown soil	ground	5	24	21	56	7
	20	8	20	18	35	5
	40	8	19	15	2	2
	60	6	15	14	25	2
	110	2	9	7	12	1
black soil	ground	6	13	38	36	2
	20	5	12	28	24	1
	40	4	18	25	20	1
	60	2	10	21	18	0
	110	0	5	12	8	0

Table 6 Evaluation of value deformation of soil by statistic program Anova

Soil type	Factor	Humidity					Total
		w_1 0%	w_2 5,5%	w_3 13%	w_4 17%	w_5 24%	
Eutric Regosol	Amout	5,00	5,00	5,00	5,00	5,00	25,00
	Sum	5,00	154,00	52,00	46,00	3,00	260,00
	Average	1,00	30,80	10,40	9,20	0,60	10,40
	Dispersion	1,00	63,70	47,30	39,20	1,80	150,92
Haplic Luvisol	Amout	5,00	5,00	5,00	5,00	5,00	25,00
	Sum	29,00	87,00	75,00	130,00	17,00	338,00
	Average	5,80	17,40	15,00	26,00	3,40	13,52
	Dispersion	6,20	32,30	27,50	438,50	6,30	154,93
Haplic Chernozem	Amout	5,00	5,00	5,00	5,00	5,00	25,00
	Sum	17,00	58,00	124,00	106,00	4,00	309,00
	Average	3,40	11,60	24,80	21,20	0,80	12,36
	Dispersion	5,80	22,30	90,70	103,20	0,70	130,32
Total	Amout	15,00	15,00	15,00	15,00	15,00	
	Sum	51,00	299,00	251,00	282,00	24,00	
	Average	3,40	19,93	16,73	18,80	1,60	
	Dispersion	7,83	103,07	85,92	219,46	4,26	
ANOVA							
Resource of variability	*SS*	*diferentiate*	*MS*	*Value F*	*Value P*	*F crit.*	*Convertibility (%)*
Lines	124,35	2,00	62,17	1,05	0,36	4,98	1,17
Column	4 704,88	4,00	1176,22	19,90	0,00	3,65	44,42
Interaction	2 217,12	8,00	277,14	4,69	0,00	2,82	20,93
Together	3 546,00	60,00	59,10				33,48
Total	**10 592,35**	**74,00**					**100,00**

4 Conclusion

On the basic of obtained results by using of laboratory measuring method we can stay that soil humidity in range from 5,5 to 17 percentages has expressive influence on the soil deformation for three selective types of soil. Also we can stay that using laboratory methods is suitable for measurement of soil deformation in various soil humidity for other soil types. For this reason we supposed the laboratory measuring method presented in this paper to use for soil compaction measurement in the future. There are possibilities the improve this measuring method by using electronically measurement equipment as strain gauge and optoelectronic transducer and so on.

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IMPACT OF EXCHANGER LEAKAGE ON THE EFFICIENCY AND RECOVERED HEAT OUTPUT

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The article is devoted to the leakage determination on a prototype of a capillary heat pipe heat exchanger installed in the stall for pig farming. As leakage allowing mixing of air streams is undesirable, many recuperative heat exchangers bear this construction lack. The impacts of leakage on the ratios of volume flows of exhausted and fresh air, the effectiveness of heat gained from the exhausted air, the recovered heat output, and other heat flows in the exchanger are analyzed based on mass and heat balance of the exchanger. Evaluation of analysis based on measured data display significant influence of the exhausted air mixed into the fresh outside air. This causes incredible efficiency increase that is purchased of fresh air quality degradation.

Keywords: recuperative exchanger; exchanger leakage; temperature efficiency; heat transfer effectiveness; mixing effectiveness; recovered output; heat balance; mass balance.

1. Introduction

The leakage in partition walls or heat exchanging surfaces causes mixing of blown out and sucked in air. This insufficiency is given by the production technology and we run up against it with all types of air – air exchangers. The issue of exchanger leakage gains in significance especially in operations, where for health reasons the mixing of the blown out and sucked in air is undesirable. The intensity of mixing is influenced especially by the size and the extent of the leakage, pressure difference on side of airs and the pollution of heat exchanging surfaces. The pollution in this case has a positive impact on filling the leakages. The exchanger leakage is expressed with the help of air mixing efficiency E_m (Marquardt, 1983). Air mixing efficiency is a simple factor defined as a share of change of measured humidities of the sucked in and blown out air caused by the steam transport. It is a suitable and frequently used criterion. The exact procedure for determining exchanger leakages is specified by CSN EN 308 (1998). The standard specifies the procedure of tests for detecting outdoor leakages and penetration of blown out air into the air being sucked in with recuperative as well as regenerative exchangers. The procedures are suitable for testing outside of the air conditioning system.

The issue of leakage with a plate recuperative heat exchanger during screening in a stall for calf farming is discussed by Kara and Adamovsky (2000). In the publication it is stated that with a new exchanger the measured exhausted air and fresh air mixing efficiency was E_m = 0.15 – 0.22. When operating an exchanger without the air humidity condensation, the mixing efficiency after 11 months of operations dropped to E_m = 0.05 – 0.02. During partial condensation of water from the blown out air, the mixing efficiency after 9 months of operations dropped to E_m = 0.005 – 0.01.

The leakage and pollution of heat exchanging surfaces impact on the exchanger efficiency from gravitational heat pipes were tracked in the stall for the feeding of broiler chickens (Adamovsky, Hutla et al., 1996). Heat exchanger leakage along with the intensive pollution of heat exchanging surfaces in the first 6 days of chicken farming, in exchanger air flow velocity of 0.51 $m \cdot s^{-1}$, caused a drop in the exhausted air heat utilization efficiency by 5.8 % in 24 h.

The impact of leakages and shared air flows in local ventilation unit on the efficiency of recovering heat, ventilation efficiency and other aspects are analyzed in the publication (Manz, Huber et al., 2001). Shared air flows are divided into outer and inner. Outer shared air flows concern the entire unit; inner flows concern just the exchanger itself. Air flows shared by leakages from the blown out air into the outside fresh air and vice versa are monitored. On 3 tested ventilation units the portion of the air flows shared by leakages in the exchanger was in the range of 5 to 24 %. Consequence of this was the decrease of heat recovery efficiency by up to 24 %, while the minimum decrease was 3 %. A similar problem, but with comparing central ventilation units is discussed in (Roulet, Heidt et al., 2001). Visualization gases injected into the air stream were used to detect unit leakages. The gas was injected alternately at the unit air flow entries. The gas concentration was measured in 7 places in the unit, including surroundings. This method helped to detect leakages of the central ventilation unit as a whole as well as the recuperative exchanger element itself. A 7% leakage was detected on the exchanger. The leakage of the entire unit was 20 %. Leakage consequences were manifested by the temperature efficiency. An efficiency drop of 12 – 45 % was measure, on average by 43%.

The goal of our work was to discover the operational leakage of the exchanger prototype being verified and to analyze the impact of leakage on the change in proportions of the exhaust waste air and inlet fresh air, efficiency of heat recovery, recuperative heat output and the overall exchanger energy balance.

2. Methods

2.1. Measuring methodology

The prototype of the recuperative exchanger from capillary heat pipes was applied in the stall for pig farming in the Agricultural coop "Hraničář" Mrákov.

Basic exchanger parameters:

- capillary heat aluminum pipe, ribbed on outside;
- pipe filling, ammonia;
- heat pipe mass $m = 2.95$ kg·pc^{-1};
- number of pipes in a row $n_t = 10$ pcs;
- number of pipe rows $n_r = 10$;
- pipe arrangement in alignment;
- diagonal span of pipes in a row $s_1 = 64$ mm;
- longitudinal span of pipes in a row $s_2 = 64$ mm;
- pipe bundle width $X = n_t \cdot s_1 = 0.64$ m;
- pipe bundle depth $Y = n_r \cdot s_2 = 0.64$ m;
- active pipe length $L = 1.455$ m;
- face cross-section of pipe bundle in both chambers $A_c = X \cdot L = 0.9312$ m^2;
- clear area in both chambers $A_p = 0.3194$ m^2.

Stall was divided into 3 sections mutually divided from each other by partitions with closing passages. Stall diagram and the location of the recuperative exchangers and distributions is on figure 1.

There were 35 late gravid, birth giving and nursing sows stabled in section I, section II contained 210 suckling pigs with an average weight of 15 kg and section II had 350 suckling pigs with the weight of 25-30 kg.

The intake of outside air to the stall was provided by an axial ventilator AGRA 630/2 placed before a recuperative exchanger. Outside air heated in the exchanger was led to the individual perforated polyethylene sleeves with a diameter of 380 mm. Diameter of openings in polyethylene sleeve was 32 mm. in the section I sleeve were 44 openings, in the return sleeve branch in section II were 48 openings and in the sleeve branch of section III, 38 openings.

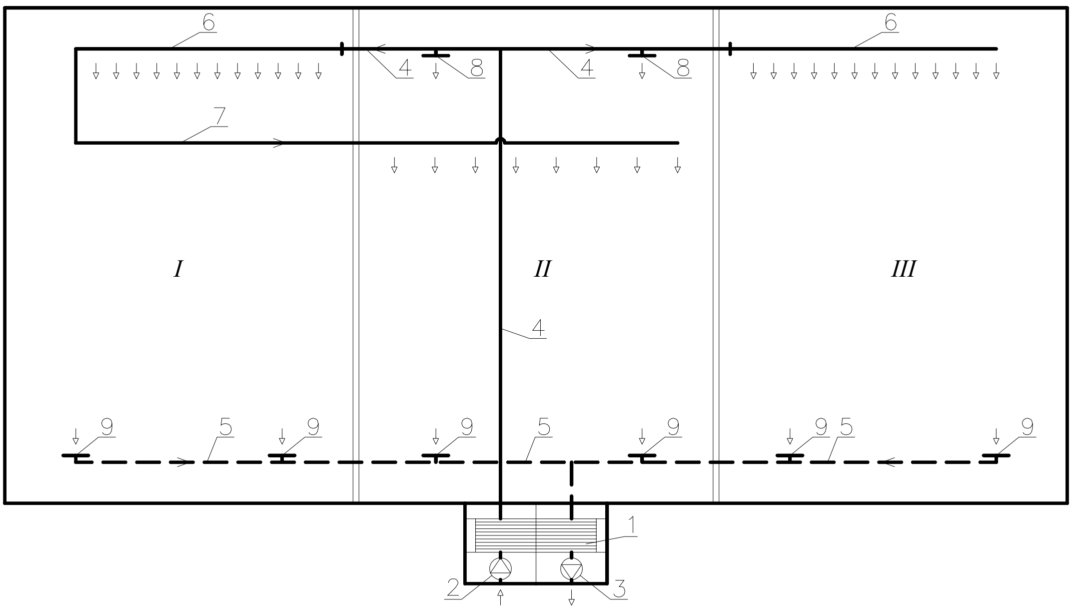

Fig. 1. Diagram of the energy system with the recuperative exchanger from capillary heat pipes in the stall for pig farming
1. Capillary heat tubes exchanger; 2. Ventilator AGRA 630/2; 3. Ventilator AGRA 465/1; 4. Sheet metal ducts for air intake; 5. Sheet metal ducts for air exhaust; 6. Polyethylene sleeve; 7. Polyethylene sleeve for extra heating and transfer of air from section I to section II; 8. Controlled ventilation openings; 9. Air filters.

Air from the stall was blown out through the sheet metal duct and axial ventilator AGRA 456/1 placed behind the recuperative ventilator. Cartridge filters with FINES PES 1 fiber had a 1m^2 face surface in section I and II, in section II this was 0.275 m^2. It was possible to adjust the surface of openings for air exhaustion. Ventilator electro motors had two rpm stages.

Recuperative exchanger with 100 capillary heat pipes had a gradient of 5° from the horizontal plane. The evaporation part of the heat pipes, which contained the air exhausted from the stall, was placed lower.

Temperatures t and relative humidities φ of the outside fresh air e (exterior) and blown out air i (interior) were measured before 1 and behind 2 recuperative exchanger. PT 100 temperature sensors with a voltage output and psychrometers with forced cooling of wet thermometer were used for measuring. Volume air flows $V_{\tau,i,ma}$ $V_{\tau,e,ma}$ were determined from the measurement of speed profiles by an anemometer from the Ahlborn company. Both volume flows were measured in the direction of the air flow behind the recuperative exchanger.

2.2. Theoretical analysis

Efficiency of secondary air heat utilization is generally given by the share of the recovered (recuperated) heat output $Q_{\tau,R}$ to the total output, which can be obtained from the cooled air $Q_{\tau,i1}$ - $Q_{\tau,e1}$:

$$\eta_R = \frac{Q_{\tau,R}}{Q_{\tau,i1} - Q_{\tau,e1}} \text{ [-]} \qquad (1)$$

Recovered heat output can be expressed by a relationship (2) based on the mass flow of outside air e recalculated per 1 kg of dry air $m_{\tau,e,da}$ and difference of outside air specific enthalpies before and after heating in the exchanger.

$$Q_{\tau,R} = m_{\tau,e,da}\left(h_{e2} - h_{e1}\right) \text{[W]} \qquad (2)$$

For heat flows $Q_{\tau,i1}$ and $Q_{\tau,e1}$ the following is valid:

$$Q_{\tau,i1} = m_{\tau,i,sv} \cdot h_{i1} \text{ [W]} \qquad (3)$$

$$Q_{\tau,e1} = m_{\tau,e,sv} \cdot h_{e1} \text{ [W]} \qquad (4)$$

We'll enter moist air mass air flow $m_{\tau,\, ma}$ into the relationships (2), (3) and (4) instead of mass flow of dry air $m_{\tau,da}$ according to formula (5).

$$m_{\tau,da} = \frac{m_{\tau,ma}}{\left(1 + x\right)} = \frac{V_{\tau,ma} \cdot \rho_{ma}}{\left(1 + x\right)} \text{ [kg.s}^{-1}\text{ da]} \qquad (5)$$

For the secondary heat from the exhausted air utilization efficiency we'll then get the equation:

$$\eta_R = \frac{\dfrac{V_{\tau,e2,ma} \cdot \rho_{e2,ma}}{\left(1 + x_{e2}\right)} \cdot h_{e2} - \dfrac{V_{\tau,e1,ma} \cdot \rho_{e1,ma}}{\left(1 + x_{e1}\right)} \cdot h_{e1}}{\dfrac{V_{\tau,i1,ma} \cdot \rho_{i1,ma}}{\left(1 + x_{i1}\right)} \cdot h_{i1} - \dfrac{V_{\tau,e1,ma} \cdot \rho_{e1,ma}}{\left(1 + x_{e1}\right)} \cdot h_{e1}} \text{ [-]} \qquad (6)$$

For exchanger, where there is no mixing of air blown out with air sucked in, it is valid that $x_{e1} = x_{e2}$ and $V_{\tau,e1,ma} = V_{\tau,e2,ma} = V_{\tau,e,ma}$, $V_{\tau,i1,ma} = V_{\tau,i,ma}$. Furthermore, equation (6) has the appearance:

$$\eta_R = \frac{\left(\rho_{e2,ma} \cdot h_{e2} - \rho_{e1,ma} \cdot h_{e1}\right)}{\dfrac{V_{\tau,i,ma} \cdot \rho_{i1,ma}}{\left(1 + x_{i1}\right)} \cdot \dfrac{\left(1 + x_{e1}\right)}{V_{\tau,e,ma}} \cdot h_{i1} - \rho_{e1,ma} . h_{e1}} \text{ [-]} \qquad (7)$$

3. Results and discussion

Results of the eight operational measurements are summarized in table 1. Designations of the quantities, as well as indexes, correspond to the diagram on Fig. 1 and specification of values stated in chapter Methods.

From the results it can be derived that in all of the stated operational measurements is $x_{e2} > x_{e1}$. From this we can decide that what occurs inside the exchanger is the mixing of exhausted stall air into the fresh air. If both of the air flows would be mixing at the exit and suction, then $x_{e2} = x_{e1}$ would apply.

Volume flow of the exhausted stall air $\Delta V_{\tau,i,ma}$, which is mixed into the outside fresh air, can be expressed from the mass exchanger balance equation:

$$\Delta m_{\tau,i,da} \cdot x_{i1,2} + \overline{m}_{\tau,e,da} \cdot x_{e1} = m_{\tau,e,da} \cdot x_{e2} \text{ [kg.s}^{-1}\text{]} \qquad (8)$$

$$\overline{m}_{\tau,e,da} = m_{\tau,e,da} - \Delta m_{\tau,i,da} \text{ [kg.s}^{-1}\text{ da]} \qquad (9)$$

Mass flow of outside air $\overline{m}_{\tau,e,da}$ in equation (9) defines the air flow without mixed in exhausted polluted air $\Delta m_{\tau,i,da}$, thus $\overline{m}_{\tau,e,da}$ is mass air flow at design conditions. Entering relationship (5) to equations (8) and (9) we'll get the following equation for $\Delta V_{\tau,i,ma}$:

$$\Delta V_{\tau,i,ma} = \frac{\left(x_{e2} - x_{e1}\right)}{\left(x_{i1,2} - x_{e1}\right)} \cdot \frac{\left(1 + x_{i1,2}\right)}{\left(1 + x_{e2}\right)} \cdot \frac{\rho_{e2,ma}}{\rho_{i1,2,ma}} V_{\tau,e,ma} \text{ [m}^3\text{.s}^{-1}\text{]} \qquad (10)$$

Table 1 Results of operational measurements

	Measurements							
	1	2	3	4	5	6	7	8
t_{i1} [°C]	14,0	13,7	15,0	15,3	14,3	17,0	19,0	14,0
φ_{i1} [-]	0,74	0,77	0,78	0,73	0,75	0,77	0,75	0,73
x_{i1} [$g.kg^{-1}$ da]	7,36	7,50	8,24	7,95	7,60	9,30	10,30	7,35
t_{i2} [°C]	3,7	1,7	4,2	4,2	4,4	4,2	5,4	2,7
φ_{i2} [-]	0,98	0,99	0,98	0,98	0,94	0,98	0,98	0,97
x_{i2} [$g.kg^{-1}$ da]	4,73	4,20	4,90	4,90	4,70	5,00	5,40	4,40
$V_{\tau,i,ma}$ [$m^3.s^{-1}$]	0,36	0,26	0,26	0,26	0,14	0,26	0,15	0,42
t_{e1} [°C]	0,0	-1,4	1,9	1,9	3,4	2,0	2,2	-2,9
φ_{e1} [-]	0,83	0,84	0,81	0,81	0,80	0,81	0,84	0,81
x_{e1} [$g.kg^{-1}$ da]	3,10	2,83	3,49	3,49	3,83	3,52	3,73	2,55
t_{e2} [°C]	10,0	6,4	9,3	9,3	11,1	11,4	15,0	8,0
φ_{e2} [-]	0,46	0,64	0,63	0,63	0,53	0,55	0,41	0,45
x_{e2} [$g.kg^{-1}$ da]	3,47	3,91	4,58	4,58	4,47	4,61	4,30	2,95
$V_{\tau,e,ma}$ [$m^3.s^{-1}$]	0,672	0,672	0,674	0,674	0,300	0,674	0,310	0,800
$V_{\tau,i,ma}/V_{\tau,e,ma}$ [-]	0,536	0,387	0,386	0,386	0,467	0,386	0,484	0,525

Design volume air flows $\overline{V}_{\tau,i,ma}$ and $\overline{V}_{\tau,e,ma}$ will be then calculated from the equations:

$$\overline{V}_{\tau,i,ma} = V_{\tau,i,ma} + \Delta V_{\tau,i,ma} \; [\mathrm{m^3.s^{-1}}] \qquad (11)$$

$$\overline{V}_{\tau,e,ma} = V_{\tau,e,ma} - \Delta V_{\tau,i,ma} \; [\mathrm{m^3.s^{-1}}] \qquad (12)$$

Balance of exchanged heat outputs in the exchanger can be expressed on one side by the heat output of the outside air $\overline{Q}_{\tau,e1}$, heat output $\Delta Q_{\tau,i}$ exchanged to the outside air by mixing with stall air and recovered heat output from exhausted air $Q_{\tau,R}$. On the other side is the heat output $Q_{\tau,e2}$ carried by air in to the stall (13).

$$\overline{Q}_{\tau,e1} + \Delta Q_{\tau,i} + Q_{\tau,R} = Q_{\tau,e2} \; [\mathrm{W}] \qquad (13)$$

In equation (13) is:

$$\overline{Q}_{\tau,e1} = \frac{\overline{V}_{\tau,e,ma} \cdot \rho_{e1,ma}}{(1 + x_{e1})} \cdot h_{e1} \; [\mathrm{W}] \qquad (14)$$

$$\Delta Q_{\tau,i} = \frac{\Delta V_{\tau,i,ma} \cdot \rho_{i1,2,ma}}{(1 + x_{i1,2})} (h_{i1,2} - h_{e1,2}) \; [\mathrm{W}] \qquad (15)$$

$$Q_{\tau,e2} = \frac{V_{\tau,e,ma} \cdot \rho_{e2,ma}}{(1 + x_{e2})} h_{e2} \; [\mathrm{W}] \qquad (16)$$

From the equation (13) we calculate the recovered heat output $Q_{\tau,R}$. For calculating the design temperature $\overline{t_{e2}}$ achieved only by recovered heat output $Q_{\tau,R}$ Marquardt (1983) uses air mixing efficiency E_m:

$$E_m = \frac{x_{e2} - x_{e1}}{x_{i1} - x_{e1}} \; [-] \qquad (17)$$

$$\bar{t}_{e2} = \frac{t_{e2} - E_m \cdot t_{i1}}{1 - E_m} \; [°\mathrm{C}] \qquad (18)$$

Secondary air heat utilization efficiency is in practice stated by temperature efficiency $\eta_{R,t}$ enabling to compare individual exchanger types. Temperature efficiency is defined for $m_{\tau,e,da} \cdot c_{p,e2} = m_{\tau,e,da} \cdot c_{p,e1} = m_{\tau,i,da} \cdot c_{p,i1}$. In the equation c_p is the specific air heat capacity in constant pressure [$\mathrm{J \cdot kg^{-1} \cdot K^{-1}}$]. Then in the sense of equation (6) the following applies:

$$\eta_{R,t} = \frac{t_{e2} - t_{e1}}{t_{i1} - t_{e1}} \; [-] \qquad (19)$$

In table 2 are summarized results of equations (7) through (19) derived from the measured values in tab. 1. Values marked with a stripe are derived from measured volume flows $\overline{V}_{\tau,i,ma}$ and $\overline{V}_{\tau,e,ma}$ and eliminates heat flows and enthalpy created by mixing in of exhausted air into the air being taken in from outside. These air volume flows represent design conditions.

Table 2 Calculated values of results

	Measurements							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
$\Delta V_{\tau,i,ma}$ $[m^3.s^{-1}]$	0,0844	0,2422	0,2395	0,2514	0,0825	0,2026	0,0427	0,0968
$\overline{V}_{\tau,i,ma}$ $[m^3.s^{-1}]$	0,4444	0,5022	0,4995	0,5114	0,2225	0,4626	0,1927	0,5168
$\overline{V}_{\tau,e,ma}$ $[m^3.s^{-1}]$	0,5876	0,4298	0,4345	0,4226	0,2175	0,4714	0,2673	0,7032
$Q_{\tau,e2}$ $[kW]$	15,601	13,646	17,387	17,387	8,265	19,088	9,758	15,400
$\overline{Q}_{\tau,e1}$ $[kW]$	5,856	3,147	5,904	5,743	3,593	6,510	3,935	3,154
$\Delta Q_{\tau,i}$ $[kW]$	1,132	3,461	3,079	3,166	0,727	2,917	0,695	1,649
$Q_{\tau,R}$ $[kW]$	8,613	7,055	8,404	8,479	3,939	9,643	5,107	10,597
$\overline{t_{e2}}$ $[°C]$	9,6	4,2	7,6	7,4	10,4	10,1	14,6	7,5
$\eta_{R,t}$ [-]	0,714	0,517	0,565	0,552	0,706	0,627	0,762	0,645
$\overline{\eta_{R,t}}$ [-]	0,687	0,371	0,435	0,407	0,646	0,540	0,739	0,613
η_R [-]	0,836	0,629	0,735	0,727	0,865	0,793	0,917	0,712
$\overline{\eta_R}$ [-]	0,587	0,176	0,187	0,169	0,333	0,284	0,641	0,525
$V_{\tau,i,ma}/V_{\tau,e,ma}$ [-]	0,756	1,168	1,150	1,210	1,023	0,981	0,721	0,735

From the measured values and calculation it is derived that:

- ratio of $\Delta V_{\tau,i,ma}$ in $V_{\tau,e,ma}$ in a given exchanger totals 12.1 – 37.3 %;
- with growth $\overline{V}_{\tau,i,ma} / \overline{V}_{\tau,e,ma}$ the $\Delta V_{\tau,i,ma}/V_{\tau,e,ma}$ increases;
- growth of $\Delta x_e = x_{e2} - x_{e1}$ corresponds with the increasing of $\Delta V_{\tau,i,ma}/V_{\tau,e,ma}$ share, while $\Delta V_{\tau,i,ma} \geq 0,3\ V_{\tau,e,ma}$ is $\Delta x_e > 1\ g \cdot kg_{da}^{-1}$;
- differences between the measured $\eta_{R,t}$ and design $\overline{\eta_{R,t}}$ exchanger temperature efficiency (19) equals to 2.7 – 14.5 %, increase with the increase of $\Delta V_{\tau,i,ma}/V_{\tau,e,ma}$;
- differences between the measured η_R and design $\overline{\eta_R}$ exchanger efficiency (7) comes to 18.7 – 55.8 %, increase with the increase of $\Delta V_{\tau,i,ma}/V_{\tau,e,ma}$;
- difference between the measured air temperature t_{e2} and design air temperature $\bar{t}_{e2}$ of air being sucked in to the stall is 0.4 – 2.2 °C, increases with the increase of $\Delta V_{\tau,i,ma}/V_{\tau,e,ma}$;
- share of $\Delta Q_{\tau,i} / Q_{\tau,R}$ increases with the increase of $\Delta V_{\tau,i,ma}/V_{\tau,e,\ ma}$ share;

5. Conclusion

In the screened recuperative exchanger from capillary heat tubes prototype, there was stall air mixed with the outside air being sucked in due to the leakage of the partition walls. The consequence of this leakage was especially the significant change in proportion of $V_{\tau,i,ma}/V_{\tau,e,ma}$, increased specific humidities, temperatures and heat flow of air being taken in to the stall.

Change in the proportions of $V_{\tau,i,ma}/V_{\tau,e,ma}$ resulted in the change of the ventilation nature. Instead of balanced ventilation, where $V_{\tau,i,ma}/V_{\tau,e,ma} = 1$, an overpressure ventilation occurred $V_{\tau,i,ma}/V_{\tau,e,ma} < 1$. This change results in an increase of heat loss by exfiltration of air by leakages of the circumference building structures. Increase of specific humidity x_{e2} of the outside air evokes the necessity of higher ventilation intensity. The reason consists in observance of required stall air parameters from the point of view of animal comfort and protection of the circumference building structures against dilapidation by dampness. Increase of outside air temperature t_{e2} as a result of the mixing in with the exhausted air t_{i1} is, from the perspective of animal comfort, a positive aspect.

The increase of heat flow value $Q_{\tau,e2}$ of air being driven in to the stall is given by high enthalpy of the mixed air and is manifested by increased efficiency of secondary heat utilization η_R. Original design efficiency $\overline{\eta_R}$ is significantly lower.

Mixing in of exhausted air with air being brought in can even have significant negative consequences in increasing of concentration of undesirable or more precisely harmful microorganisms in the stall air. These influences have not been proven during the screening.

The issue with leakage is not a problem specific to exchangers from capillary heat pipes or more precisely heat pipes in general. We've encountered leakages when screening flat plate recuperative exchangers as well as exchangers from gravitational heat pipes.

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Nomenclature:

h_{e1} - specific enthalpy of outside air before heating in the exchanger [J.kg^{-1} da]
h_{e2} - specific enthalpy of outside air after heating in the exchanger [J.kg^{-1} da]
$h_{e1,2}$ - specific enthalpy of air corresponding to air temperature $\frac{t_{e1}+t_{e2}}{2}$ [J.kg^{-1} da]
h_{i1} - specific enthalpy of stall air before the exchanger [J.kg^{-1} da]
h_{i2} - specific enthalpy of stall air after the exchanger [J.kg^{-1} da]
$h_{i1,2}$ - enthalpy of air corresponding to air temperature $\frac{t_{i1}+t_{i2}}{2}$ [J.kg^{-1} da]
$m_{\tau,e,da}$ - mass flow of outside air recalculated per 1 kg of dry air [kg.s^{-1} da]
$\overline{m}_{\tau,e,da}$ - design mass flow of outside air (without mixed in air) recalculated per 1 kg of dry air [kg.s^{-1} da]
$m_{\tau,i,da}$ - mass flow of stall air recalculated per 1 kg of dry air [kg.s^{-1} da]
$\Delta m_{\tau,i,da}$ - mass flow of the stall air mixed into the fresh air recalculated per 1 kg of dry air [kg.s^{-1} da]
$V_{\tau,ma}$ - volume flow of moist air [m^3.s^{-1}]
$\overline{V}_{\tau,i,ma}$ - design volume flow of exhausted moist air [m^3.s^{-1}]
$\overline{V}_{\tau,e,ma}$ - design volume flow of outside moist air [m^3.s^{-1}]
x - moisture content [kg.kg^{-1} da]
$x_{i1,2} = \frac{x_{i1}+x_{i2}}{2}$ - mean moisture content [kg.kg^{-1} da]
ρ_{ma} - specific density of moist air [kg.m^{-3}]
$\rho_{i1,2,ma}$ - mean specific density of exhausted air in temperature $t_{i1,2} = \frac{t_{i1}+t_{i2}}{2}$ [kg.m^{-3}]
da - dry air
ma - moist air

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UTILIZATION OF INFORMATION TECHNOLOGY FOR FUELS AND VITAL FLUIDS STOCK CONTROL WITH MAINTENANCE SYSTEM

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Function evidence system is essential for thorough management with fuels and vital fluids. Such a system provides an actual summary of particular machinery consumption and current stock state. Another important part of this system is derived from data required for planning and controlling machinery maintenance. This article pinpoints software solutions realized in Microsoft Excel.

Keywords: stock control, fuel consumption, maintenance, evidence system.

1 Introduction

Evidence of fuel and vital fluid consumption of agricultural machines is highly surveillance data in agricultural companies. A lot of companies administrate this evidence roughly and incorrectly. Essential condition for accurate, well arranged, effective managing of fuels and vital fluids evidence is usage of information technologies. Nowadays there are a lot of software tools available for complex data processing. Middle sized companies can not afford this solution because software products are too expensive. Solution in this situation can be taking advantage of standard software equipment which is available on most of personal computers. A sufficient software tool for this purpose is the application Microsoft Excel.

2 Concept of complex evidence

At the beginning it is necessary to set up range and amount of data about consumption which will be tracked. Important thing is pragmatic aspect of information about fulfilled consumption.

All collected information about consumption according to its content must be:
- relevant for the main purpose (relevancy)
- sufficiently accurate (currency)
- sufficiently complete (completeness)
- appropriately punctual (punctuality)

According to a form of presentation it is important to transfer this information to:
- qualified personnel (competency)
- time aspect (well-timed)
- eligible form (comprehensibility)

Important information about consumption is this data:
- machine data
- type of fuel and vital fluid
- amount in proper units
- date of consumption

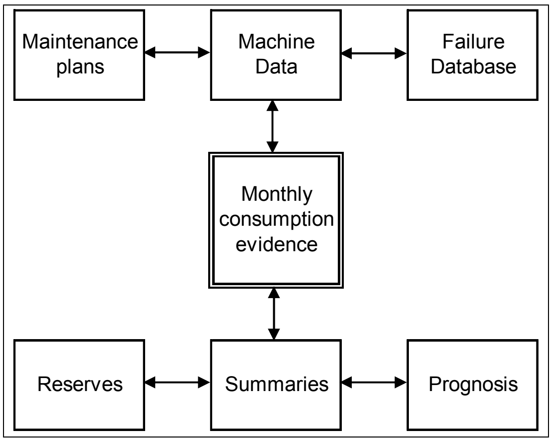

Figure 1 - Scheme of the evidence

It is suitable to collect data in monthly periods for lucid data proceeding. Data captured from these monthly reports is used to obtain other important information. Figure 1 shows this scheme. Monthly consumption evidence has tight linkage to machine data.

3 Machine data

Each machine has its own data sheet which contains precise technical specification (type of machine, brand-name, year of production, output power, total cylinder capacity, total dimensions, wheel base, type and volume of transmission oil and other vital fluids).

Besides, this data sheet is linked to monthly consumption evidence which provides information about consumption throughout the whole year. Advantage of this evidence is that it is available to see cumulative consumption.

Both following figures 2 and 3 represent fuel consumption of tractor Z-7245 in the year 2006. The biggest increase is significant in April when consumption reached 500l. This high consumption is because of removing and clearing of fallen trees in the forest. Compared to other branches the utilization of agricultural machinery is very seasonal. The influence of seasonal fuel consumption is most significant for self-propelled agricultural machinery. The example of such a machine would be a harvester E 303 as shown below. Figure 4 shows fuel consumption for the months of April through September 2006.

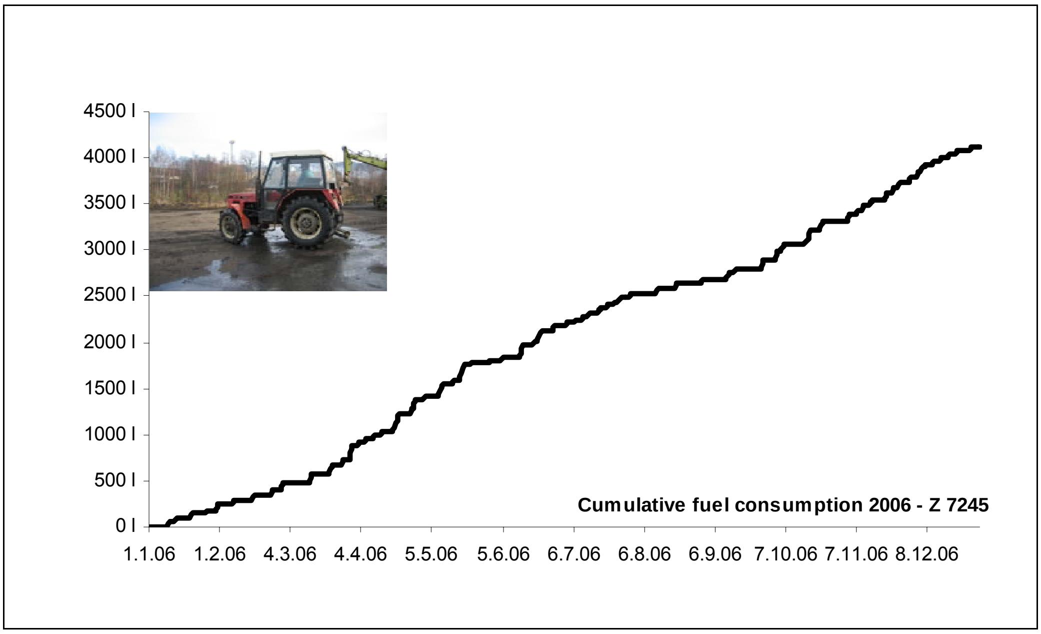

Figure 2 - Cumulative fuel consumption of tractor Z 7245 for the year 2006

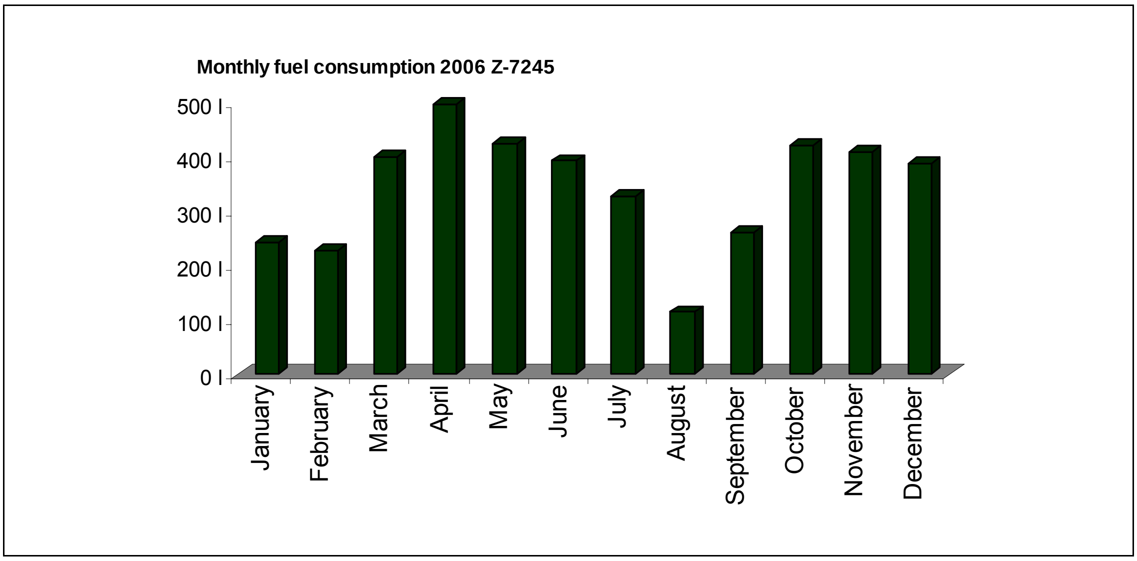

Figure 3 - Monthly fuel consumption of tractor Z 7245 for the year 2006

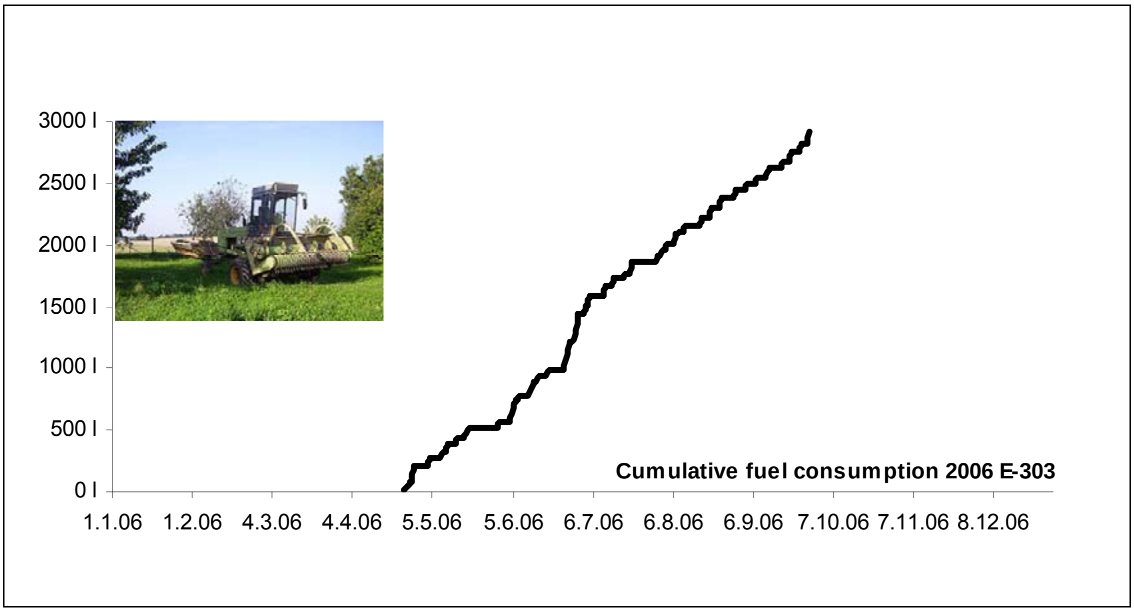

Figure 4 - Cumulative fuel consumption of tractor Z 7245 for the year 2006

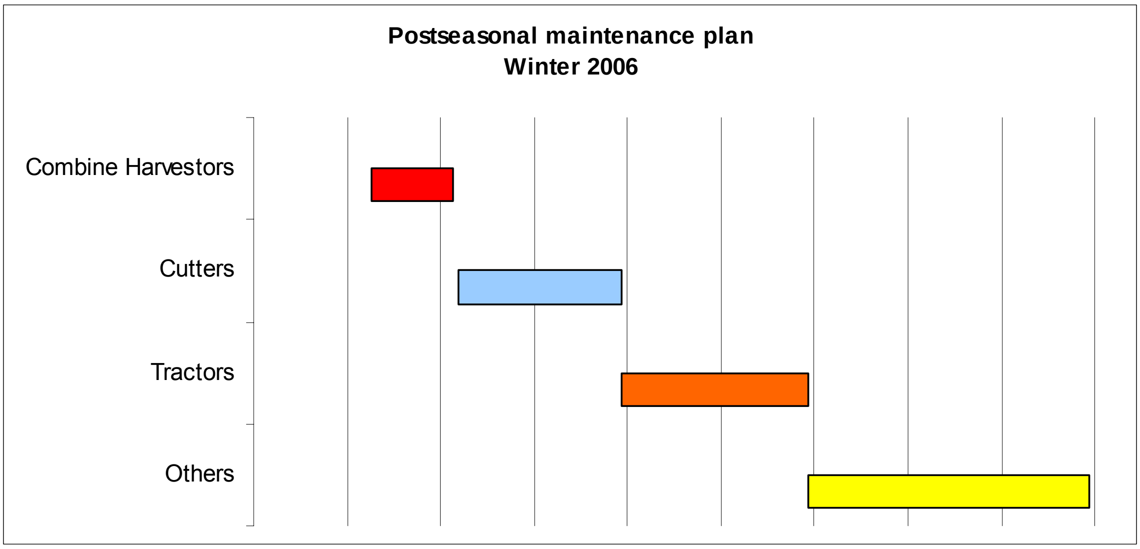

Figure 5 - Post seasonal plan of maintenance activities for winter 2006

It is important to have information for each machine about the periods for their vital fluid change. This especially occurs in transmission oil. Also set up an indicator which provides information about right time for vital fluid change. After each completed change it is necessary to file this information in evidence. Such data is closely linked with maintenance plans. It is suitable to create summary by the help of tools in MS Excel or programming language Visual Basic for Applications. Such a summary informs the maintenance man about planned maintenance for machines in any given week or month. Thanks to this scheme, it is also possible to plan postseason maintenance. Figure 5 shows possibility of post seasonal maintenance plan.

Last but not least it is necessary to have evidence of failures for every machine in the company. This data is used in the “Failure Database” on the detached sheet. This sheet provides complete evidence of all failures which occurred in the past. Information obtained from the “Failure Database” is useful for planning spare part needs and also determining weak points of the whole production process.

The main purpose of this evidence is to acquire different summaries. Monthly evidence provides information only about one month. But when the evidence is already filled with data it is available to get summaries for a longer time period how shows figure 6.

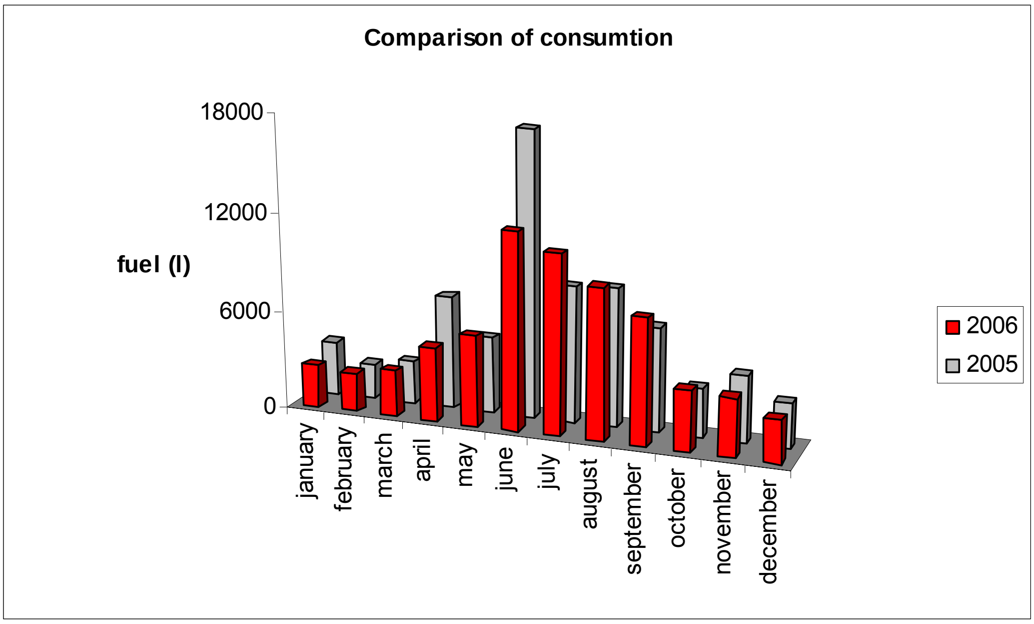

Figure 6 - Comparison of two year consumption

Also these summaries are convenient to diversify according to the type of machine or different production departments of company. For better data comparison it is suitable to set up different ratios (fuel consumption for production unit). Such a ratios and indexes can be easily comparable between each other. This scheme provides optimized evaluation of the machines effectiveness. Besides, based on information obtained from the summaries it is possible to plan stock reserve of fuels and vital fluids. Furthermore, this information is very useful when planning finance sources for next production period and also for making the prognoses.

4 Conclusion

Computer aided fuel and vital fluids consumption provides a suitable way of monitoring individual machine consumption. Using such a system in a company which has implemented standards of ISO 14 000 helps company to keep tracking data of consumption of fuels and vital fluids which are according these standards considered as dangerous. With the proceeding collected information it is possible to evaluate and compare for different time period by return. Considering the collected data and seasonal process of company production it is possible to plan maintenance activities and organize post seasonal maintenance. It is also suitable to keep track of failures and evaluate weak points to eliminate them and in doing so, improve the whole company production process. The entire evidence system provides a possibility to control fuels, vital fluids, and spare parts reserves. If the evidence system is filled with data it is possible to make prognoses of financial sources in order to purchase fuels, vital fluids and spare parts for on-coming period. For the needs of a middle sized company, paper and pencil system is not efficient and complex software product is too expensive. Thus, this system is optimal.

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COST ANALYSIS OF MACHINE-LINES

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The aim of this paper is to present information about influence of individual cost items connected to farming on permanent grassland (FPG). Three machines line used for FPG are compared. Evaluation of FPG is focused on costs. The cost is main factor which is mostly effect economy of machinery operation.

Key words: economy effect, three machines line used for FPG are compared

Introduction

Agriculture politics changes caused crucial change in range management on small and large protected territories. The main goal is organism protection above all plants and animal protection in Natural Preserves and I. Zones of protected landscape areas and National Parks. Contrariwise relatively large areas of semi-naturals greens in large protected territories (II.-IV). Zones and National Parks protected zones and protected scenic areas), it is not possible only to provide range management to preserve biodiversity, but the compromise has to be found between requirements for natural protection and economic way of agriculture production.

Materials and Methods

There were three machine lines that provided green land mowing on monitored lands in the article. Cost of lines **NEW HOLLAND TM 165 + moving machine KÜHN S.A. FC300 GT,** then costs of lines **JOHN DEERE 6910 + rotary moving machine PÖTTINGERCAT NOVA 215 CZ** and cost of lines **Zetor 8045 + moving machine John Deere 328** were compared**.**

Calculation of single unit costs was made based on sheet 1. The three lines are considered stepwise. The lines differ from input data that are characteristic for each line (power unit, mowing-machine and efficiency of the line). Cost indicators of technology of permanent grassland mowing are indicated in sheet 2.

Cost indicators table for understanding single factors are indicated in sheet 3.

Table 1 - Calculation of single unit costs

Calculation of single unit costs			
Power unit		**Mowing-machine**	
Unit cost of...		*Unit costs of...*	
...amortization	jNat=Ct/(Tot.rTt.hW$_{08}$)	*...amortization*	jNas=Cs/(Tos.rW)
...power unit valorization	jNut=Ct.ut/(2.100.rTt.hW$_{08}$)	*...mowing machine valorization*	jNus=Cs.us/(2.100.rW)
...power unit parking	jNgt=Smt.rNmt/(rTt.hW$_{08}$)	*...mowing unit parking*	jNgs=Sms.rNms/rW
...charges and insurance	jNspt=Ct.pt/(rTt.hW$_{08}$.100)	*...charges and insurance*	jNsps=Cs.ps/(rW.100)
...services	jNot=jNat.kot	*...services*	jNos=jNas.kos
...power supply	jNe=haQ.Ckn	-	-

Calculation of single unit costs		
Power unit		**Mowing-machine**
Unit cost of power unit		jE=jNat+jNut+jNspt+jNgt+jNot+jNe
Unit cost of mowing-machine		jS=jNas+jNus+jNsps+jNgs+jNos
Unit cost of labour		jNzp=(1+0,36).(hNzpt+n.hNzpo)/hW$_{08}$
Unit cost of machine line		jNp=jE+jS+jNzp+jNzm+jNpm
-	-	jNzp = 0; jNzm = 0

Table 2 – Calculation of cost indicators

Cost indicators calculation in maintenance of FPG – mowing of FPG				
Power unit	**Units**	**NEW HOLLAND TM 165**	**JOHN DEERE 6910**	**Zetor 8045**
Purchase price (Ct)	[CZK]	2 935 320	2 880 420	136 187
Period of depreciation (Tot)	[year]	6	6	6
Period of usage in a year (rTt)	[Mth]	1 500	1 700	600
Efficiency of the line (hW_{08})	[ha.h^{-1}]	1,72	1,91	1,69
Bearing interest of paid-up capital (ut)	[%]	3	3	3
Insurance (pt)	[%]	0,3	0,3	1,5
Surface of storage (Smt)	[m^2]	16	16	16
Annual costs of storage (rNmt)	[CZK.m^{-2}.year]	60	60	60
Repairs ratio (kot)	[-]	0,5	0,4	0,5
Power consumption (haQ)	[l.ha^{-1}]	14,48	5,408	8,23
Diesel price (Ckn)	[CZK.l^{-1}]	23	23	23
Mowing-machine	**Units**	**Rotary mowing-machine** *KÜHN S.A. FC 300 GT*	**Rotary mowing-machine** *PÖTTINGER CAT NOVA 215 CR*	**mowing-machine** ***John Deere 328***
Purchase price (Cs)	[CZK]	376 614	207 000	752 500
Period of depreciation (Tos)	[year]	6	6	6
Annual efficiency of the line (rW)	[ha.year^{-1}]	200	200	250
Bearing interest of paid-up capital (us)	[%]	3	3	3
Insurance (ps)	[%]	0,8	0,8	0,8
Surface of storage (Sms)	[m^2]	10	12	12
Annual costs of storage (rNms)	[CZK.m^{-2}.year]	34	34	34
Repairs ratio (kos)	[-]	0,8	0,9	1,2
Labour cost	**Unit**	**Line 1**	**Line 2**	**Line 3**
Hour-wage of tractor driver (hNzpt)	[CZK.h^{-1}]	100	100	80

Table 3 - Unit costs outcomes table

Outcomes table of costs calculations				
Unit cost of power unit (jE)	[CZK.ha^{-1}]	638,23	347,60	227,63
Unit cost of mowing-machine (jS)	[CZK.ha^{-1}]	609,59	353,60	1 173,98
Unit cost of labour (jNzp)	[CZK.ha^{-1}]	79,07	71,20	64,38
Total unit costs of line	[Kč.ha^{-1}]	***1 326,89***	***772,40***	***1 466,0***

Fraction of single costs of single machine lines are indicated in table 4 Outcomes are presented on figure 1.

Table 4 - Cost indicator calculations

Outcomes table of costs calculation				
	Unit	**Line 1**	**Line 2**	**Line 3**
Unit cost of power unit (jE)	[%]	48,10	45,00	15,53
Unit cost of mowing-machine (jS)	[%]	45,94	45,78	80,08
Unit cost of labour (jNžp)	[%]	5,96	9,22	4,39
Total unit costs of line	[%]	100,00	100,00	100,00

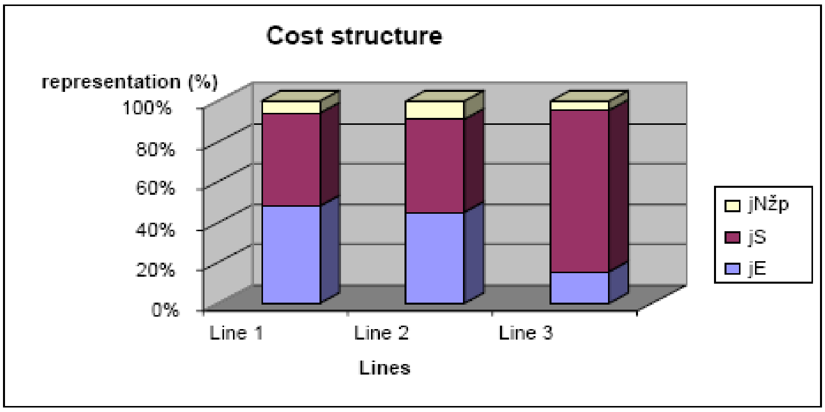

Figure 1 - machine-lines cost structure

There are evident divergences in percentage representation of single unit costs to total unit cost of single machine-lines in figure 1. By detailed survey of the unit costs it was found out that the proportion among power units in single lines is substantially different as from the proportion of its unit costs. Similar evaluation can be proved by evidence in mowing machine. As value 1 is always chosen the line that has the lowest purchasing price and the lowest unit costs (sheet 5).

It is evident that a new purchasing price does not necessary has to negatively affect unit costs of power unit, if the power unit and its suitable mowing-machine has sufficient efficiency. As well the mowing-machine has the proportion of purchasing prices different from the proportion of its unit costs.

Values from table 5 are in figure 2 – lines evaluation.

Representation of unit costs emerged from the next evaluation in dependence on purchasing price of power unit and mowing-machine. There are values in table 6 and figure 3.

Table 5 - Calculation of proportion among lines

	Power supply unit					
	Line 1	**Line 2**	**Line 3**	**Average**		
Ct	2 935 320	2 880 420	136 187	21,6	21,2	1,0
jE	638,23	347,6	227,63	3,1	2,9	1,0
	Mowing-machine					
	Line 1	**Line 2**	**Line 3**	**Average**		
Cs	376 614	207 000	752 500	1,8	1,0	3,6
jS	609,59	353,6	1 173,98	1,0	1,0	1,7

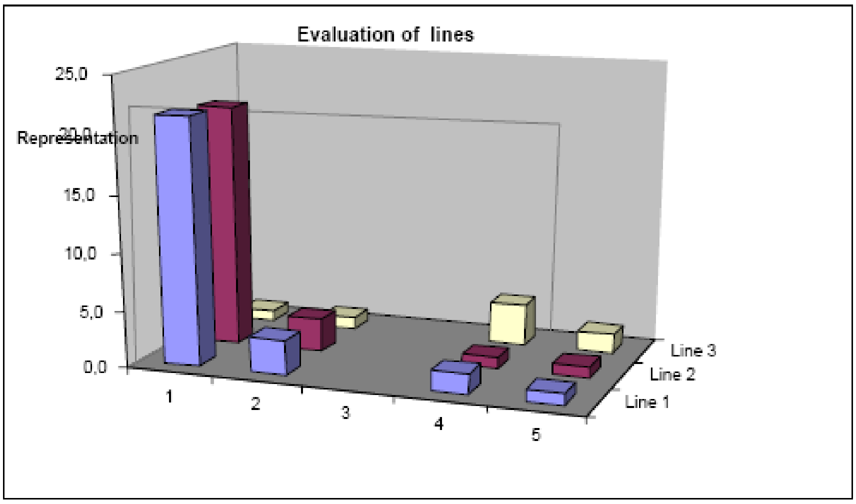

Figure 2 – evaluation of lines

Table 6 - Unit costs calculation to purchasing price

Power supply unit	Line 1	Line 2	Line 3	Mowing-machine	Line1	Line 2	Line 3
Ct	2 935 320	2 880 420	136 187	Cs	376 614	207 000	752 500
Je	638,23	347,6	227,63	jS	609,59	353,6	1 173,98
%	0,02	0,01	0,17	%	0,16	0,17	0,16

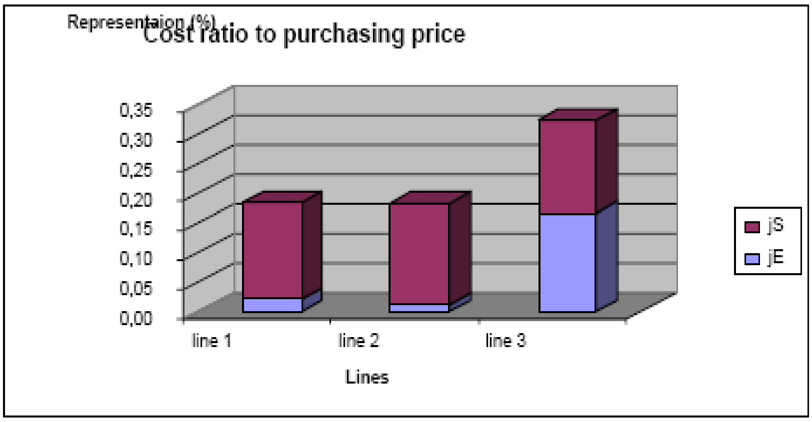

Figure 3 – cost ratio to purchasing price

The economy of operation will be affected by unstable diesel price. There is fuel consumption per 1 ha and price deviation in table 7. Deviation is presented by the cheapest line. Outcomes are processed in figure 4.

Table 7 – Power supply costs

Power supply costs						
	Line 1		Line 2		Line 3	
Averageconsumption ($l.ha^{-1}$)	14,48		5,408		8,23	
DIESELPRICE - 23 (Kč)	333,04	208,656	124,384	0	189,29	64,906
- 26 (CZK)	376,48	235,872	140,608	0	213,98	73,372
- 29 (CZK)	419,92	263,088	156,832	0	238,67	81,838
- 32 (CZK)	463,36	290,304	173,056	0	263,36	90,304

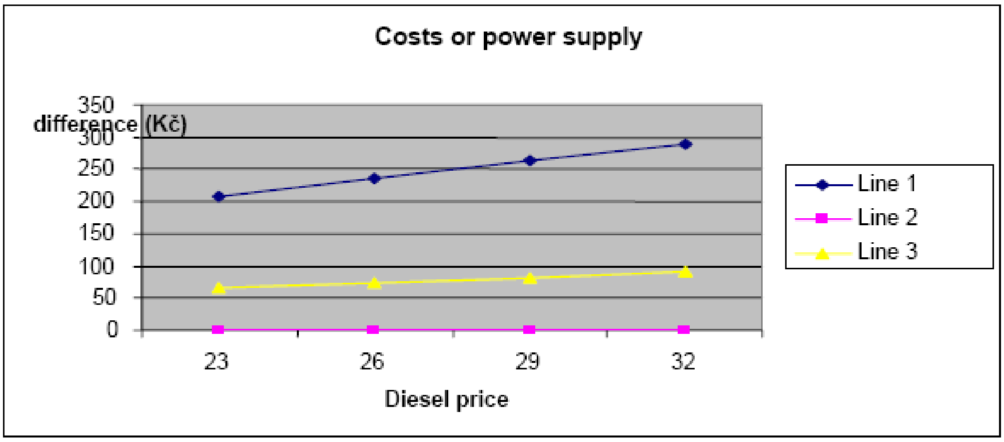

Figure 4 - costs of power supply

Conclusion

To improve economic situation of mower-machine lines it is necessary to chose, if possible, from wider range of power units and mowing-machines, so that it would be the lowest level of unit costs per line. As well take account of efficiency of the line that can be reached by the line. Efficiency of the line will depend on other factors too (landscape, slope, area and others).

It is evident that the variability of the final costs per operating step is wide. It is always necessary to choose the line with care and applied it in process with regard to available machine equipment.

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HEATING FRUITS AS A QUARANTINE TREATMENT

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The use of heating as quarantine treatment increases the postharvest storage stability and shelf – life of fruits by disinfecting fruit flies and fungi , and by reducing respiration rate and sensivity to chilling injury. The section of a suitable time and tempreature is the most critical step in the application of heat treatment. This is because even the sligtest over heating may cause the destruction of heat labile enzyme systems or membrane integrity in fruit cells and may lead the sequent formation of a disorder called " heat injury".

The heat injured fruits are not acceptible by consumer. This is because they exhibit many defects such as discoloration , surface pitting, non-softening or non –ripening . In this article general principles for the selection of suitable heating time and tempreatures, and the heating procedures in quarantine treatment were introduced.

Key Words : Quarantine Treatment , heating, heat injury,enzymes

Introduction

Fruits and vegetables are quarantined in mild heat to increase their preservation period . By this way we want to eleminate micro-organisms that have infected the product during different stages of past time, and the nits and larvae remained in it (Civello and Ark.,1997)

Besides it , the treatment is to increase product resistance against the chill injury, and to decrease the rate of ripenning after crop(Lurie and Klein,1990). This is done by floating it in hot water or putting in steam pool. It's very important to choose the suitable time and temperature for this process. Plant tissues are sensitive to heat . So high heats causes the heat injury , which is seen as a blight at fruit surface or a brown spot.

In addition this injury causes the stop of maturing and softening in fruit. It's observed that yellowing of some green fruits or increasing of some fruits sensitivity against pathogens is because of the stages of keeping them in very high heat . Products sensitivity to heat is different. For example, the pear, banana, mango and papaya are resistant, but peach, green pepper and melon are sensitive to heat (Couey 1989).

This sensitivity is variable in different varieties. That's why this is necessary to check the product for variety before quarantine.

2- Defining the range of sensitivity to heat:

Generally,to define the quantity of sensitivity to heat, a high amount of fruits are chosen .And by using different temperature,the time of heat injury is written. By performing this experience, the suitable temperature and time get defined for every fruit . Here is a semi –logarithm diagram for every product. Axis X indicates temperature,and axis(y)indicates period of heating.

The results are shown as solid points that indicate heat injury , and hollow points indicats the product without heat –injury Limits of required heat and time is shown by a direct line (Fig 1) . The spots beneath this line indicate the heat injury and shouldn't have been existed. This means there is no difference between this diagram , and the one for thermal death time .

So , it can ve mentioned that to find out the necessary time of heating a product at a fixed temperature , we can use this formula , which is the equation of the line mentioned before.

$$t_{\max} = A \cdot B^{(T-C)}$$

t max = maximum time (in min) for heating the product at 0 ˚C , not causing heat injury .
A= Maximum time (in min) for heating the product at reference temperature, not causing heat injury.
B= Diagram factor
T= Heating temperature
C= Reference temperature
At quarintine treatment the reference temperature is 42°C which is the minimum required temperature to eliminate the larvae and nits effectively.

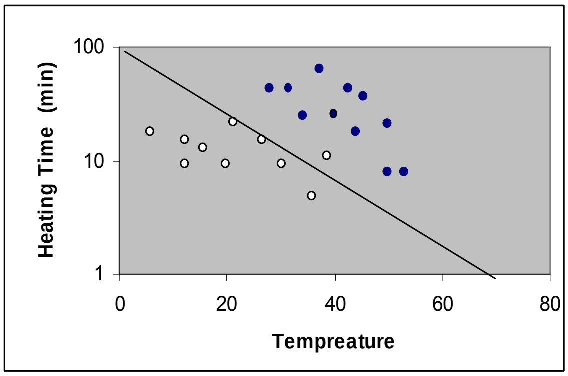

Fig 1: Determain temperature and time for heat injury in product ○: without heat injury ●: with heat injury

Using enzymes as indicator in heating : It will not be a simple way to heat every product lonely and then define the heat injury . So the most easiest way for finding out products sensitivity to heat injury is using enzymes as indicator .

EFE (Ethylene forming enzyme) is usually used for this action . It changes the L – amino cylopropane – L-carboyxylic acid to ethylene at plant tissues. This material is very sensitive to heat , and get nonactive by heat affect . Nonactivation of this enzme leads to heat to heat injury in product (Chan and Ark .,1996 Chan and Linse ,1989 a).

Therefore that's necessary to keep this enzyme active during heat quarintine. Trying to increase the resistance of this enzme against heating results in reduction of heat injury in product .(Chan,1991; Chan and Linse, 1989a). The way used to increase this resistance is named "conditioning" which was performed on cucumber. By putting it at 32.5 °C for 24 hours ، this enzyme resistant got increased . In result the heat injury decreased a lot . (Fig 2). (Chan and Linse ,1989 b).

It seems that the reason of this action is synthesis of some proteins named 'heat shock proteins " (HSP).(Couy , 1989; Civello and et.al ., 1997). This way benefit is not just inst increasing the heat resistance, also by using appropriate time and temperture , product sensitivity to chill injury decreases during keeping product at depository . Also the resistanceof product against pathogenic micro – organisms encreases by this way. (McCollum and et .al., 1993).

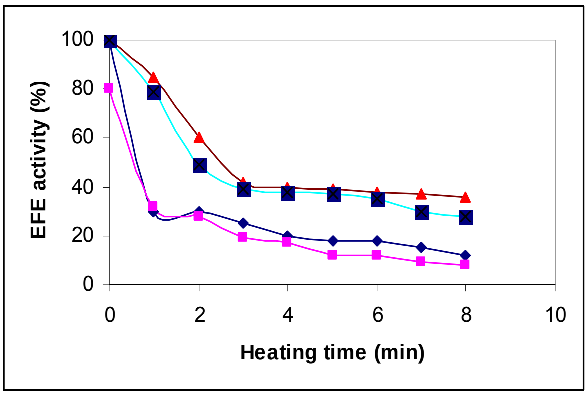

Fig 2: Heat inactivation of EFE enzyme by conditioning on cucumber

Besides EFE, other enzymes also got used as indicator at tests. For example to define the suitable heat and time for strawberry during depository period it`s very important to avoid of Phenylalanine amonialayse (PAL) enzyme nonactivation, besides micro – organisms reduction. (Civello and et.al 1997). Because by nonactivation of PAL Enzyme which is very sensitive to heat, synthesis of anthosyanin gets stopped either .This synthesis occurs in Strawberry during storage . Also maturation of fruits which happen along with softening of tissue stops.

Another way to find the quantity of tempreture and time in quarintine treatment is to use some enzyme activities as indicator which leads to undesirable changes in product . This way is usually used for products that are sensitive to enzmic browning . For example tempreture and time of quarintine tratment in apple is definded by studying ployphenoloxidase (PPO) enzyme. Table 1 showes time of start to enzymic browning in different temperature at various specious of apple . In table 2 we see affect of time and temperature on Polyphenoloxidase (PPO) enzyme activity in different specious of apple .

Table 1 : Effect temperature and time on the browning degree of apple specious

	T° C	Browning Time start (min)	% Brown fruit
Rome	40	60	92.5
	45	30	90
	50	15	85
Monroe	40	60	75.5
	45	30	52.5
	50	15	67.5
Liberty	40	60	32.5
	45	60	32.5
	50	30	55
RI Greening	40	120	42.5
	45	30	50
	50	30	35
Idared	40	180	45
	45	105	67.5
	50	30	52.5
Cortland	40	180	25
	45	105	52.5
	50	30	32.5
Empire	40	180	17.5
	45	90	12.5
	50	30	20
Mclntosh	40	180	12.5
	45	105	25
	50	30	60
Delicious	40	240	20
	45	120	15
	50	60	52.5
G.Delicious	40	240	17.5
	45	120	15
	50	60	12.5

Table 2:Effect temperature and time on PPO enzyme acctivity in Apple specious

Change of activity %						
Apple Specious	**60 ° C**		**73° C**		**78 ° C**	
	7 min	15 min	4 min	10 min	2 min	4 min
G.delicious	8	0	31	20	-8	-44
S Delicious	17	11	24	17	17	12
Starcrimson	80	105	90	99	42	14
Gloster	140	230	70	100	14	-27
G. Smith	60	90	60	70	53	2
Amasya	8	4	6	-13	-34	-64

Comparing these two tables , it’s found that ppo enzyme activity is limited in Golden delicious variety of apple . And also start time of browning increases by heating and is seen in few numbers of apples. So this variety is very suitable for heat quarinthine . Where as the results given from Gloster show that ppo enzyme activity is so sensitive in this variety . And it doesn’t have the ability to get heat – quarintined. After using heat - quarintine for G.delicious and Gloster observed that there is unbelievable browning in Gloster during storage period while there is not at all in G. Delicious . The best benefit of heat quarintine in apples is that it decreases the required time for maturing in deposit and fulfill the request for stiff and acceptable tissue (Lurie and Klein, 1990; Kim and et.l ,1993)

The reat points of this subject is to eliminate hurts caused by insects . In this case,heat resistance of nits and larve should also be considered. Always resistance in larvae is higher than nits .At the beginning fate of both of them is limited , but gradually increases by the time .

The equations for figures drawn in this treatment is exponential (Jang, 1986). So we can write :

N0=amount of alive larvae or egg

N= amount of alive larvae or egg after heating for (t)time. t = time of heating (min)

K = division of curve for log (N0-N) to time table 3 : TDT Parameters in Mediterranean fruit fly

form	T°C	TDT Parameters			% Death		
		a	b	k	R^2	90 %	9.999%
egg	45	0.680	-0.053	0.045	0.0945	23.40	63.19
	46	0.680	0.223	0.084	0.901	9.25	30.57
	47	0.680	0.190	0.296	0.939	2.74	8.79
larvae	45	0.427	-0.086	0.041	0.923	26.49	48.56
	46	0.427	-0.092	0.074	0.952	14.75	26.98
	47	0.427	-0.116	0.104	0.966	10.74	19.44
	48	0.427	-0.116	0.211	0.912	5.53	9.82

In table number 3 the necessary prarameters to draw the TDT (Thermal death time) diagram of Mediterranean fruit fly is shown .Considering these data we can calculate amount of heat affect on elimination of nits and larvae . In florida heat quarintine to reduce the amount of insects has got usual in citrus.

One ways of this process is to increase product temperature to 43˚ c by satured steam in 8 hours , and keep it in this temperature for 8 hours . Another way for this action is also performed by satured steam, but the difference is that this time product temperature should get increased to 47˚ c in 6 hours and then get cold fast. This way can be used for green pepper and egg plant, too. (Couey, 1989).

Generally we get this important fact from our research that in heat quarintine product temperature should be increased gradually not fast. Specially in products sensitive to heat , We should calculate the time for heat quarintine in a way that , most part of this period pass at temperature not harming the product and the less part at high temperature .

Therfore it's necessary to follow up the temperature changes during quarintine and its possible by putting a thermocouple in geometric center of our object. This is done to avoid heat injury by increasing the temperature gradually. Changes are shown by thermocouple Heat quarintine is not a simple treatment . To get positive and desirable results , the time and temperature should be chosen consciously.

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STUDIES ON DESULFITING METHODS OF DRIED APRICOTS

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Sulphited dried apricots were exposed to hot air flows at 40°C, 50°C and 60°C as physical method. On the other hand removal of sulfites from excessively sulfited dried apricots at 20°C , 40°C into 1% solution of H_2O_2 use as chemical method. Analysis of kinetic data suggested a first – order reaction for removal of SO_2 in different Temperature in both methods.Critical factors for H_2O_2 application are choosing the appropriate H_2O_2 concentration,temperature and exposure time .

Key words: Dried apricots ,Desulfiting , hydrogen peroxide, reaction kinetics

Introduction

In IRAN large amount of apricot produce and large percent of apricots are commercially dried for later consumption, dried apricots lose their characteristic golden yellow color during storage as a result of non- enzymatic browning (Joslyn and Braverman 1954).Traditionally, apricots in Iran are treated with fumes of burning sulphur in an enclosed room before sun drying. Fresh apricots are very sensitive to microbial spoilage, even at refrigerated conditions; therefore, they must be preserved in some way. (Bolin et al, 1981).

Sulphited is applied for the production of dry apricots on large scale, because of the high quality of the final product.

Many factors affect the absorption and retention of sulfur dioxide (SO_2) by fresh apricots, including variety, maturity, form of apricot, concentration of SO_2 in the sulfur house, and exposure time (Gokce 1966; Stafford and Bolin 1972).

Therefore, dried apricots sometimes contain much higher So_2 levels than the legal limits allow, and it may become necessary to decrease the final so_2 level in oversulfited dried apricots. The traditionally sulfured apricots can contain So_2 from less than 1000 to over 6000 ppm (McBean and others 1964). The legal limits for dried apricots are given in terms of So_2. The maximum limit of 2000 ppm for SO_2 in dried apricots is accepted by most countries, including Iran. (Codex Alimentarius Commission 1989). The safety of sulfites has been questioned because of its alleged role in initiating asthmatic reactions in some sensitive individuals (Taylor and others 1986).

Desulphiting various fruit products preserved with sulphites has long been practiced.(joslyn MA and Braverman ,1954). Desulfiting dried apricots by hot air flow and aside physical methods; hydrogen peroxide (H_2o_2) has been recommended for desulphiting fruit Juices and dried fruits as chemical method. This study was undertaken to provide experimental data on desulphiting dried apricots exposed to hot air flow and hydrogen peroxide. Specific objectives were to determine the kinetics of the removal of sulphites from dried apricots by two methods.

Materials and Methods

Commercially sun-dried and excessively sulifited (over 2000 mg/kg) apricots were obtained from the market in Tabriz- Iran.

Sulfur dioxide analysis

Sulfur dioxide was determined by distillation method as `The iodine volumetric method for the determination of sulfur dioxide in dried fruits` published by dried fruit association of California that translated by institute of standard and industrial research of Iran ISIRI 569. The So_2 Contents of dried apricots were reported as $mg.kg^{-1}$ on dry weight basis.

Physical method

Exposure of apricots to hot air : Apricots with high Sulfur dioxide were exposed to hot air flows at 40°C, 50°C and 60 °C for 216,130, 96h respectively.This study was carried out in a forced air oven (Memmert ULM 600, Germany). 1 kg of samples was put in oven and after certain time 100g were removed from the oven at various intervals during drying, placed in plastic and stored in a freezer at until used for analysis.

Table 1 shows that exposure to hot air flow was effective in reducing the So_2 content . In fig

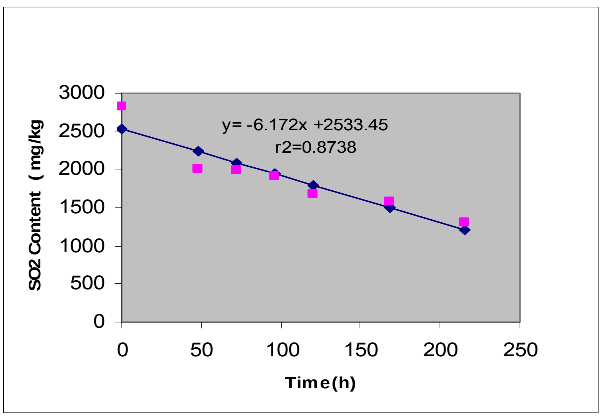
1 the So_2 contents of dried apricots exposed to various air temperatures are plotted as a function of time. The linear relation indicates that the removal of So_2 followed first- order kinetics .Reaction rate constants (K) were calculated at a given temperature using equation (1).

$$In(Ct/Co) = -kt \quad (1)$$

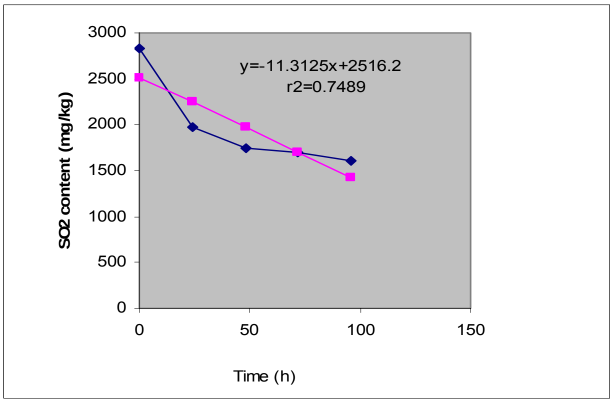
Table 1. SO_2 contents of dried apricots treated with hot air at various temperatures

Temp. (^{oC})	Time (Min)	So_2conrent ($MgKg^{-1}$dry wt)	% Decrease in So_2 Content
40	0	2826	0
	48	2014	28.7
	72	1987	29.6
	96	1908	32.4
	120	1680	40.5
	168	1575	44.2
	216	1300	54
50	0	2826	0
	24	1980	29.9
	48	1750	38
	72	1703	39.7
	96	1607	43.1
	130	1345	52.4
60	0	2826	0
	15	2002	29.1
	25	1560	44.7
	72	1178	58.3
	96	1011	64.2

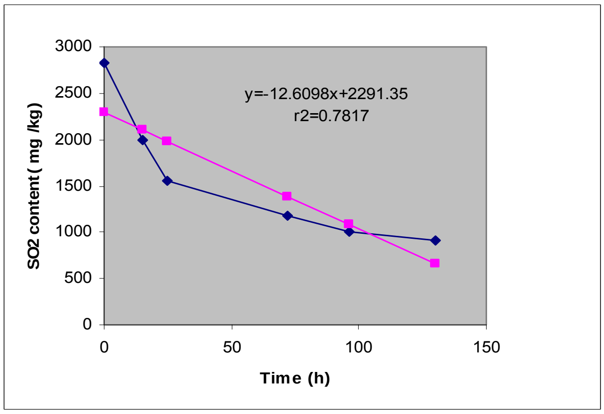
Where $C_\circ$ is the initial SO_2 concentration and C_t is the SO_2 concentration after t minute of exposure to hot air at a given temperature. For example, the SO_2 Content of dried apricots after 72h of drying declined by (29.6%) at 40 $^{\circ C}$,39.7 % at 50 $^{\circ C}$ and 58.3% at 60 ° C.



A = 40º C



B= 50ºC



C=60ºC

Fig.1 Effect of various air temperatures (A-B-C) on So_2 content in dried apricots

The temperature dependence of SO_2 removal by hot air flow was determined by calculating the activation energy (E_a) and temperature quotients (Q_{10}) between 40˚C and 60˚C from equations (2) that show in table 2.

$$K = K_o e -^{-Ea/RT} \qquad (2)$$

$$Q_{10} = (K_2 / K_1)^{10/(T_{2Y}}$$

Table 2. Effect of temperature on removal of SO_2 from dried apricots

Temp ($^{\circ C}$)	K (10^3 h^{-1})	E_a ($Kjmol^{-1}$)	Q_{10} 40- 50 $^{\circ C}$ 50 – 60$^{\circ C}$
40 50 60	3.225 5.296 8.060	80.5316	1.644 2.521

Chemical method

Hydrogen peroxide is one of the most powerful oxidizers with reactivity third after fluorine and ozone (Ozkan and kirca 2001). Sulfites in dried apricots can be oxidized by a reaction with H_2O_2. The reaction between H_2O_2 and sulfites has described in detail by Hoffmann and Eswards (1975).

Hydrogen peroxide treatment

Apricot dipped into aqueous solutions of 1% H_2o_2 for 4, 8, 12 min at 20° and 40 ° C. After H_2o_2 treatment, apricots washed with water to remove the H_2o_2 on the surface of samples.

Residual H_2o_2 analysis

Hydrogen peroxide residues must be removed from H_2o_2 treated- dried apricots to comply with FDA regulations (Code of Federal Regulations 2000) .To test H_2O_2 residues, the semi – quantitative test strips were selected .The color in the reaction zone of test strip was compared with the color scale and the formation of blue color indicated the presence of H_2o_2 .

Effect of hydrogen peroxide treatment on So_2 content :

The analyses with test strips revealed that no residual H_2O_2 was detected in dried apricot samples treated with H_2O_2. The SO_2 contents of dried apricots treated with H_2O_2 are given in Table3. Hydrogen peroxide was very effective in reducing the SO_2 contents of dried apricots. The percent decrease in SO_2 contents for these treatments was plotted in figure2.

Table 3- So_2 Contents of dried apricots treated with at various temperatures

H_2o_2 conc. (%)	Temp. (°C)	Time (Min)	SO_2 content	% Decrease So_2
1	20	0	2826	0
		4	2260	20
		8	2111	25
		12	1978	30
	40	0	2826	0
		4	1978	30
		8	1837	35
		12	1469	48

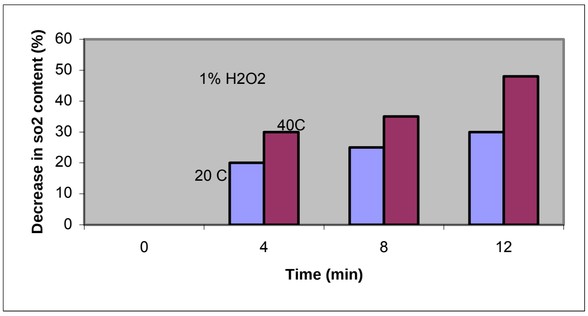


Fig. 2 Effect of %1 H_2O_2 concentrations on SO_2 content of dried apricots at 20°C and40 °C

At 20 °C, 30% of the total SO_2 was removed from dried apricots treated 1% H_2o_2 whereas the decrease in So_2 content was 48% at 1 % H_2O_2 con centrations at the 40°C after 12 minute.

Kinetic of So2 removal by hydrogen peroxide

The removal of SO_2 by H_2O_2 from dried apricots was fitted to a first – order kinetic model (Figure3).The reaction rate constant (K) were calculated at a given temperature and H_2o_2 concentration by the following equation 3:

$$In(C_t / C_o) = -kt \quad (3)$$

The temperature dependence of the So_2 removal by H_2O_2 was determined by calculating activation energy (E_a) from the Arrhenius equation 4:

$$k = k_o.e^{-Ea/RT} \quad (4)$$

The calculated $E_a$value is presented in Table4. At 1% H_2o_2 from dried apricots was 14.286 KJ mol^{-1}. The low $E_a$value indicates that the reaction for the removal of So_2 by H_2o_2 is comparatively insensitive to temperature changes (Nielson and other 1993).

Table 4- Effect of temperature on the removal of So_2 at Various H_2o_2 concentrations

H_2o_2 conc. (%)	Temp. (°C)	K ($10^2 min^{-1}$)	E (KJ mol^{-1})
1	20	2.855	14.286
	40	5.091	

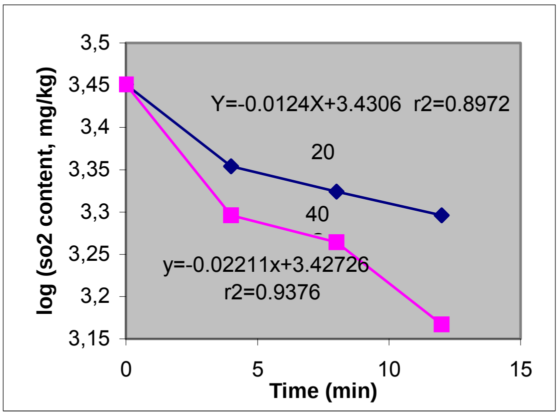


Fig.3- Decrease in the So_2 content of dried apricots reated with 1% H_2o_2 at various temperatures

Conclusions

SO_2 contents of dried apricot samples were between 2800 and 3000 and mg.kg $^{-1}$ on the basis of dry weight. The result from this study suggest that the SO_2 content of dried apricots sulphited over the limit can be reduced by exposure to hot air flow. For get best quality, decrease of moisture content must be bringing to initial moisture by rehydration.

The removal of so_2 from oversulfited dried apricots was accomplished using H_2O_2 .The most important factors are choosing the appropriate H_2o_2 concentration, temperatures and exposure time. Instead of removal of sulfites from oversulfited dried apricots, we recommend either traditional sulfuring practice be optimized or new methods of sulfiting be established.

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OPTIMIZATION OF IRRIGATION WATER SUPPLY FROM RESERVOIRS BY GENETIC ALGORITHM (G. A.)

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Optimum supply of irrigation water is an important task in precision farming management, especially in arid and semiarid regions. In this study, the G.A. has been used to optimize supply of irrigation water from a reservoir. The Jiroft dam reservoir which is established on the Halil River at the north of Jiroft city, Iran, has been used as the case study. The G.A. toolbox of the Matlab software version-7 was used for computation. High ability of this toolbox for different variables of each option in G.A. was the main reason to use this algorithm for optimization of irrigation water supply of agricultural lands at downstream of the Halil river. Results show that, at worst condition of drought, it is possible to satisfy demands of irrigation water by a precision farming management.
Keywords: optimization, irrigation, Genetic algorithm

Introduction

GA which is based on the Darwin's theory was introduced by Holland (1975) for the first time. Then Goldberg (1989) and Michalewicz (1992) were presented a complete introduction of this method [1].

Fahmy et al. (1994) applied GA for optimization of a reservoir system. They compared the results of this model with dynamic programming model and showed that GA has a high potential for optimization of large water recourses systems. Olivera and Loucks (1997) used GA to obtain rule curves of a multi-reservoir system. Chang and Cheng (1998) applied two types of GA (the binary and the real-value coding) to optimize a flood control reservoir and showed that both algorithms were more effective than random-search methods. Wardlow and Sharif (1999) used this algorithm to optimize a four reservoirs system of limited time horizon. They also solved a non-linear four-reservoir system of wide horizon and a complex ten reservoirs system by GA. Sharif and Wardlow (2000) used GA to optimize a multi reservoirs system in Indonesia, and compared the results with the dynamic programming results and concluded that GA results are more confident. Yoon and Shoemaker (2001) applied a real-coded genetic algorithm (RGA) coupled with two newly developed operators: directive recombination and screened replacement for an in-situ bioremediation of ground water. They concluded that RGA performs better than the binary-coded GA. Srinivasa Raju and Nagesh Kumar (2004) used the GA method to design irrigation systems for a suitable cultivation pattern in India. Chang Jian–Xia, et.al (2005) used GA to optimize water release of 12 monthly periods to maximize the hydropower electricity. Juran Ali Ahmed and Arup Kumar Sarma (2005) used GA to optimize the operation of a multi-purpose reservoir. They compared the obtained results with the results of stochastic dynamic programming and concluded that GA has a better performance. In the present study, GA has been used to optimize the operation of the Jiroft dam reservoir. Considering the efficiency of GA in many fields, genetic algorithm toolbox in version 7 of the Matlab software has been used for this purpose [2].

Genetic Algorithm Toolbox

Initially, the Matlab software was written to solve the problems in the field of matrices, linear algebra, and numerical analyses in the Stanford and Newmexico universities in 1970. Today, the capability of the Matlab software is more than the first matrix library. The main element of this software is a matrix that doesn't need to specify its dimensions. So, solution of the problems are as easy as writing them.

There are several different toolboxes in Matlab which can be used in engineering area. One of these toolboxes is Genetic Algorithm which is accessible from: Start/Toolboxes/Genetic Algorithm and Direct Search/Genetic Algorithm Tool menu.

For initial run of program, defining the objective function in an M-file and identifying the number of variables are necessary. Then, the user can choose necessary plots such as mean distance between individuals in plot option and see them as the algorithms run. Finally, the user can change any options of running GA such as: selection, cross over, mutation and so on. As an example, for the option of selection the user can choose any kind of selections such as: stochastic uniform, reminder, uniform, tournament and custom which accept the function that is defined by user.

Table (1) Parameters of the Jiroft Dam

1	Height from bottom	128 m
2	Height from foundation	133 m
3	Crest length	250 m
4	Crest width	5 m
5	Foundation width	17 m
6	Total storage volume	369 MCM
7	Useful storage volume	332 MCM
8	Regulating annual volume of water	332 MCM
9	Capacity of power plant	32 MW
10	Spillway	Gated spillway
11	Mean annual rainfall	360 mm
12	Mean discharge of river	13.52 m^3/s

Jiroft Dam

The Jiroft dam was built on the 'Halil River', which is one of the largest rivers in the Jiroft city of Kerman province in Iran. This river with length 387 Km, is passing the Jiroft and Roodbar plains and ending the Jazmooriyan. This river is a flood type river with at least a big flood annually. Halil River is one of the most important sources of water for Jiroft and Roodbar plains. The Basin of Halil River is located in 45° 15' to 58° 30' eastern longitude and 27° 45' to 29° 33' northern latitude. The total catchments area of this river is over 18832 Km^2. The Jiroft dam is located in the Narab valley, 40-Km north-west of the Jroft city. It is a thin concrete twin-arch dam. The mean annual inflow to the Jiroft dam is 426 MCM. Table (1) presents some parameters of this dam.

Model Identification

To define the objective function, a number of optimization methods of reservoir operation, developed by other researchers have been investigated [3,4,5]. However, in this work the objective function is defined as below:

$$Minimize\ F = \sum_{t=1}^{n=12}\left(R_t - D_t\right)^2 + \sum_{t=1}^{n=12}\left(S_t - S_{t+1} + I_t - R_t - E_t\right)^2$$

$$t+1 \leq 12 \qquad (1)$$

Where, R_t: Monthly release of water from reservoir

D_t: Monthly downstream demand for water

S_t: Storage volume of water at the beginning of each month

E_t: Monthly Evaporation

The first term of equation (1) demonstrates the difference between demand (D_t) and release (R_t). The second term defines continuity. Different values for probability of inflow can be used in equation (1).

Generally GA solves unconstrained problems. So, a constrained problem should be converted into an unconstrained one. There are some methods which convert the fitness function and constrains into an unconstrained function which is called 'pseudo fitness' function. One of the most common methods is 'exterior penalty function method', where fitness functions and constrains are transformed into a pseudo fitness function as shown below [6]:

$$\varphi = F + R_p.\sum_{i=1}^{n_c}\left[\max\left(\frac{g_i}{\bar{g}_i} - 1{,}0\right)\right]^2 + R_p.\sum_{j=1}^{n_c}\left[\max\left(1 - \frac{g_j}{\bar{g}_j},0\right)\right]^2 \quad (2)$$

Where, φ is pseudo fitness function, F is fitness function, g_i, g_j, $\bar{g}_i$, $\bar{g}_j$ are constraint terms and R_p is a coefficient which get a big value.

According to hydrological studies, the inflows to The Jiroft dam reservoir have a log normal distribution. Initially, the probability of inflows to the reservoir is selected as 90%. This means that, with probability of 90% the stream flow will be equal to or more than the specified value. In other words, optimization has been carried out in the most critical situation of drought. Considering the structure of objective function and capability of genetic algorithm toolbox, it is possible to optimize the operation of a reservoir for various inflows.

Genetic Algorithm Toolbox Parameters

For different parts of genetic algorithm such as initial population size, probability of crossover, mutation type and so on, different options are available. Accurate selection of these options will affect the functioning and running speed of GA program. So, in this study, for each part of genetic algorithm based on the ability of its related toolbox, different options have been chosen and examined for the best solution.

In running genetic algorithm, one of the most important parameter is population distribution; it will be controlled by regulating the initial size of population and determining its suitable size. In this study, the initial rang of population is selected equal to 0 to 10. In order to obtain the best population size, using sensitivity analysis, different population sizes have been considered. The best population size equal to 300 corresponding to the minimum value of objective function is resulted. Figure (1)

Two curves of GA toolbox (the fitness value and the average distance between individuals in each generation) are selected and used. Figs (2) and (3). Fig (2) shows the behavior of average and best fitness value in each generation. The average fitness value curve shows population scattering, which is decreases by increasing the generation number and becomes minimum at 1200 generations.

Fig (3) illustrates the average distance between individuals (ADBI) in different generations, it becomes equal to zero after 1200 generations, which means, there is no difference between individuals, or individuals are similar to each other.

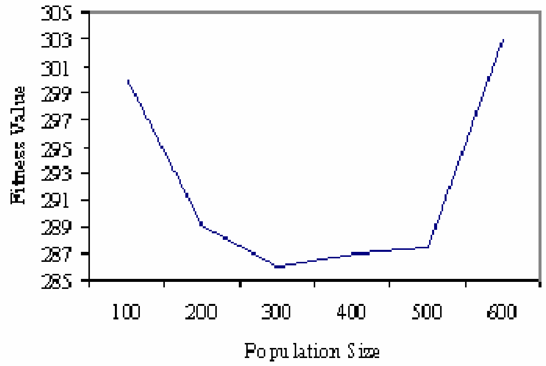


Figure (1). Results of sensetivity analyes for population size determination

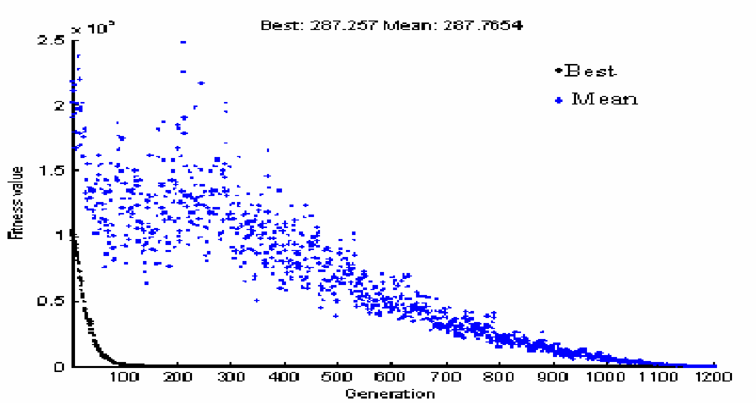


Figure (2). Fitness value in each generation

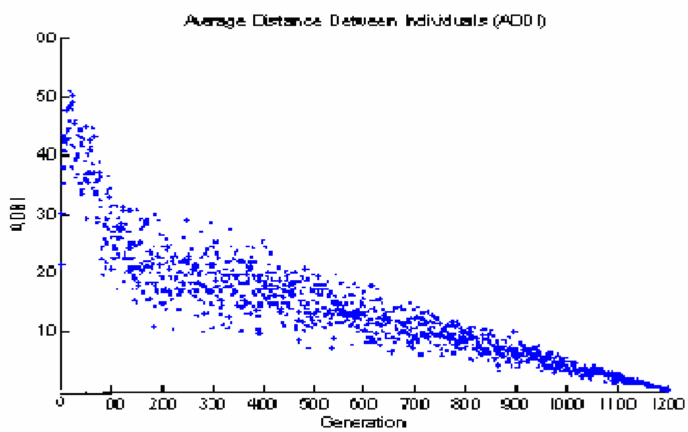


Figure (3). Average distance between individuals

Some other parameters used in this study are: ranking for fitness scaling, stochastic uniform selection, scattered crossover, forward migration and two elite counts. The crossover fraction is considered 0.9. Figure (4)

Another advantage of genetic algorithm toolbox is option of the hybrid optimization function. Running this function is after the genetic algorithm is terminated, improves the value of fitness function. The hybrid function uses the final value of the fitness function obtained by the genetic algorithm as its initial point. In this study, the hybrid function is used, but the optimization results obtained by GA were not improved significantly, that is the GA results are fair enough.

There are five criteria presented by genetic algorithm toolbox for stopping the algorithm. In this work, the stopping criteria was selected as 1200 generations, and the best results were obtained according to this choice.

Another important option in genetic algorithm toolbox is vectorization of fitness function. Vectorizing the fitness function increases the running speed of GA significantly [7]. Figure (5)

Results

After the fitness function was defined and the parameters were identified in genetic algorithm toolbox, 24 variables were computed. The first 12 variables included monthly release of water from reservoir. The rest of variable were the storage volume of reservoir in different months. Figure (6) and (7)

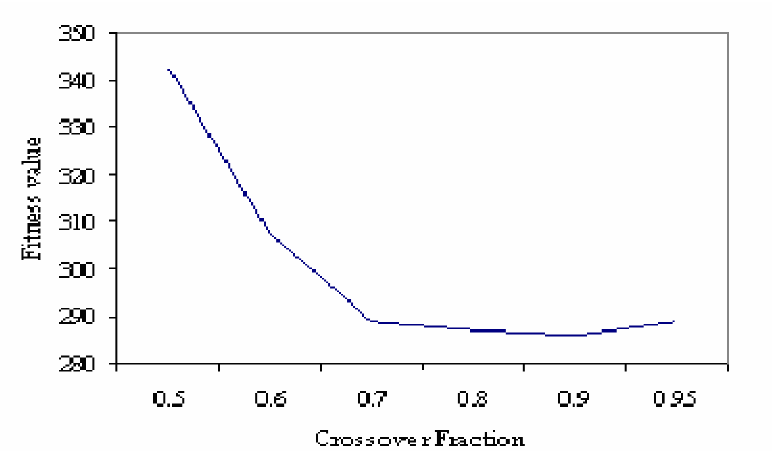


Figure (4). Sensitivity analysis cure

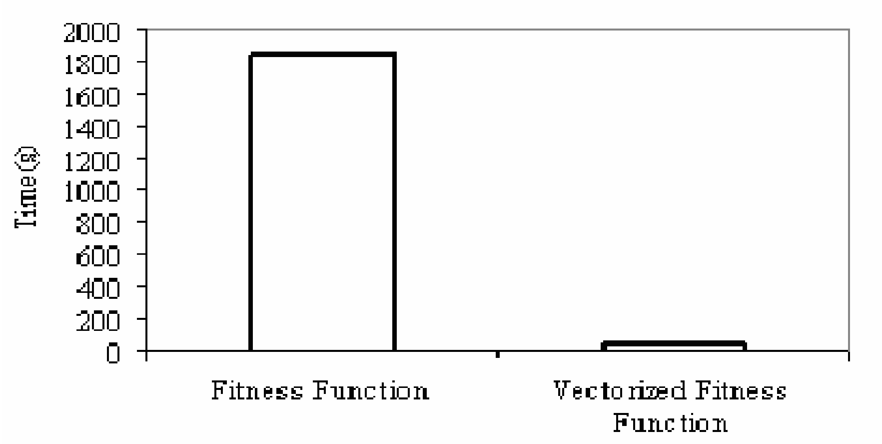
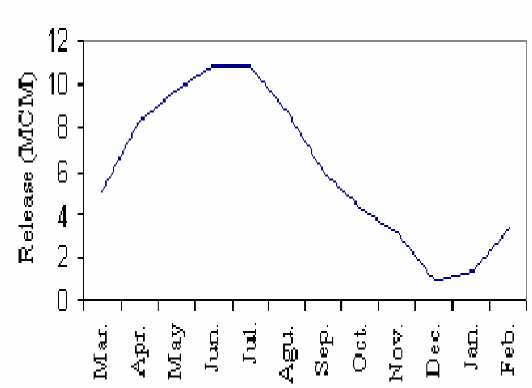


Figure (5). Comparison of the runinning speed of GA in two states



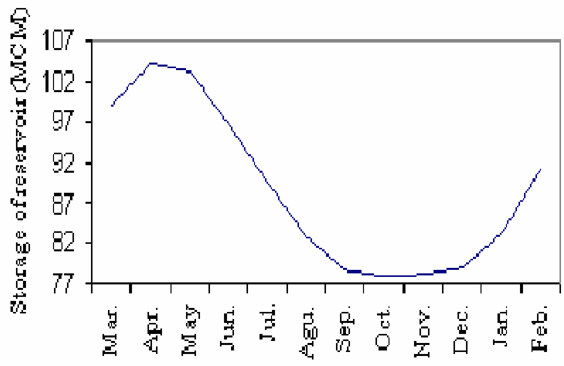


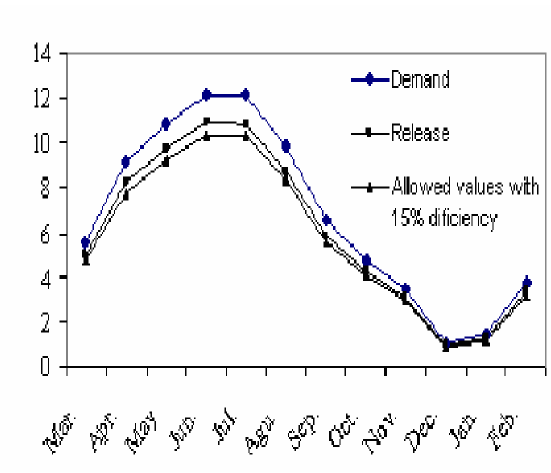
Figure (6). Montly release of water from reservoir. & Figure (7). Reservoir storage volume of water at the begining of each month

Fig (6) illustrates that the high release of water is related to the hot season (through June until the middle of September) which is quite compatible with the high demands of water during this period. Fig (7) shows that the reservoir storage volumes are high enough to satisfy release of water during the above mentioned period. Also, the reservoir storage volumes are low enough during the months October through February with high probability of flood flow.

The monthly downstream demands for water are computed based on the downstream requirements. Fig (8) shows monthly release of water from reservoir computed by GA, the monthly downstream demands and the monthly allowed release of water from reservoir which is computed based on 15% deficiency of downstream demands. This figure shows that the monthly release of water computed by GA is more than the allowed values. Also, the curve of computed monthly release of water from reservoir quite matches to the curve of downstream demands for water. It is concluded that by a good management, it is possible to satisfy downstream demands for water even during drought periods.

As mentioned before, the optimization processes are considered for inflows with 90% probability. Based on the high capability of GA toolbox, it is possible to consider different probability of inflows to the reservoir in optimization processes. Fig (9) illustrates monthly storage volume of water for different probability of inflows. As shown on fig (9), changes of inflows affect the storage volume of water at the beginning of each month, while it doesn't affect downstream releases of water. Also, storage volume of water during the drought period of year is high while it is low during the flooding period.

So, by genetic algorithm toolbox it would be possible to change different options and obtain the results in short time , (in this work the results obtained in 44 seconds).



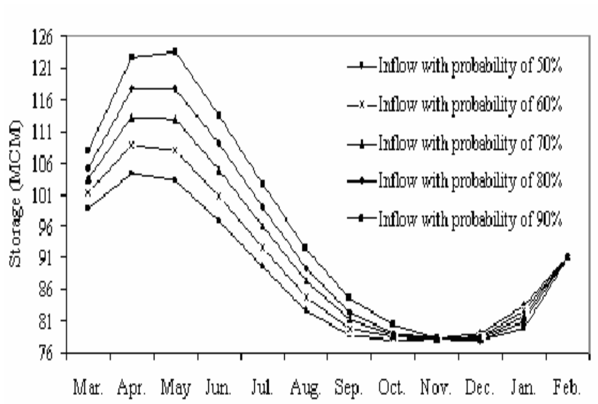


Figure (8). The Monthly demand, computed release and allowed deficiency of water.
& Figure (9). Monthly reservoir storge volume for different probablity of inflow

Conclusion

Optimization of reservoir system operation was carried out using genetic algorithm. Genetic algorithm toolbox in Matlab-7 software has been used to optimize operation of the Jiroft dam reservoir. It is concluded that a real-value representation, population size of 300, stochastic uniform selection, scattered crossover and 0.95 crossover fraction operate most effectively and produce the best results. Ranking for fitness scaling, 2 elite count, 1200 generation and forward migration are appropriate for this case. The inflow to dam reservoir has been considered uncertain. Applying inflows with different probabilities to the optimization model, the release of water from reservoir are not changed significantly, but the reservoir volumes are changed for different probabilities of inflows. The computed monthly release of water from reservoir is in a good consistency with monthly downstream demands. Also, storage volume of reservoir is low during the flood period of year and it becomes high enough during the drought period with high demands for water.

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DRYING CURVES SHAPE FOR HOP CONES AND ENERGY CONSUPTION DURING DIFFERENT DRYING AIR FLOW RATE AND DRYING TEMPERATURE

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There was no significant difference when comparing drying curve's shape for hop cones drying in the season 2004, 2005 and 2006. Constant air flow rate was used in 2004 and gradually declining air flow rate was used in 2005 and 2006. Heat input for declining air flow drying was smaller in comparison with constant air flow drying. Energy input at constant drying temperature is significantly influenced by the outside air temperature.

Key words: hop cone, moisture content on dry basis, drying curves of drying, air flow, heat input.

Introduction

Department of Agricultural Machines at University of Life Sciences in Prague has a long lasting cooperation with Hop Research Institute Co. Ltd. in Žatec and Hop Growing Cooperative in Žatec – Agriculture Machinery Section concerning development of energy-saving drying processes for hop cones and together, respecting high brewing qualitative properties.

Materials and methods

Hop cones from the hop variety - finest aroma Saaz hops was used for all measurements and drying processing.

Drying curves

Data for drying curves plotting was measured by means of a laboratory dryer at Department of Agricultural Machines, University of Life Sciences Prague (Fig. 1).

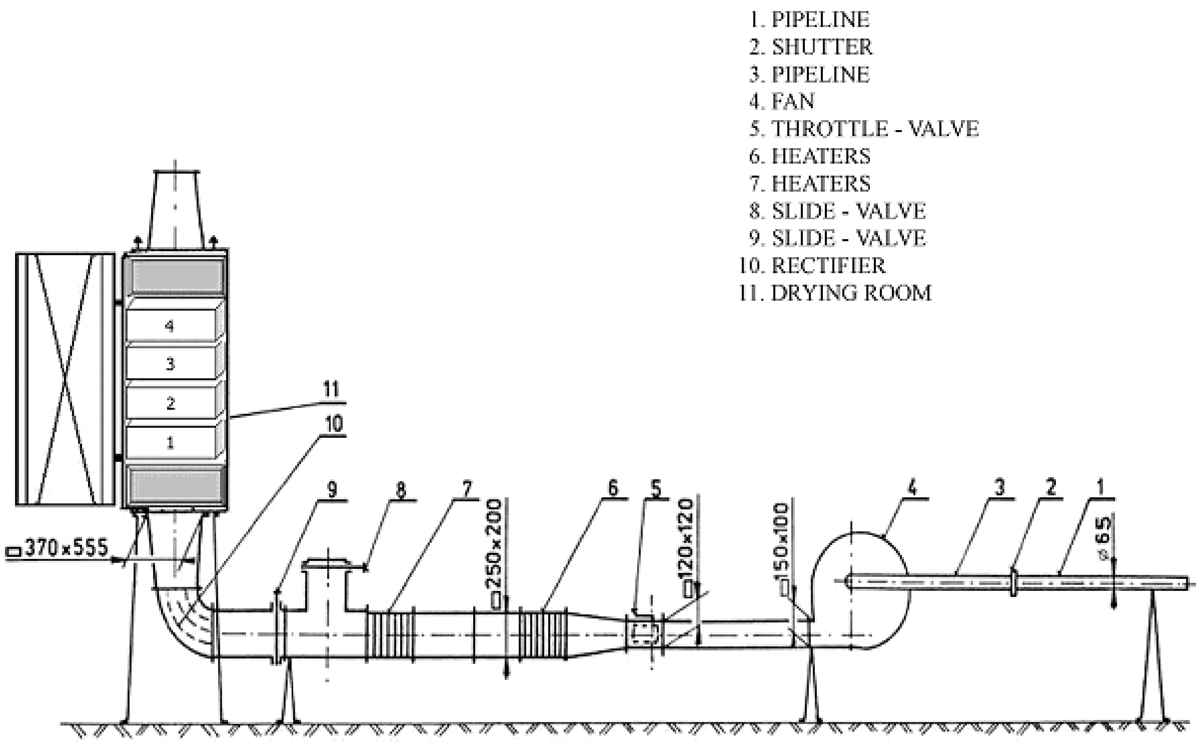
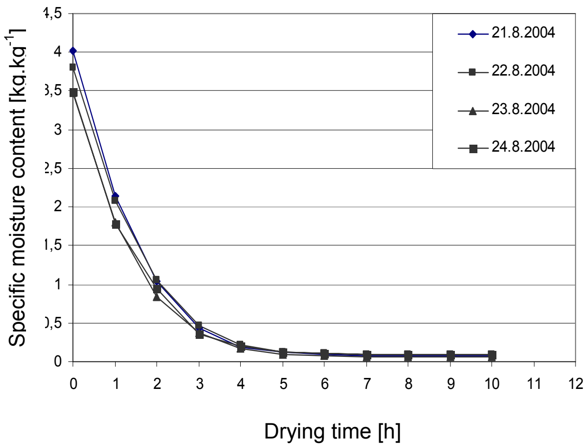
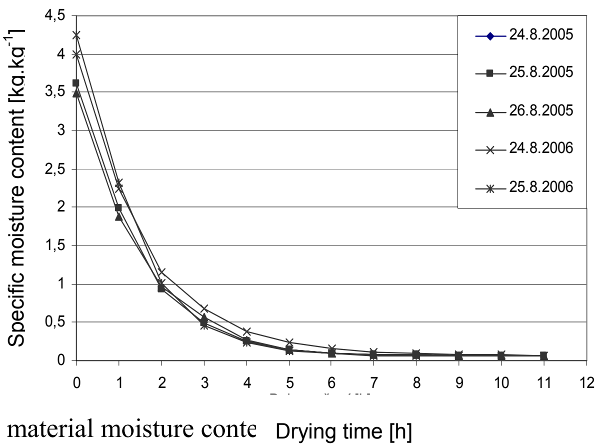


Figure 1: Laboratory dryer used for the measurements

Constant drying air flow rate



Declining drying air flow rate



- material moisture conte

Four boxes with dimensions of 555 x 370 x 200 mm and filled with hop cones was used in the dryer. The boxes were arranged one above another to represent the layer of hop cones in a real dryer under common real drying conditions.

The boxes were taken out from a dryer and weighed in one-hour intervals and then placed back to the dryer. The initial input weight of dried material in each box were 3000 g ± 1 g. Drying air temperature was 60 °C which was heated by means of electric heating elements with a control unit. Energy consumption was measured and recorded by an electrometer. The second parameter – air flow rate, was measured by an orifice (shutter).

In the season 2004, the air flow rate has a constant value 355 $kg.h^{-1}$ for all measurements carried out. In the season 2005 and 2006, the air flow rate was controlled and reduced every two hours as follows: first two hours 353 $kg.h^{-1}$, next two hours 236 $kg.h^{-1}$ and the rest of drying time 120 $kg.h^{-1}$.

Mean specific moisture content of hop cones in all four boxes (it means for the full layer of hop cones – approx. 4 x 18 = 72 cm, at the start of drying) was determined for each one-hour step measurement. The mean specific moisture content values of hop cones are shown in Fig. 2 for different air flow rate drying. It is possible to compare visually both variants there.

The initial specific moisture content u of hop cones was $u = 3.5 – 4.2\ kg.kg^{-1}$ which corresponded with relative moisture content $W = 77 – 80$ %. The final (balanced) specific moisture content was $u = 0.064\ kg.kg^{-1}$ and relative moisture content $W = 6$ %.

Drying process was stopped when minimally two consecutive measurements showed a decrease in weight smaller then 7 g, which corresponded with les then 1 % of final weight of hop cones in each box.

When comparing charts in Fig 2, it is possible to say that there is no evident difference between both variants with different drying air flow rate control on drying curves.

Energy consumption

Drying air was heated to the constant drying temperature $t_{oh} = 60$ °C from the outside air with variable temperature t_{ok}.

The difference $\Delta t = (t_{oh} - t_{ok})$ determines heat which is necessary to warm up drying air, it means the difference of heat content (enthalpy) of outside air and heated air Δh :

$$\Delta h = h_{oh} – h_{ok} = 1{,}01(t_{oh} – t_{ok}) + \{ [(2500 + 1.84\, t_{oh}) x_{ok}] - [(2500 + 1.84\, t_{ok}) x_{ok}] \} \qquad (1)$$

After formula (1) correction the formula (2) is:

$$\Delta h = 1.01(t_{oh} – t_{ok}) + [1.84(t_{oh} - t_{ok}) x_{ok}] \qquad (2)$$

where:

Δ h [$kJ.kg^{-1}$ da] enthalpy for drying air heating,

x_{ok} [kg $oa.kg^{-1}$ da] specific moisture content of outside air, which is constant during heating.

At the outside temperatures ranging between 12 and 26 °C, the outside air specific moisture content was ranging between 0,008 and 0,006 kg $oa.kg^{-1}$ da. Then under following condition:

$\Delta t = (60 - t_{ok}) = \{48 ; 34\}$ °C , the given formula (3) applies

$$[1.84\{48; 34\} * \{0.008; 0.006\}] = \{0.7; 0.4\} \qquad (3)$$

it equals to approx. 2 % from the difference $\Delta t = (60 – t_{ok})$, and it represents a negligible value.

Thus, the following equation (4) applies to our measurements:

$1\ °C = 1\ kJ.kg^{-1}\ da$ (4)

The mean value of enthalpy necessary for drying air heating was calculated according to the formula (5):

$\Delta h = \Delta t \cdot M_a$ (5)

Tables 1 and 2 shows selected measured values to represent and compare two different drying procedures for comparable drying time 9 hours.

Table 1: Measured values at constant drying air flow rate

	t_{ok}	t_{oh}	Δ t	M_{vz}	W%	Δ h	Q_T	Q_E
21.08.2004	26.1	58.9	32.8	3195	7.08	104796	29.1	48.7
22.08.2004	26.0	59.3	33.3	3195	8.59	106394	29.6	47.0
23.08.2004	26.8	59.5	32.7	3195	5.75	104477	29.0	48.3
24.08.2004	20.2	60.0	39.8	3195	9.05	127161	35.3	55.4
22.08.2005	25.2	61.8	36.6	3177	7.17	116278	32.3	46.3

Table 2: Measured values at declining drying air flow rate

	t_{ok}	t_{oh}	Δ t	M_{vz}	W%	Δ h	Q_T	Q_E
24.08.2005	23.4	59.2	35.8	1788	6.37	63652	17.7	29.0
25.08.2005	21.6	60.4	38.8	1778	6.12	68986	19.2	29.6
26.08.2005	24.2	61.8	37.6	1778	7.35	66853	18.6	24.7
24.08.2006	22.8	59.0	36.2	1778	5.34	64364	17.9	25.0
25.08.2006	18.8	60.1	41.3	1778	5.34	73431	20.4	25.7

where:

t_{ok} [°C] outside temperature,
t_{oh} [°C] temperature of drying (heated) air,
$\Delta t = (t_{oh} - t_{ok})$ [-] difference between drying and outside temperature (for air),
M_a [kg] total mass of air used for 9 hours of drying,
W [%] final mean relative moisture content of dried matter layer after 9 hours of drying,
Δ h [kJ] enthalpy of heated air fed under the first measuring box,
Q_T [kWh] thermal energy of heated air fed under the first measuring box,
Q_E [kWh] input electric energy.

Results and discussion

Influence of outside air temperature and drying air flow rate on energy consumption of drying process.

Constant drying air flow rate:

21. - 23.08.2004 t_{ok} = 26.3 °C and t_{oh} = 59.5 °C , Q_E = 48.0 kWh **taken as 100 %**

24.08.2004 t_{ok} = 20.2 °C and t_{oh} = 60.0 °C , Q_E = 55.4 kWh 115 %

22.08.2005 t_{ok} = 25.2 °C and t_{oh} = 61.8 °C , Q_E = 46.3 kWh 96 %

Low outside air temperature resulted in higher thermal energy demand and higher energy consumption. Higher outside air temperature resulted in lower energy demands.

Declining drying air flow rate:

24. - 25.08.2005 t_{ok} = 22.5 °C and t_{oh} = 59.8 °C , Q_E = 29.3 kWh **taken as 100 %**

26.08.2005 t_{ok} = 24.2 °C and t_{oh} = 61.8 °C , Q_E = 24.7 kWh 84 %

24.08.2006 t_{ok} = 22.8 °C and t_{oh} = 59.0 °C , Q_E = 25.0 kWh 85 %

25.08.2006 t_{ok} = 18.8 °C and t_{oh} = 60.1 °C , Q_E = 25.7 kWh 88 %

Higher t_{ok} a t_{oh} 26.08.2005 and in 2006 influenced favourably energy consumption and resulted in lower electric energy consumption for drying hop cones in comparison with the measurements on 24. and 25.08.2005.

All measurements from 26.08.2005; 24. and 25.08.2006 show the lowest and very similar values of energy input despite different temperature t_{ok}.

Comparison of electric energy consumption at constant and declining drying air flow rate:

21.- 23.08.2004 Q_E = 48.0 kWh = 100 %
24.- 25.08.2005 Q_E = 29.3 kWh = 61 %
26.08.2006 Q_E = 24.7 kWh = 45 %
24.08.2004 Q_E = 55.4 kWh = 100 %

ENERGY SAVING 39 %
ENERGY SAVING 55 %

Conclusions

It follows from the presented measurement results that lower outside air temperature increased considerably thermal energy demands for drying and on the contrary lower or declining drying air flow rate in a dryer significantly decreased the energy demands. This fact is in accordance with the theory of drying materials.

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ELECTRORHEOLOGICAL COMPONENTS IN COMPRESSION OF TISSUES OF BIOLOGICAL ORIGIN

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The equipment for electrorheological measurements on soft agricultural products is presented. This equipment makes possible either to perform mechanical tests of the products during controlled influence of electric current of different frequencies or to perform measurement of complex electric permittivity during the controlled mechanical test. These possibilities depend on the current level used during the test. In the first above mentioned case the level of current has to be limited to values not leading to increase of the tested specimen temperature more than about 1 ^{o}C, in the second case the higher temperature effect of the current is supposed. The first case of application is demonstrated on loading unloading test of potato tissue deformed in compression.

Introduction

The term electrorheology is explained in most dictionaries by the following definition: "*the study of the changes in flow properties that occur in certain fluids exposed to electric fields*". There are usually fluids with special structure units that are polarizable in electric fields. These fluids demonstrate dramatic changes (Dassanayake et al., 2004) in their rheological properties including yield stress, loss and storage moduli etc. in response to an externally applied electric field are known as electrorheological fluid (ERF). ERF exhibit a very fast, reversible transition from a free-flowing liquid state to a solid like state. This behaviour is often described as Bingham plastic characteristics having shear modulus and yield stress dependent on external field that must be overcome to initiate gross material deformation or flow. The majority of the electrorheological fluids (ERF) are composed of solid particles suspended in nonpolar liquids.

General particles used in preparing ERF are silica, titania, zeolites and the medium used in preparing ERF are silicone oil, mineral oil, cast oil. In electric field, each particle acquires an induced dipole. When aligned along the field direction, the particles attract one another, whereas the particles in the plane perpendicular to the field direction repel one another. The dipole-dipole interactions cause chain structures in direction parallel to the field vector. Physical properties of ER under external field are due to the formation of this chains and columns of the field responsive constituent. Mechanical energy from shocks or vibrations can be absorbed by these materials under external field. The influence of external electric field on the deformation or flow properties of certain fluids has been a subject of scientific or practical interest for many years. The change in viscosity and other macroscopic properties has been investigated in a number of systems including molecular polar liquids (Andrade and Hart, 1954) and electrorheological fluid (Gast and Zukoski, 1989). Among the class of these field-responsive fluids, special focus has been placed on the materials having the features such as rapid, reversible, and tunable transition from a liquid-like state to a solidified state upon the application of an external electric or magnetic field. These materials are known as electrorheological (ER) fluids.

Classical electrorheological effects are observed usually in strong electrical fields where the electrostatic forces are strong enough to polarize the structural units of the fluid. New type of electrorheology could be observed in biological cellular objects where the wall effects make the cellular structure more sensitive to the electric field (Malmivuo and Plonsey, 1995, Schwan 1957 and 1977). This paper contains description of equipment for study of the electrorheological effects in cellular materials of biological origin either in living state or in postmortem state in which the cellular structure was conserved including of its original moisture content.

Basic Assumptions and Theory

The electric properties of the biological tissue are determined mainly by properties of the tissue cell walls. Different concentration of ions inside and outside the cells produces so called Nernst potential ((Malmivuo and Plonsey, 1995) on the cell walls. This potential usually less then 0.1 V is modified by the external electric field that is concentrated in the cell walls. The cell wall resistivity is much higher than resistivity of the cellular sap; for potato cells this difference represents about four orders (Blahovec and Million, 1985). Similarly, the thickness of the cell wall can be omitted in comparison to the cell dimension. Under this assumption, the voltage on the tissue is concentrated in the cell walls so that the cell wall potential U_{cw} caused by external potential U on the specimen of length l is estimated as:

$$U_{cw} \approx \frac{Ud}{2l} \qquad (1)$$

where d is dimension of the cell. In plant parenchyma with cells of dimension in hundreds of μ and of length in cm, the cell wall potential of 0.1 V is produced by external field in tens of V. Equation (1) losses its force when the frequency of the field increases and the cell wall resistivity decreases (Schwan, 1957,1977).

The power of the current P in the sample is determined by the sample total resistivity ρ_e:

$$P \approx \frac{4U_{cw}^{2}V}{d^{2}\rho_e} \qquad (2)$$

where V is the specimen volume. Equation (2) can be used as a basis for estimation of rate of heating due to electric current in case when the specimen is not cooled:

$$\frac{dT}{dt} = \frac{4U_{cw}^{2}}{d^{2}\rho\rho_e c} \qquad (3)$$

where T is temperature, t time, ρ the specimen density, and c the specimen's thermal capacity. Equations (2) and (3) shows that both the current power and the temperature rates are quadratic functions of ratio U_{cw}/d, i.e. the cell gradient of the electric potential, and reciprocal function of the specimen resistivity.

At low U_{cw}/d values, high frequencies and long and slow deformation, the mechanical properties of the plant cells are controlled by increasing temperature caused by the electric current, whereas when the ratio U_{cw}/d reaches value ~0.1 V, the mechanical properties of the loaded tissue can be changed quickly due to changed equilibrium at the cell walls. The cell wall permeability for water and ions can be changed seriously followed by changes of the product rigidity.

Materials and Methods

The equipment for electrological studies of deformations in compressed plant tissues is displayed in Fig. 1. The equipment is a logical continuation of the equipment used for permittivity studies of the same materials during their compression test (Blahovec and Sobotka, 2007). The equipment is enriched by amplifier that saves changes of the electric signal levels in the tested specimen. The equipment arrangement makes possible to have under control both the current and potential in the tested sample. These two values can be changed during the deformation by changes either of amplifier volume or of the normal resistor value. The arrangement of the voltmeters saves to determine the current complex impedance or in other words complex permittivity of the tested specimen (Sobotka et al., 2007).

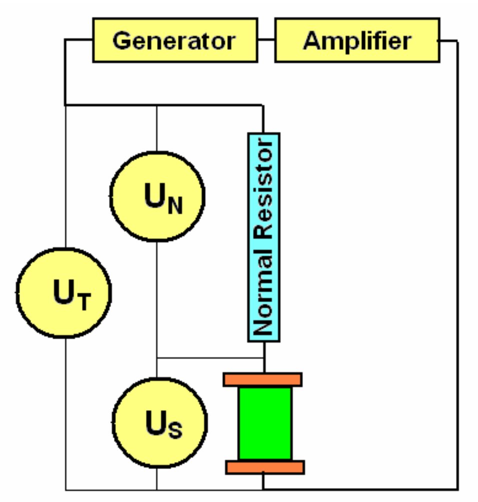


Fig. 1 Scheme of the equipment for study of electrorheology of soft agricultural products. The total voltage U_T is produced by AC generator followed by amplifier. The current value is determined by the voltmeter U_N. The voltage on a deformed specimen is determined byvoltmeter U_S.

The frequency of the AC generator should be low not to overcome the characteristic frequency $f_{char} = 1/(C_mR_m)$ (Schwan, 1977), where C_m an R_m are respectively the area capacity and the area resistance of the cell wall. The characteristic frequencies for some animal cell walls are in range of kHz (Schwan, 1977).

The method is based on testing of specimens prepared from soft vegetable products like bulbs, roots, or tubers by cutting using sharp knives, razor blades and/or cork borer. We suppose specimens of cylindrical shape (approximately 15 mm in diameter and 20 mm in height) tested in axial direction by compression with deformation rate less than 0.05 $mm.s^{-1}$. The mechanical tests were performed in a testing machine Instron® 4464. The compression metallic isolated plates served at the same time as electrodes for a continual two point impedance measurement of the tested specimen.

Fig. 2 The electric equipment for measurement of dielectric properties of the specimen during its mechanical testing. The testing machine Instron is in the left part of the photo with the tested specimen fixed below loading cell. In the right upper part, there is electric part of the equipment.

The source of the signal in the circuit was a generator (Agillent Generator 33220A) working with sinusoidal signal (10 V as the maximum amplitude). In the serial circuit the three AC voltages were measured continuously by three 34401A digital multimeters as is given in Fig. 2. The measured voltages corresponded: to the normal stable Ohmic resistor (220 Ω) – U_N, the tested specimen U_S and the total voltage on the serial connection of the normal resistor and the tested specimen U_T. The frequency of the generator could be changed to different values in some periodical sequence. In our current tests the following frequencies were used: 0.1, 0.5, 1, 5, 10 kHz was used periodically and for each frequency the above mentioned voltage data were stored. A computer controlled whole process by using the Agillent software VEE, version 7.

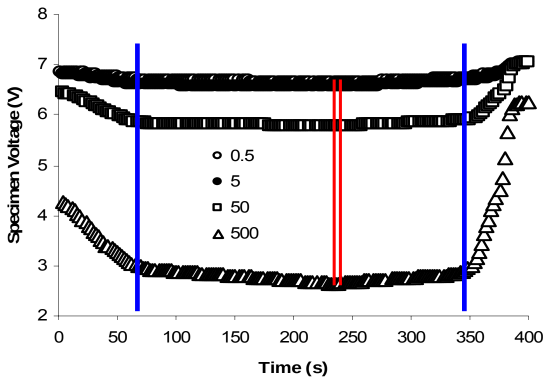
Fig. 3. Specimen arrangement in testing machine: between two metallic plates in Faraday cage.

The arrangement of the specimen between two plates in the testing machine is displayed in Fig. 3. The data from mechanical part of the test (time, displacement and force) were recorded every 0.1 s, the data in electrical part (time, frequency and the corresponding three voltages) were recorded every 1 s. The data were stored in two computers; the mechanical data and electric ones separately had to be unified after test on the base of the common time unit given by computer controlling the testing machine by the standard Instron software.

The corresponding strain (ε_i) and stress (σ_i) values were the basic data in mechanical tests and further calculations. The true (Hencky's) strain and stress were calculated as:

$$\varepsilon_t = -\ln(1-\varepsilon_i) \qquad (4a)$$

$$\sigma_t = \sigma_i(1-\varepsilon_i) \qquad (4b)$$



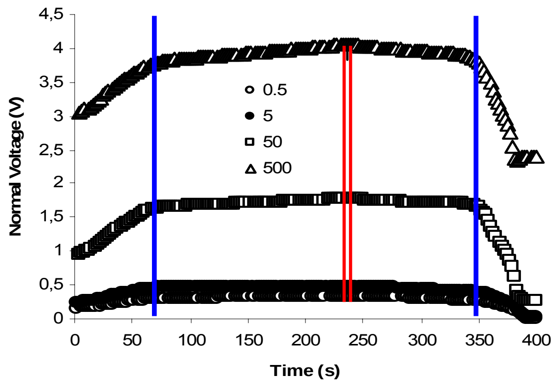


Fig. 4 The voltages measured at the specimen (left) and at the normal resistor (right) in loading/unloading test in compression (the time of the test reversion is denoted by double line) at different frequencies denoted by numbers in kHz. The parts of different slopes are separated in the figure by the single lines.

Results and Discussion

Our measurements have preliminary character. Figure 4 contains results obtained during loading/unloading test in compression where the total compression prior loading reversion represents 4 mm (denoted by double line in Fig. 4). Both the loading and the unloading parts are divided into two parts: the part with lower level of the compression (with deformation about 1 mm corresponding to time about 60 s) and the part with higher level of deformation. Both the parts are separated in Fig. 4 by simple vertical lines. The main difference between the two parts consists in steepness of the voltages plotted versus time; in the first mentioned part the steepness is much higher than in the second mentioned part where the voltages are approximately constant. The differences are higher at higher frequencies. The strain of the first above mentioned area represents approximately 5 % that corresponds to the quasi-yield point observed on the compression deformation curve in vegetable tissues (Blahovec et al., 1984).

The electrorheological aspects of the observed parallel changes in rheological and electric properties is a thing of the following research.

Conclusions

There was prepared equipment for experimental study of electrorheology of cellular materials of biological origin for which the theoretical frames were developed. The first experiments indicate electrorheological effects correlated with the quasi-yield point in vegetable tissues.

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THERMAL CONDUCTIVITY, THERMAL DIFFUSIVITY AND SPECIFIC HEAT OF POTATOES

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Abstract: Biological materials have complicated structure. During processing they are heated, cooled, dried, moistured or they are mechanically manipulated. If we want to protect quality of biological materials or food we need to know its physical properties, especially thermophysical properties. For thermophysical parameters measurements were used transient methods. In the first series of measurements we measured relations between thermal conductivity, thermal diffusivity and specific heat in temperature range (6 –22) ºC by instrument Isomet. In the second series of measurement we measured thermophysical parameters of three different potatoes cultivars during the storage process. The results of measurements showed that temperature stabilisation process and storage conditions had influence to variation of thermophysical parameters. All measured relations between thermophysical parameters and temperature have evident linear increasing progress in temperature range (6 –22) ºC. There were also founded differences of thermophysical parameters between different cultivars of potatoes.

Keywords: potatoe, thermal conductivity, thermal diffusivity, specific heat, temperature

1 Introduction

Materials research and the rapid industrial development create a demand for experimental methods that give reliable data of the thermophysical properties of materials in a short time. Great number of experimental techniques has appeared in literature so far. The methods differ in basic principles of measurement; in number of thermophysical properties they allow to estimate simultaneously; they disinguish in suitability to test different materials and under various experimental conditions. Very popular are photothermal methods of measuring the thermal diffusivity - the laser flash method (Parker – Jenkins –Butler - Abbott, 1999) and the step heating method (Bittle and Taylor 1984); electroresistive heat source methods (Kubičár and Boháč, 1998) of measuring the thermal conductivity – transient hot wire method (Davis 1984, Assael et al 2002, Labudová – Vozárová, 2002), the hot plate (Dowding.- Beck. - Blackwell, 1998), the guarded hot – plate method (Tye – Kubičár – Lockmuller, 2005). The other methods give two thermophysical parameters – the transient hot strip method (Gustafsson and Karawacki 1983), the step – wise transient method (Vukovič, Maqlič, 1998) and the transient plane source method (Gustafsson and Karawacki 1983).

For our measurements were used transient methods – Plane source (PS) and Hot wire method (HW). Transient methods represent a large group of techniques where measuring probes, i.e. the heat source and the thermometer, are placed inside the sample. This experimental arrangement suppresses the sample surface influence on the measuring process which can be described as follows. The temperature of the sample is stabilized and made uniform. Then the dynamic heat flow in the form of a pulse or step - wise function is generated inside the sample. From the temperature response to this small disturbance, the thermophysical parameters of the sample can be calculated. The article presents thermophysical parameters measurements of apples and apple products which are biological materials with non - uniform structure in microscopic and macroscopic meaning. Biophysical and physiological processes are realised within biological materials. Heat transfer can not be isolated from the solid transfer and from the heat – moisture transfer. It means that specification of biological materials is difficult to determine, but for protection of apple and apple products quality it is necessary to know its thermophysical properties as one of very important parameters.

Table 1 – Transient methods

Name of method	Heat source	Heat generation	Heat flow	Heat source-thermometer	Measured parameters
Hot Wire	line	step-wise	radial	united	λ
Pulse Transient	plane	pulse	1-dimensional	apart	*a* , λ
Step-Wise Transient	plane	step-wise	1-dimensional	apart	*a* , λ
Hot Plate Transient	plane	step-wise	1-dimensional	united	effusivity
Hot Disc Transient	disc	step-wise	3-dimensional	united	*a* , λ
Gustafsson Probe	circles	step-wise	3-dimensional	united	*a* , λ
DPS	plane	step-wise	1-dimensional	united	*a* , λ>2W/mK
Extended DPS	plane	step-wise	1-dimensional	united	*a* , λ<2W/mK

2 Materials and methods

All samples were storage in special cool box with temperature 3 °C. In the 1st series of measurement were measured samples after the basic temperature stabilisation to 6 °C. There were measured thermophysical parameters for different variety of potatoes during the temperature stabilisation. For the 2nd series of measurement we need temperature stabilisation of potatoes samples on laboratory room 22 °C. For measurements was used instrument Isomet which works on transient methods (HW or PS).

The HW method - Thermal conductivity is derived from the resulting change in temperature over a known time interval. The ideal analytical model assumes an ideal – infinite thin and infinite long line heat source (hot wire), operating in an infinite, homogenous and isotropic material with uniform initial temperature T_0. If the hot wire is heated for the time $t=0$ with constant heat flux q per unit wire length, the radial heat flow around the wire will occur. The temperature rise $\Delta T(r,t)$ in any distance r from the wire as a function of time. From the temperature response to this small disturbance the thermophysical parameters of the sample can be calculated (Carslaw - Jeager, 1959).

Thermophysical parameters measurements by Isomet are based on HW method. For the right construction of probe and enough long measuring time t we can express temperature relation in probe with equation (Dowding,- Blackwell, 1998):

$$T(t) = A \ln(t) + B \tag{1}$$

Where A, B are constants which depends on probe parameters and thermophysical parameters of measured sample. From equation (1) we can obtain for right selected time interval linear regression between parameters T a $ln(t)$, where A is line direction.

$$A = \frac{K_1}{A} + H \tag{2}$$

Thermal diffusivity we obtain from equation:

$$a = \frac{\left\{\left(K_2\, A^2\, e^{B/A}\right)^2 + 4K_3\, A\, e^{B/A}\right\}^{1/2} - K_2\, A^2\, e^{B/A}}{2} \tag{3}$$

where $K_1 = \frac{R\, I^2}{4\pi\, L}$, $K_2 = \frac{m_1\, c_1\, r_0^2}{8\pi\, K_1}$, $K_3 = \frac{r_0^4}{8}$ (4-6)

A, B are constants, depending on parameters of sample and its thermal characteristics. K_1, K_2, K_3, H - are constants of used spike probe. R – is resistance of wire, I - is electrical current and L - is active length of probe, m_1 - is mass of probe length unit, c_1 - is specific heat of probe and r_0 - is characteristic dimension of probe. Third thermophysical parameter – specific heat we can calculate from equation:

$$c = \frac{\lambda}{a\,\rho} \tag{7}$$

Where ρ - is density of measured sample.

The PS method - Thermal source is located between two identical samples with thickness L. In time $t=0$ s thermal source starts affect with constant thermal power q on unit area, than we can express relation between temperature and time by equation:

$$\Delta T(x,t) = \frac{qL}{\lambda\sqrt{\pi}}\sqrt{\frac{t}{\Theta}}\left[1 + 2\sqrt{\pi}\sum_{n=1}^{\infty}\beta^n ierfc\left(n\sqrt{\frac{\Theta}{t}}\right)\right] \tag{8}$$

Where

$$\beta = \frac{\frac{\lambda}{\sqrt{a}} - \frac{\lambda_M}{\sqrt{a_M}}}{\frac{\lambda}{\sqrt{a}} + \frac{\lambda_M}{\sqrt{a_M}}}, \Theta = \frac{L^2}{a}, \quad \Delta T(x,t) = \frac{q\sqrt{a}}{\lambda\sqrt{\pi}}\sqrt{t} \tag{9 – 11}$$

Θ- is characteristical time, a - is thermal diffusivity of measured sample, a_M - is thermal conductivity of metal blocks, β - parameter which describes the heat sink imperfection, *ierfc* - is error function integral. For short time $t < 0{,}3\,\Theta$ equation (8) has simplified form. Equation (11) is identical with equation for one-dimensional heat flow in infinite homogenous medium. The principle of method resides in fitting of the theoretical temperature function given by (8) over the experimental points. In case of the best fit, both parameters λ and a can be determined. The method of fitting based on least-squares procedure was described in detail (Liang, 1995, Assael, - Wakeham, 1992).

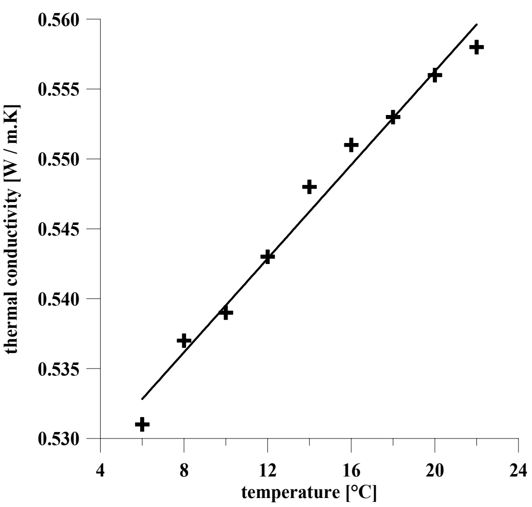
We had to use several corrections to account for the heat capacity of measuring probe, the thermal contact resistance between the probe and the test material, the finite dimension of the sample and the finite dimension of the probe embedded in the sample.

3 Results

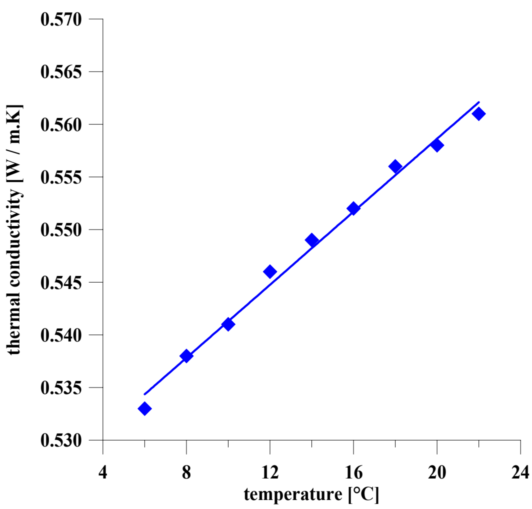
In the first series of measurements we measured relations between thermal conductivity, thermal diffusivity, specific heat and temperature in temperature range (6 –22) ºC by instrument Isomet, which use for thermophysical measurements by transient methods. Results can be shown on figures 1-9.

Table 2 – Results of thermophysical parameters measurements during the storage process.

month / cultivar		**Thermal conductivity [W/m.K]**	**Thermal diffusivity [m^2/s]**	Specific heat [J/kg.K]
december	**Cyrano**	0,563	14,45	3522
	Nikola	0,562	14,60	3530
	Lipta	0,572	15,20	3534
january	**Cyrano**	0,559	14,38	3516
	Nikola	0,555	14,57	3521
	Lipta	0,567	15,16	3530
february	**Cyrano**	0,551	14,29	3506
	Nikola	0,548	14,50	3512
	Lipta	0,563	14,12	3526

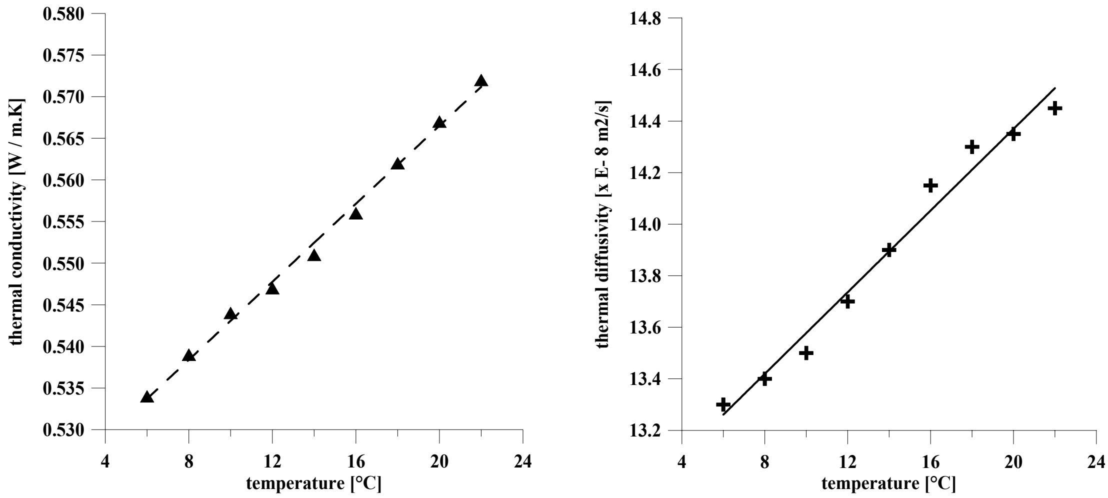


Cultivar 1 – Cyrano



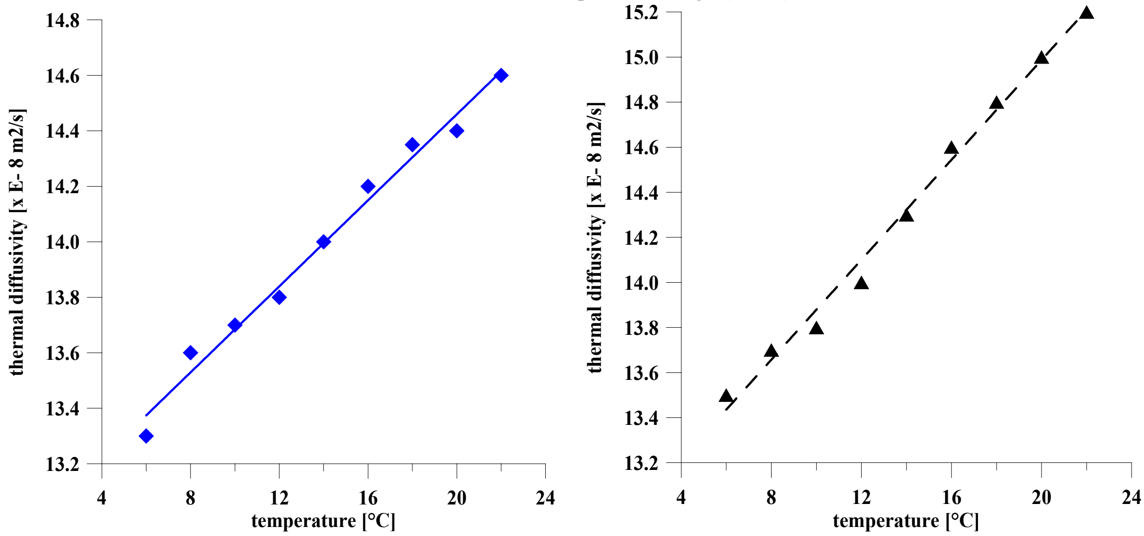
Cultivar 2 – Nicola

Fig. 1-2 Relations of thermal conductivity to temperature for different cultivars during the temperature stabilisation in temperature range (6 –22) ºC



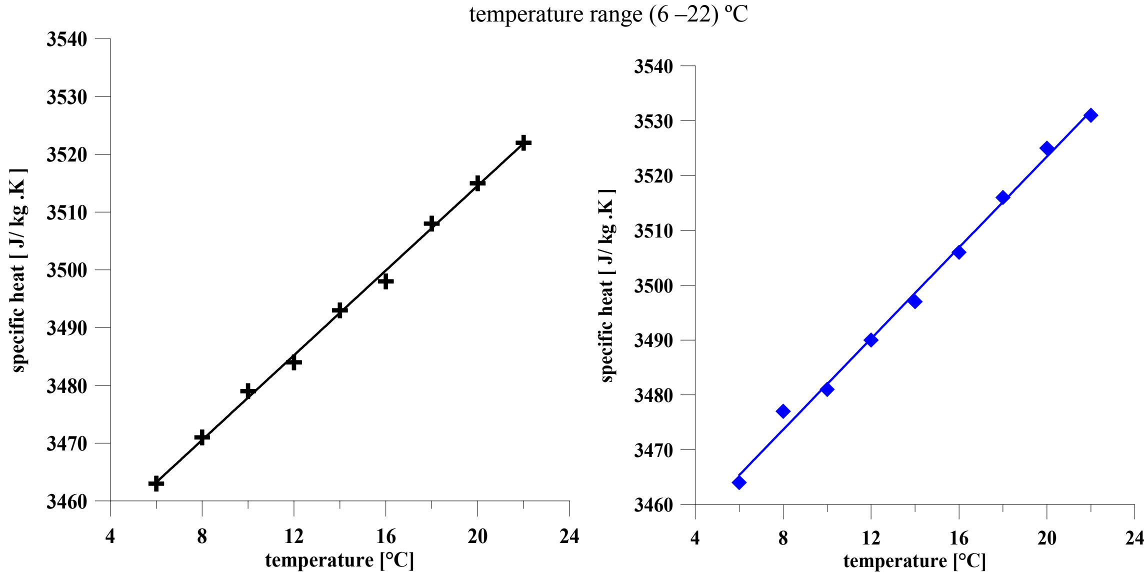
Cultivar 3 – Lipta *Cultivar 1- Cyrano*

Fig. 3-4 Relations of thermal conductivity and diffusivity to temperature for different cultivars during the temperature stabilisation in temperature range (6 –22) °C



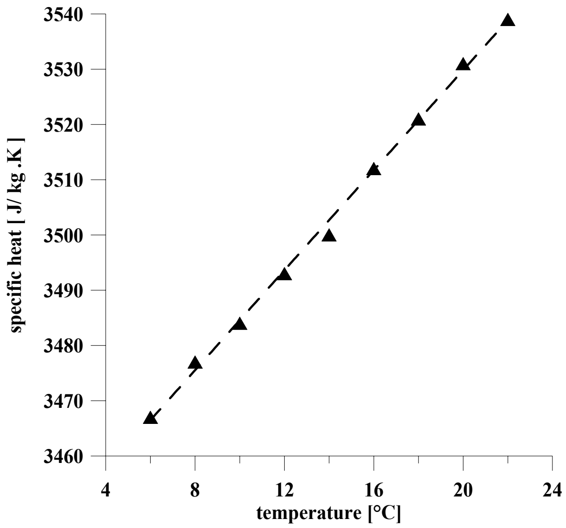
Cultivar 1 – Nicola *Cultivar 2 – Lipta*

Fig. 5-6 Relations of thermal diffusivity to temperature for different cultivars during the temperature stabilisation in temperature range (6 –22) °C



Cultivar 1 – Cyrano *Cultivar 2 – Nicola*

Fig. 7-9 Relations of spefic heat to temperature for different cultivars during the temperature stabilisation in temperature range (6 –22) °C



Cultivar 3 – Lipta

4 Conclusion

The results of measurements showed that temperature stabilisation process and storage conditions had influence to variation of thermophysical parameters. All measured relations between thermophysical parameters - thermal conductivity, thermal diffusivity and specific heat and temperature have evident linear increasing progress in increasing temperature in temperature range (6 –22) ºC. There were also founded differences of thermophysical parameters between different cultivars of potatoes. Table 2. shows results which were obtained during storage process, from presented values is evident, that the most stable thermophysical parameters during three months storage period had cultivar – Lipta. Present values of thermophysical parameters also show, that changes of moisture content and biochemical changes in potatoes structures during the storage process have influence on thermophysiacal parameters which have decreasing progress. Measured relations and values confirm, that it is necessary to know thermophysical properties of biological materials if we want to protect high quality of biological products and if we want to choice optimal technological procedure.

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IS THERE A POSSIBILITY OF CLINICAL APPLICATION OF INFRARED-THERMOGRAPHY FOR DIAGNOSTICS IN OESTRUS DETECTION IN DAIRY COWS?

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The main aims of our basic research project are to assess infrared measuring methods for diagnosing pregnancy and detecting oestrus in dairy cattle and for discovering injuries and inflammations on the animal's body. We present initial trend results of a basic research project examining the possibility of clinical application of infrared thermography for diagnosing oestrus climax in dairy cows. Cooperation between the Veterinary University, Hanover, and the Institute of Agricultural Engineering, Bornim was started in summer 2002 with six dairy cows in a clinic barn. All cows were synchronized and Prostaglandin F² was administered to them three days after starting the investigation. A vaginal data logger measured the body core temperature in the oestrus cycle to show oestrus climax for best insemination. The question was whether it is possible to identify the climax in the oestrus cycle with infrared thermography pictures showing the temperatures of the labia, too. The answer to our question is "yes". The results from five test animals show an oestrus climax measured with data logger and infrared thermography pictures of the vaginal labia as well.
One test animal suffered massive udder inflammation in the test period and an oestrus cycle was not visible. The limited number of pages allowed for proposals is the reason why we are only presenting the results of one animal.

Keywords: dairy cattle, oestrus detection, infrared thermography, herd management.

Introduction

Infrared thermography is a non-invasive diagnostic method. No direct animal contact is necessary. The body surface temperature of an animal is measured from a distance with an infrared camera, and the photographed part of the animal's body is displayed as a thermal profile picture. The aim of our investigation was to establish whether there was a possibility of identifying the oestrus climax, considered as the optimal point for successful insemination of dairy cows, from a thermal profile in an infrared picture when the subject of the picture was only the external vaginal area of the cow's labia (body surface temperature). A further objective was to look for a way to replace the exact, but very expensive and complicated, invasive measurement system with a data logger located in the vagina . We wanted to investigate whether infrared or laser technique could be an alternative measurement system for oestrus detection in dairy cows. In our contribution a thermal profile is defined as an infrared picture of a detail of an animal body with its surroundings. The thermal profile of the animal's body can supply information or indications regarding certain aspects of the animal's health status, e.g. its current general thermoregulation or local temperature changes.

Infrared thermography in zoo and wildlife medicine has been applied very successfully in recent years for diagnosing injuries, as well as for oestrus and pregnancy detection.

The question considered was whether it was possible to use this non-invasive method for monitoring oestrus detection of dairy cows on farms, too. An investigation with six dairy cows was started in summer 2002 in cooperation between ATB Bornim and the Veterinarian University, Hanover.

Materials and methods

Infrared thermography is a very complicated and sensitive system. We found that this measuring system is currently not usable under real conditions in practice. Environmental conditions such as atmospheric humidity, air temperature and air velocity influence and change the body surface temperature of animals, too. This can lead to major errors in temperature measuring. We therefore ensured precise animal housing conditions over the entire test period in a separate compartment in the clinic building. It was guaranteed that there was no wind or draught. The heat was constant with an indoor temperature between 22.0 and 27.0 °C. Six dairy cows from the Clinic for Cattle Obstetrics and Gynaecology at the Veterinarian University in

Hannover were included in an investigation covering 14 days.

All test animals were dry cows. All cows were oestrus-synchronized before starting the investigation. At the beginning of the test all cows were equipped with a data logger inside the vaginal tract to measure body core temperature and activity for oestrus detection. In the first part of the investigation the collected data sets were transferred daily via radio directly from the animal's body to a PC. The data loggers were configured with a continuous measuring interval of 5 min for both parameters. The animal body surface temperature was measured from a distance of 1.5 to 2.0 m with a fixed infrared camera (Thermacam PM 545) on a tripod. These cameras are very precise with a resolution of 0.1 to 0.2 K and take 30 pictures in 1 sec. The great advantage of this measurement method is that no direct animal contact is necessary. The test animals a separate compartment in a tied stall.

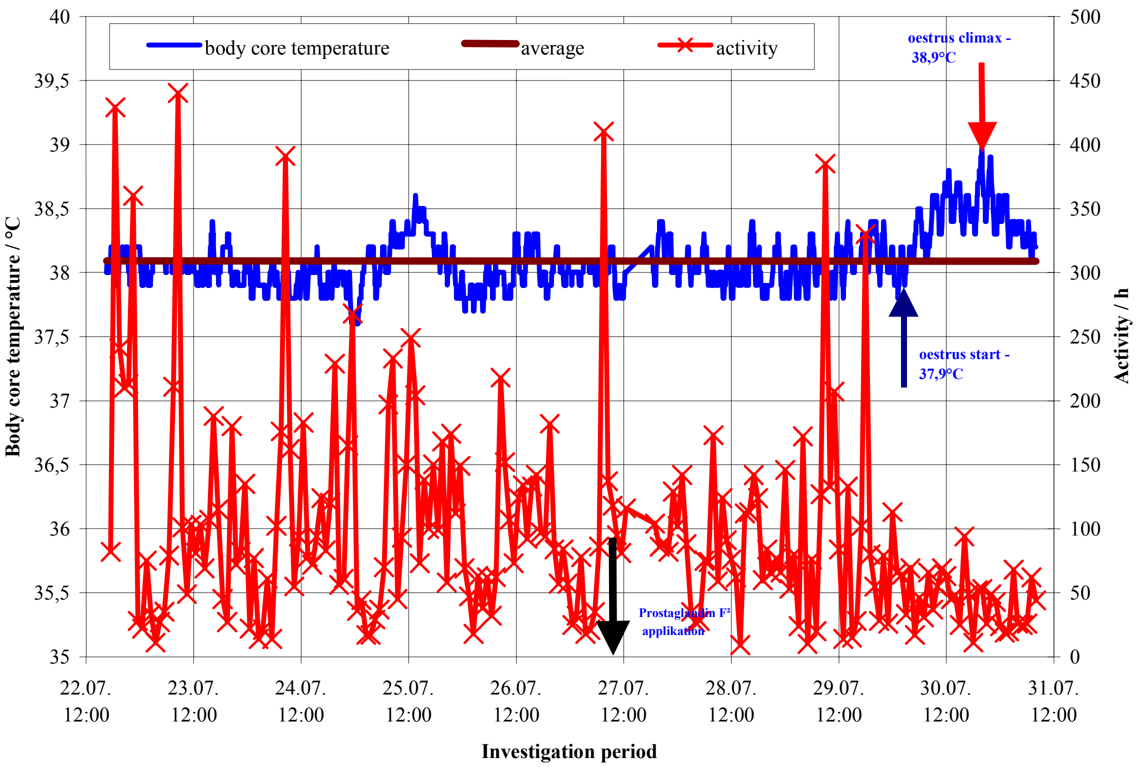
The time interval for infrared pictures of the external vaginal area (labia) in the first part of the test was six hours. The tripod of the camera was positioned in the general passage in the barn, at distance of 1.5 to 2.0 m from the anus area (labia) of the cows . One person drew aside the tail of the cow for a good view of the labia area, while the second person operated the camera. When the cow stood calmly and the camera had an exact view of the vaginal area, we took 2 to 3 photos of each test animal at each time interval. Five days after starting the investigation all cows received a Prostaglandin F^2 application to stimulate artificial oestrus three to four days after the application. Looking at the values of the body core temperature curve after each reading of the logger data sets, we could see the exact situation of the oestrus cycle with the exact time of oestrus climax for all cows. The main problem was to establish whether we could identify the very slight change in body core temperature during oestrus of only 0.3 to 0.6 °C in an infrared thermal picture of the external vaginal area of the cows. During the oestrus period with the expected oestrus climax of the test animals we shortened the thermographic picture interval from six to two hours.

When the oestrus was over we took thermographic pictures at intervals of six hours for two days again, after which the investigation was terminated. For reference purposes we measured the surface temperature of the cows' external vaginal area with a laser-thermometer pistol from the same distance as the infrared camera too.

After completion of the test the data loggers were withdrawn from vaginal tract.

Results

Figure 1 shows the results of measurements with the data logger in the vaginal tract. We see the course of body core temperature and activity of a test animal with oestrus three days after Prostaglandin F^2 application.



The average body core temperature of this cow was 38.0 °C, shown by the straight (brown) line in the figure. The oestrus climax is also evident.

The best point for successful insemination was the evening of 30 July. The oestrus started in the early morning of 30 July and the oestrus climax was visible in the evening of the same day. The morning temperature was 37.9 °C, the evening temperature was 39.0 °C.

These results confirm the findings of the investigation conducted two years ago. Data loggers are an excellent sensor-aided measuring system for oestrus monitoring and decisions in herd management of dairy cows. This exact dating of an oestrus cycle is only possible by measuring important physiological animal data such as body core temperature and activity with a data logger inside the animal's body. The difference between the average body core temperature before and after oestrus of 37.9 °C, and body core temperature on oestrus climax of 39.0 °C is +1.1 K, which represents a very high value. Figure 2 provides an overview of the results of body surface temperature, obtained with an infrared camera, and represents a thermal profile of the external vaginal area (labia).

The same conditions prevailed for both measurement systems in the barn, for the animals at measuring time, and as regards the time interval.

During the oestrus cycle we took thermal profile pictures with an infrared camera of the external vaginal area of all test animals at now 2-hour intervals. The figure shows the selected area of the labia for all infrared photos taken with the camera.

We can only see a rise in temperature during the oestrus cycle in this area with good blood circulation. In this surrounding area we determined the average temperature at five control points. On the left the results at the start of oestrus are shown, on the right the results at oestrus climax.

Very exact measurements are required to determine the surface temperature at these points. The surface temperature variation in the labia area is normally high (between 37.0 and 38.5 °C) when the selected area in all pictures is the same. The results show a possibility of oestrus detection using a non-invasive measuring system. They only indicate a trend. Further investigations with improved infrared thermography equipment are necessary. As a reference temperature for the body surface temperature measured with the infrared camera, we measured the same labia area with an infrared thermopistol at the same time. The results of these different measuring systems showing temperature change in the oestrus cycle are set out in Table 1.

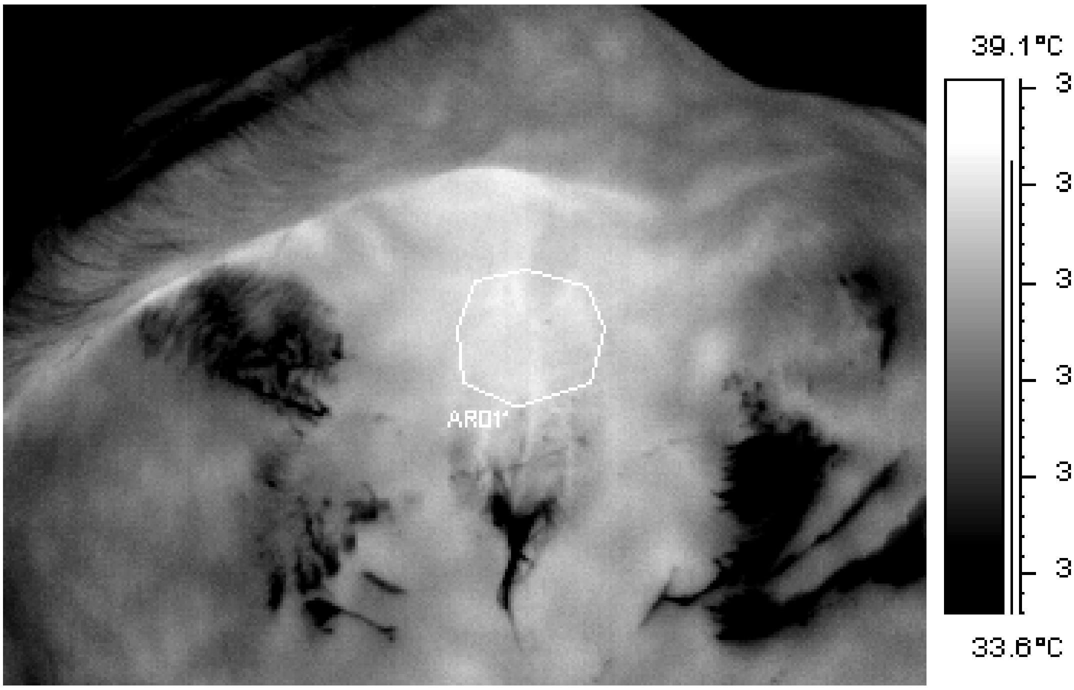


Figure 2: Thermal profile of body surface temperature at the labia area in oestrus cycle, with average temperature in this area at the start of oestrus climax on 30 July 2002

Tab. 1: Temperature results, measured with different systems for oestrus detection in dairy cows (test animal 5, date: 30 July 2002)

measurement system / **measurement time on 30th July**	04:00 a.m.	06:00 a.m.	08:00 a.m.	10:00 a.m.	12:00 a.m.
vaginal data logger **body core temperature °C***	38.1	37.9	38.1	38.6	38.6
infrared camera **body surface temperature °C****	37.9	37.9	37.8	37.6	37.6
infrared thermometer pistol **body surface temperature °C*****	37.4	37.6	37.7	37.8	37.4
	02:00 p.m.	04:00 p.m.	06:00 p.m.	08:00 p.m.	10:00 p.m.
vaginal data logger **body core temperature °C***	38.5	38.7	38.7	39.0	38.9
infrared camera **body surface temperature °C****	37.7	37.6	37.9	38.3	38.0
infrared thermometer pistol **body surface temperature °C*****	37.4	37.5	37.8	37.8	37.5

* absolute temperature (data logger) in vaginal tract
** average temperature (Thermacan PM 545) five control points in labia area
*** average temperature (Raynger MX 4) three control points in labia area

The body core temperature values are absolute temperatures. The results of body surface temperature obtained with the infrared camera and the infrared thermometer pistol at the labia area of the test animal are average values. No statistical calculations are available yet. The temperature measurements for the test animal presented here can be summarised as follows:

- The best time for insemination was the evening of 30 July with the high temperature period between

06:00 and 10:00 p.m. (oestrus climax = 39.0 °C at data logger; 38.3 °C at infrared camera; 37.8 °C at infrared thermometer pistol).
- We also can define the start of the artificial oestrus after Prostaglandin F² application as the early morning of 30 July, with a low temperature period between 04:00 and 08:00 a.m. (oestrus start = 37.9 °C at data logger; 37.9 °C at infrared camera; 37.4 °C at infrared thermometer pistol).
- The temperature differences between these measurement times are 1.1 K for the data logger , 0.4 K for the infrared camera, and 0.4 K for the infrared thermometer pistol.
- The temperature increase of 0.4 °C identified by infrared thermography technique is a good indication of changes in the body surface temperature in dairy cows showing oestrus or illness.
- The infrared thermometer pistol for monitoring body surface temperature will be an excellent system in future, when the equipment, the technique and the precision are improved. - This is a non-invasive method, inexpensive, and easy for the farmer to use. An ideal distance for measuring good temperature values is 2.0 to 4.0 m.
The results of this first basic research investigation are promising for establishing infrared thermography in diagnostics, for oestrus detection in cattle and for animal health. We plan further investigations with still better equipment.

Conclusions

-Infrared thermography show new ways for diagnostics in cattle such as oestrus detection, animal health, pregnancy, discovery of injuries and inflammations in animal bodies. In our project oestrus detection was the main aim of the investigation .
-We found precise indications of oestrus climax in five dairy cows with infrared thermography pictures of the external vaginal area and with data logging of body core temperature. The 6th test animal could not complete the investigation due to an udder inflammation after the start.
-A temperature increase of 0.4 °C at the vaginal labia was discovered with infrared photos (between 06:00 a.m. and 08:00 p.m.).
-Infrared thermography is a complicated, sensitive and very expensive system. At present it is not usable under real conditions in practice.
-The influence of atmospheric humidity, air temperature and air velocity is enormous, causing body surface temperature to change strongly.

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TECHNICAL-ECONOMICAL EVALUATION OF THE OVERLAY APPLICATION IN AGRICULTURE

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The paper presents the field tests results of chosen parts (exchangeable parts of the mouldboard) without and with overlays. During the tests the relationship between the single chosen parts wear and the plough operation time was watched. Using the in this way determined time behaviour of wear and the basic economical materials the average renovation and operation costs for each used chosen part were calculated. Using this criterion it is easy to compare single technical-economical solutions.

From the results of the carried out field tests it is evident that the use of the tested overlay type results in a considerable service life prolongation. With regard to the relatively low price of used coated electrode (280 CZK.kg^{-1}), to the low costs of used technology (method 111 according to CSN EN ISO 4063, 05 0011) and to the low filler material consumption (about 115 g per one part) the renovation costs were expressed in about 53 CZK. With regard to about three times higher service life of surfaced parts the result of the technical-economical evaluation is very positive – total costs are about 40 % compared with parts without overlay.

Keywords: wear, overlay, field tests, technical-economical evaluation

1 Introduction

Friction and wear are the most often cause of the agricultural technique operating parts premature outage. Many times the damage of only one part affects the shutdown of the whole assembly. Such parts are e.g. plough shares and exchangeable parts of the mouldboards. Minor or major economical losts are the consequence, especially using complicated machines. Therefore it is clear why the task of service life prolongation (or wear decrease) of exposed machine parts is in foreground. They are several possibilities of this problem solution. Technology of overlaying – making of special wear resistant overlay on the functional surface – is one of them.

2 Overlay application in practice

In practice the technology of overlaying is used by two methods:

- so-called "preventive overlays" – surfacing on the functional surfaces in the last sequence of the production (in the works); most often the deposit increases the wear resistance (Fig. 1), another reason can be e.g. the betterment of the corrosion resistance, of the increased temperature resistance etc.,
- so-called "renovation" – surfacing on the worn out surfaces (conventionally by the owner); the overlay fills up the lacked material.

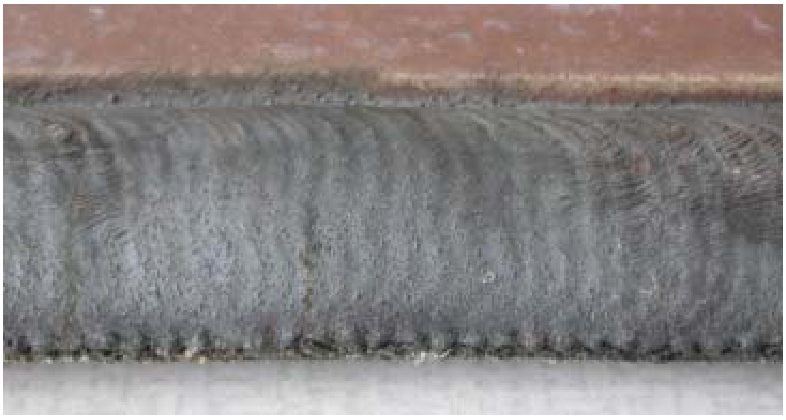

Fig. 1 The preventive overlay: the plough share and the detail of the overlay

Overlays can bring the considerable profit (if they are correct used), namely in fields:

- material and energy saving – the production of the new part is mostly more material and power consuming than the surfacing of worn out surfaces,
- the decrease in labour consumption – machining of functional surfaces after surfacing is mostly minor labour consuming than machining of all functional surfaces of the new part. In special cases the overlay can be used without surface working (e.g. at agricultural machines for soil treatment), or with only minimum finish (e.g. at free-hand grinding using the portable grinding machine),
- the increase in the service life of the surfaced part – from the offer of producers it is always possible to choose the suitable overlay material for concrete service conditions. Choosing the correct overlay material the higher service life of the surfaced part can be reached than that of the new part. In this way the changing frequency of worn out parts, the outage time at renovations etc. decrease.

3 Wear resistance evaluation of metallic materials

For wear resistance determination of single wear types it is in principle possible to use field or laboratory tests. Each of them has advantages and disadvantages and in this way the suitable field of use. Therefore the testing method of various types wear resistance must be chosen in view of dominant wear conditions and of demanded results.

Field tests are carried out in real material medium. They make possible to study and to evaluate the wear directly on machine parts of functional groups. But the results are often influenced by the variability of operation factors. The results are applicable only for the concrete engine plant or for the machine plant working under similar conditions. The wear study at field tests are often more costly and time consuming than at laboratory tests. On the basis of field tests statistic data processing the service life of single parts or functional groups is possible to predict.

The laboratory tests make usually possible to simulate only some of wear process parameters. Therefore their results are possible to be applicated in practice only after thorough analysis of real service conditions. But using laboratory tests the single factors influence on wear character and rate can be studied. Their advantages are usually minor costs and good test reproducibility.

4 Determination of service life of plough parts

Chosen part (exchangeable parts of the mouldboard) or plough share are a typical multistate element. In the course of growing amount of performed work (acreage of ploughed ground area) the change of structural and operating parameters occur. Significant and measurable external changes are:

- owing to wear the share blunts, the curve radius increases,
- the share width gradually decreases, especially in the fallow edge area,
- the share reduces gradually owing to the flank side friction against the soil,
- owing to wear in the fallow edge area and furrow nose the overall share length decreases,
- irreversible deformation occurs namely at the bouldery ground ploughing (bending of the nose or if need be of other parts of the edge),
- the breaking out of share parts occurs (braking out of the nose by the collision with a compact impediment etc.).

The most cogent progressive defect – abrasive wear of various share parts – is affected by several operating factors:

- owing to the blunting the cutting resistance (pull resistance) and the specific power consumption increases,

- as a rule the aggregate capacity decreases,
- the ploughing quality gets gradually worse, especially the plough sinking, the variation of the ploughing depth increases, the cutting of some weed roots gets worse etc.

In the costs area the following costs are connected with the production and with the operation of plough parts:

- production costs in the producer domain (pay, material, indirect costs), acquisition price in the user domain (production costs plus profit) indicated as N_c, CZK,
- costs of damaged for new or renewed share interchange, as a rule labour costs and indirect costs, indicated as N_v, CZK,
- outage time costs of the whole plough when changing shares, indicated as N_{pd}, CZK,
- costs of advanced energy owing to the share wear, indicated as N_e, CZK,
- labour and indirect costs owing to the loss of the plough capacity caused by the increased wear of the shares, as a rule labour and indirect costs (e.g. amortization of machines etc.), indicated as N_b, CZK,
- costs (losses) caused by the worse ploughing quality owing to the increased wear of the shares, indicated as N_o, CZK,
- overall costs owing to the share in case of its renovation, indicated as N_r, CZK,
- net book value of the share after the operating life ending (as a rule it is equal to the iron scrap price), indicated as N_{zu}, CZK.

After nearer considering of items it is evident that it is possible to divide them in two basic groups:

- costs of the own renovation N_o, expressed as

$$N_O = N_c + N_v + N_{pd} + N_r - N_{zu} \quad \text{CZK} \tag{1}$$

which do not change with the carried out labour (or ploughed area). The fact that they are constant means that the costs converted to ploughed area unit decrease with the increasing operating time,

- operation costs $N_P(t)$ expressed as

$$N_P(t) = N_e(t) + N_b(t) + N_q(t) \quad \text{CZK} \tag{2}$$

owing to increasing share wear these costs grow progressively; each next hectare of ploughed area is more charged.

From the analysis of costs defined by the equations (1) and (2) it follows that the problem of the quality evaluation divides into two phases:

- for concrete product (for concrete plough share, e.g. without and with the overlay) the finding of the optimum time of its renewal (interchange or repair) and in this way the determination of the operating life t_o and for each time the determination of the ploughed area unit costs for the renewal N_o and for the operation $N_P(t_0)$, or the determination of the average unit costs $u(t_0)$ for renewal and operation

$$u(t_o) = \frac{N_O + N_P(t_o)}{t_o} = \min \quad \text{CZK.ha}^{-1} \tag{3}$$

It is evident that t_0 is such a operation time (ploughed area value) when the function u(t) will reach the minimum value,

- from the data files of various evaluated plough parts (various size, material etc.) the finding of the optimum, when for the concrete share the value $u(t_0)$ is minimal – when the unit of ploughed area in the course of the share operating time is in general the cheapest.

Graphical interpretation of above mentioned relations is evident from Fig. 2.

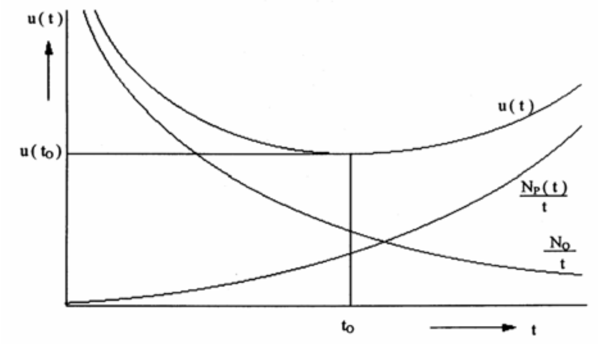

Fig. 2 Principle of the minimum operation and renewal costs $u(t_0)$ determination and its optimal operating life t_0

5 Test result and their discussion

The experiment was divided into two parts. In the first stage the field tests of chosen parts (exchangeable parts of the mouldboard) were carried out. The parts were tested without and with overlays. For the surfacing the ESAB coated electrode OK 84.78 of the nominal chemical composition 4.5 % C, 0.8 % Si, 1 % Mn, 33 % Cr was used. The tests were carried out using the seven-bottoms plough of an inland manufacturer. The ploughing was carried out in an extreme abrasive sandy soil containing arenaceous marl.

The tests results of the first stage are presented in Fig. 3. It is evident that the chosen part without the overlay were put out of operation after about 30/7 = 4.29 ha, shares parts with overlay after about 90/7 = 12.86 ha.

When we introduce the technical and economical data in the relations (1), (2) and (3) we calculate the average unit costs. The results are shown in Fig. 4. It is evident that the exchangeable parts of the mouldboard with overlay is from the technical and from the technical-economical point of view advantageous. It is caused by costs for overlay making – the price of the chosen part with overlay is about 40 % compared with parts without overlay. The operation time increase is about 3 times higher. On the basis of the field tests and of the technical-economical analysis for comparable conditions it is possible to recommend the overlay.

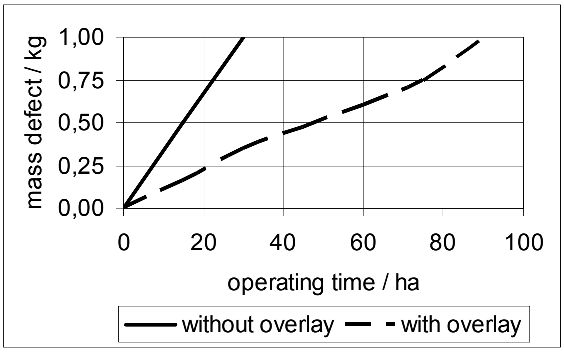

Fig. 3 Field tests results

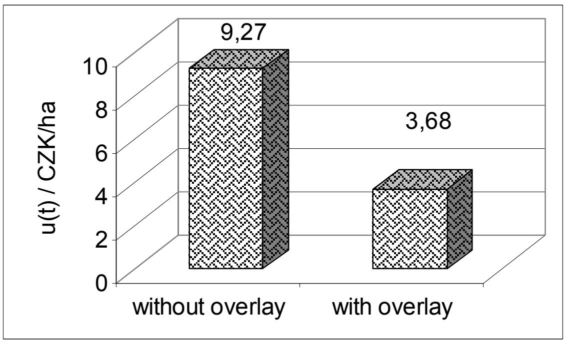

Fig. 4 Average unit costs u(t)

6 Conclusion

The paper contains the universally applicable method of the technical-economical evaluation of the machine parts without and with various overlay types. The example of the ploughing tests shows that the evaluation of the product quality cannot be performed only on the basis of its technical parameters. For the quality objective evaluation the economical parameters must be taken into account, too. Therefore the total technical-economical evaluation is necessary.

From the results of the carried out field tests it is evident that the use of the tested overlay type results in a considerable service life prolongation. With regard to the relatively low price of used coated electrode (280 CZK.kg^{-1}), to the low costs of used technology (method 111 according to CSN EN ISO 4063, 05 0011) and to the low filler material consumption (about 115 g per one part) the renovation costs were expressed in about 53 CZK. With regard to about three times higher service life of surfaced parts the result of the technical-economical evaluation is very positive (Fig. 4) – total costs are about 40 % compared with parts without overlay.

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IMPULSIVE EXCITATION OF ACOUSTIC VIBRATIONS IN HEN`S EGGS EXPERIMENTAL AND NUMERICAL STUDY

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Eggs were excited by the ball impact on the blunt side or the hip side or the equator, and the response signals were detected by the laser-vibrometers. The response wave signals were then transformed from time to frequency domain and the frequency spectrum was analysed. Relationship between the dominant frequency and the egg properties (mass, egshell thickness, eggshell stifness and egg shape) has been established. The numerical analysis of the egg impact has been performed using LS DYNA 3D finite element code. The main features of the used numerical model are discussed in details.

Keywords: egg dynamic resonant frequency numeric

Introduction

Dynamic excitation and response analysis is an acceptable method for determination of physical properties for quality evaluation of fresh products. Fruit response to impact and sonic excitation has been well documented in the literature for the last three decades; see e.g. Duprat et al. 1997. Many researchers have analysed acoustic impulse response in various kinds of products. This procedure has been also used for the study of the acoustic behaviour of the eggs (COUCKE et al. 1999,2003,KETALAERE et al. 2000,2003,SINHA et al. 1992). This research revealed that the acoustic response of the eggs to the impulse loading could be used for the identification of many physical properties of the eggs including the crack detection. Our research is focused on the performing of the common impact experiments with the aim of the numerical simulation of the egg behaviour under this kind of the loading. The reliable numerical model should very useful at least in order to minimize the number of the experiments.

In order to achieve these goals, eggs were excited by the impact of the steel ball on the blunt side, and the response signals were detected by the laser vibrometers at the different points on the eggshell surface. The response wave signals were then transformed from time to frequency domain and the frequency spectrum was analysed. The specific objectives of the research were to:
- analyse the response time signals and frequency signals of eggs
- to develop a finite element model of the egg .

Material and experimental method

Eggs were collected from a commercial packing station. The main properties of the eggs (length,width,eggshell thickness and mass) were presented e.g. in (BUCHAR et al. 2007a,b).

The measurement set-up is shown in Fig. 1 and has three major parts, namely the product support, the excitation device and the response-measuring device. When eggs were excited, the response velocity signals in time domain were detected, and MATLAB computer program was used to transform the response from time to frequency domain, by means of FFT. We then gained and analysed the dynamic response curves in the time and frequency domain of all the eggs, statistically. The experiments were conducted five replicates. After excitation experiments, the shell stiffness of experimental eggs was measured in egg equator orientation using a TIRA Testing Machine. Compression tests were conducted, the loading rate of the crosshead was 20 mm/min. The stress of eggshell rupture point (failure point) was used to evaluate the eggshell stiffness.

Experimental results and their discussion

Because the examples of the experimental results have been presented in some previous papers (BUCHAR 2007a,b) we limited our presentation to the main conclusions. The main response characteristics can be obtained in the frequency domain. The peak frequency (the response magnitude is the most, called as the dominant frequency) can be observed in the frequency domain . It has been found that the value of this frequency was independent on the positron of the point of the surfaře velocity detection.

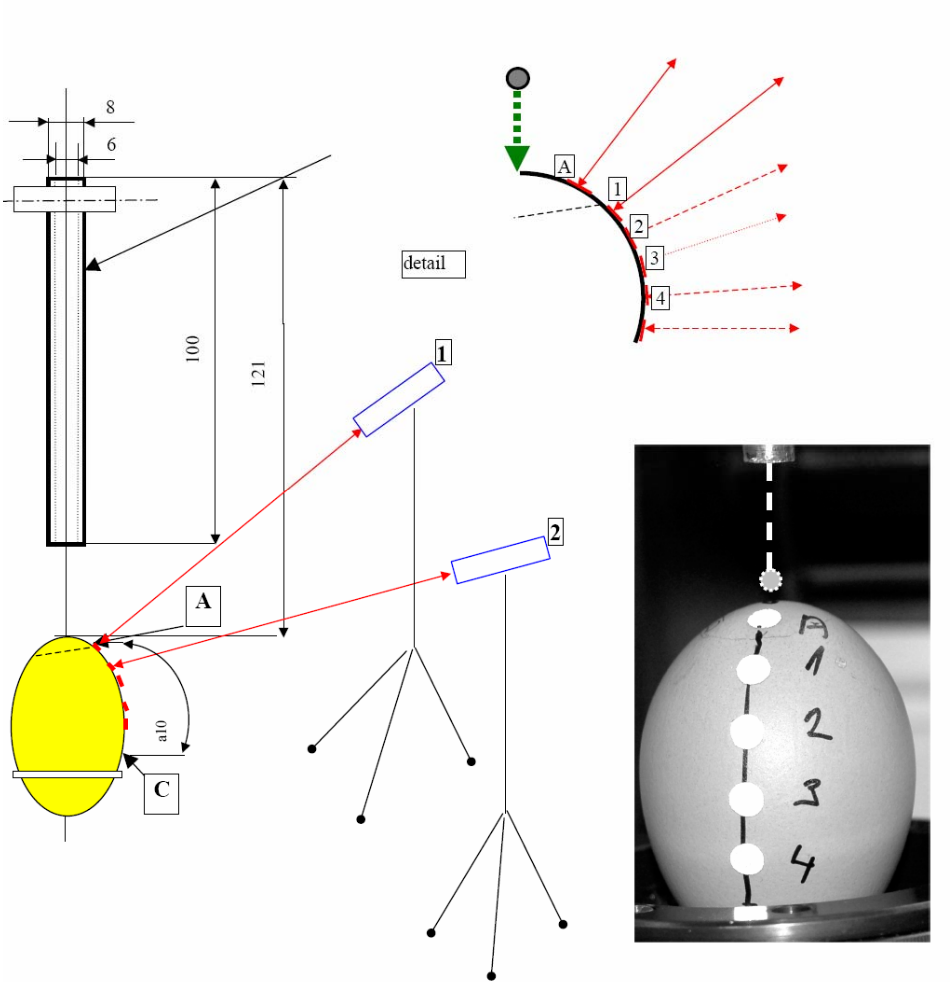

Fig.1. Experimental set up.(Positions A,1,2,3,4 are denoted as A0,A1,A2,A3,A4).

The dominant frequency was significantly affected by the shell stiffness, the egg mass, the egg shape and by the eggshell thickness. Preliminary results also show the great influence of the crack occurrence.The experimental data can be fitted by the following functions :

$$f = 3.92 + 0.063\sigma_m - 0.0017\sigma_m^2 \qquad R^2 = 0.8925 \qquad (1)$$

$$f = 1620.12 - 35.27m10.1865m^2 \qquad R^2 = 0.9107 \qquad (2)$$

$$f = 1652.83112.41t - 0.11t^2 \qquad R^2 = 0.9207 \qquad (3)$$

$$f = 1583.11 - \left(\frac{W}{L}\right)^2 \qquad R^2 = 0.9083 \qquad (4)$$

Where f is the dominant frequency (Hz), σm is the eggshell stiffness (MPa), m is the egg mass (g), t is the eggshell thickness (mm), W is the eggshell width and L is its length. Very similar results have been obtained in (   ).

Numerical modelling

In the first step a numerical model of the egg has been developed. This model is baesd on the following assumptions:

a) Eggshell is homogeneous isotropic linear elastic material. The properties of such material are described by the Young modulus E, Poisson ratio ν and material density ρ
b) Membranes are also taken as linear elastic material. No difference between membranes has been considered.
c) Air is considered as ideal gas.
d) Egg yolk as well as egg white are considered as compressible liquids

The next problem consists in the description of the egg shape. We have used a graphical user interface (GUI), which allowed the user to accurately determine the necessary dimensional properties of eggs from digital photographs of the eggs. The application required one measured dimension (the egg length, *L*, measured with vernier callipers), and calculated any user-defined distance on a digital egg photograph from the derived number of pixels per unit length. Based on a user-defined 2-D cartesian coordinate system, the coordinates of the required points were defined in a plane of symmetry. Based on a user-defined 2-D cartesian coordinate system, the coordinates of the required points were defined in a plane of symmetry. After this determination step, the egg contour was calculated . The counter is described by the function:

$$\rho(\phi) = 2.211320659 + 0.174969018\cos\phi + 0.3287435070\cos^2\phi$$
$$-0.1126432253\cos^3\phi +$$
$$+0.3596025314\cos^4\phi - 0.03193874987\cos^5\phi$$

Cross section of the used model is shown in the Fig.2. The elastic properties of the eggshell has been obtained using of the procedure developed in (BUCHAR and SIMEONOVOVA 2001). Elastic properties of the membranes weree determined by the method described in (BING FENG JU ET AL. 2002). The compressibility of the egg liquids was taken from the study (CHUNG, R. A., STADELMAN, W. J.1965). Parameters of the model are :

- Total number of nodes 141249
- Total number of solid elements 88050
- Total number of shell elements 46710

Numerical analysis has been performed by LS DYNA 3D finite element code The attenuation of the surface velocity along the meridian is shown in the Fig.3. The main decrease in the surface velocity has been observed for the transition from the air bubble to the egg liquid area. It means that the wave propagation in the eggshell is probably significantly affected by the interaction between the eggsshell and the egg white. The interaction between the single part of the egg is shown in the Fig.4. In this figure the time histories of the force interactions are plotted. The maximum force occurs for the interaction ball – eggshell (curve B). The curve A describes the interaction between the eggshell and membrane, The curve C describes the interaction between the membrane and the gg white. The interaction between the membrane and the air is negligible (curve D) By the more detail analysis has been shown a relatively very good agreement between experimental and numerical results. It means that the used finite element model can be used for the solution of some other problems mentioned e.g. in (WITTEL, F.K.ET AL. 2005)

.Fig.2. Schematic of the egg model used for the numerical simulation of the impact loading.

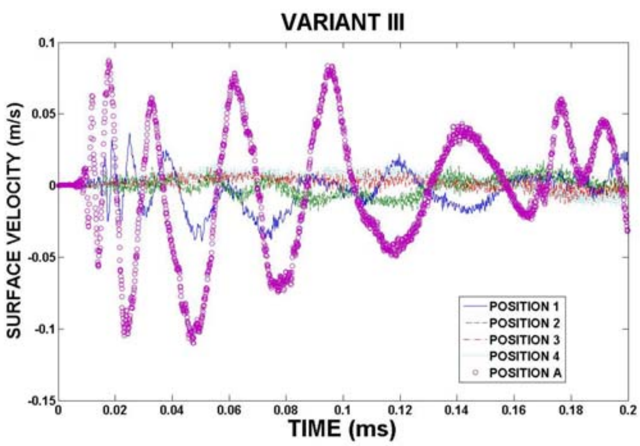

Fig.3. Numerical results.

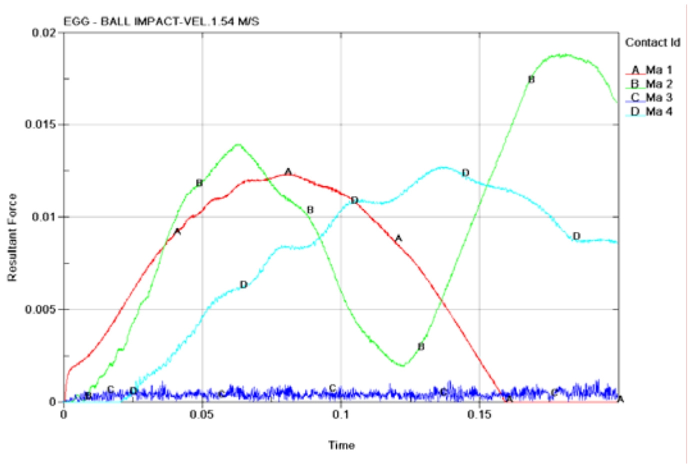

Fig.. The force nteraction betwen the single part of the egg.(time is in ms, the force is in kN).

Conclussions

The egg dynamic response to the ball impact has been examined both experimentally and numerically. The experiments revealed that there is a dominant frequency which is independent on the point of measurement. This frequency is in very good relation with some main egg characteristics (physical and geometrical). The relations given by the Eqs.1-4 should be futher verified by the next experiments. The numerical model of the egg has been proposed. Even if this model uses many simplified assumptions the good agreement between the experimental results and numerical ones suggests that there is a good chance to obtain reliable model. The proposed numerical model should be ablenot only to minimize the number of experiments but it could be also used to describe many others dynamic eggs loads. Its improvement will be also subject of the next research.

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THEORY OF THE SUGAR BEET ROOT CROPS VIBRATION DIGGING UP

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New mathematical model which describes process of a beet root crop direct extraction from soil, realized under act of vertical disturbing force and tractive effort which are transmitted the root crop from a vibration digging out end-effector is developed. The sets of differential equations which solution has enabled to determine the law of the root crop movement during its direct vibration extraction are received.

Keywords: sugar beet, root crop, vibration digging out end-effector, elastic medium, differential equations of movement, oscillation, amplitude, frequency.

Introduction.

Use of sugar beet root crops vibration digging up from a soil has a number of essential advantages in comparison with other ways. It is characterized by less damage of root, lowering of crop losses at harvesting, more intensive cleaning of root crops from the stuck soil, smaller blocking up of a digger working channel by soil and by plant residues. Therefore this technological process requires detailed analytical research, further development, and manufacturing application of advanced vibration digging out end-effectors.

Problem statement.

Theoretical studies of technological process of sugar beet root crops vibration digging up from a soil enable to justify scientifically constructive and kinematic parameters of vibration digging up end-effectors. Such investigations are necessary first of all for the theoretical analysis of vibration digging up end-effectors operation in adverse conditions, on heavy and hard soils where reliability of beet-harvesting machines operation essentially decreases. In turn the deep theoretical analysis of any technological process is possible only at presence of adequate mathematical models which describe the given process.

Analysis of researches and publications

Thorough theoretical and experimental studies of sugar beet root vibration extraction are richly described in [Vasylenko et al. 1970, Pogorelyy et al. 1983, Bulgakov et al. 2003, 2004, 2005, 2006].

Thus, in [Bulgakov et al. 2006] the process of a root crop extraction out from a soil is considered in most general case – at asymmetrical capture of a root crop by vibration digging up end-effector. This process is described by means of kinematic and dynamic equations of Euler. The set of differential equations received in [Bulgakov et al. 2006] describes spatial oscillatory process of the root crop fixed in the soil, as in the elastic medium, with one fixing point.

In present work the process of a root crop vibration extraction out from a soil is considered at symmetric capture of a root crop by both shares of vibrating digging up end-effector.

At such capture of a root crop by digging up shares the process of the further full extraction of a root crop out from a soil is possible. Therefore let's examine process of a root crop direct extraction out from a soil at its symmetric capture by vibration digging up end-effector.

Research objective

To develop mathematical model of a sugar beet root crop direct extraction out from a soil, realized under act of vertical disturbing force which is transmitted a root crop from vibrating digging up end-effector, and tractive effort which arises owing to translation movement of digger.

Research results

At first let's make the necessary formalization of technological process which will be considered. Despite the fact that process of a sugar beet root crop extraction out from a soil will take place in a short time interval (thus forward speed of root diggers can amount to 2 m/s) all process can be divided into the separate interconnected sequential operations conditionally. As was noted above, the extraction is possible only at symmetric capture of a root crop by the end-effector, and simultaneously with translation oscillations of a root crop its angular oscillations around of a conditional fixing point on some angle are occurs.

At the first stage of the extraction, and especially at the first oscillations, restoring force at angular oscillations, and so, and its moment concerning a conditional fixing point will be maximal. That's why the angle of inclination of a root crop will be sufficiently small and full (or partial) restoration of its vertical position owing to forward movement of the digger will be possible. Nevertheless, owing to action of root crop forward oscillations together with a soil surrounding it, the compactness of the soil will decrease, and restoring force at angular oscillations will be decrease too. So, with each following oscillation the angle of inclination of the root crop will increase, and restoration of the previous position – to decrease. The root crop will be loosened around of conditional fixing point with gradual increase of its inclination angle forward on a digger course. It will lead to the break of root crop connections with loose soil in the direction of digger's movement, beginning from the top part of the root crop conic surface, gradually approaching to its conditional fixing point. So as it was stated above it follows, that the destruction of root crop connections with a soil occurs simultaneously in two directions – along the forward digger's movement and in the direction perpendicularly to specified (along the full depth of the root crop arrangement in a soil). Thus the forces of root crop connections with a soil and elastic forces of a soil will gradually decrease to such minimal magnitude when oscillatory processes will pass into the processes of root crop continuous moving upwards and forward – along the translational digger movement, and also continuous root crop rotation around its the center of mass on some angle down to full root crop extraction from a soil. Elastic forces of a soil will pass in forces of resistance of loose soil at a root crop movement in a digger working channel. After that the stage of the sugar beet root crop direct extraction out from a soil is begun.

For developing of mathematical model first of all we shall make the equivalent scheme of a root crop interaction with working surfaces of vibration digging up end-effector at root crop direct extraction (fig.). Let's present a vibration digging up end-effector in the form of two coupled digging up surfaces (wedges) $A_1B_1C_1$ and $A_2B_2C_2$, each of which has some slope in a space under angles α, β, γ and which thus one to one are located, that the working channel is formed, the back part of it is narrowed. The pointed wedges realize oscillation movements in longitudinal-vertical plane (the mechanism of shares drive into oscillation movement is not shown), with corresponding amplitude and frequency. A direction of vibration digging up end-effector forward movement is shown by an arrow. Projections of points B_1 and B_2 to an axis O_1y_1 are designated by points D_1 and D_2 accordingly.

Let's consider, that the root crop interacts with surfaces of wedges $A_1B_1C_1$ and $A_2B_2C_2$ in the corresponding points. It is approximated by a solid of the cone-shaped form, and the capture of the root crop by end-effector occurs symmetrically from its both sides.

Let's assume further, that the working surface of the wedge $A_1B_1C_1$ realizes direct contact to a root crop in a point K_1, and the surface $A_2B_2C_2$ – in a point K_2. Lines lead through points K_1 and K_2 of a root crop contact and points B_1 and B_2 form at section with the sides of wedges A_1C_1 and A_2C_2 corresponding points M_1 and M_2. Thus, δ is dihedral angle ($\angle B_1M_1D_1$) between the bottom basis $A_1D_1C_1$ and the working surface of the wedge $A_1B_1C_1$ or accordingly a dihedral angle ($\angle B_2M_2D_2$) between the bottom basis $A_2D_2C_2$ and a working surface of a wedge $A_2B_2C_2$.

Let's show forces which arise owing to interaction of the root crop with vibration end-effector.

Let's from vibration digging up end-effector the vertical disturbing force $\overline{Q}_{tr}$ operates which changes under the harmonious law of the form:

$$Q_{tr} = H \sin \omega t$$

where H – amplitude of disturbing force; ω – frequency of disturbing force.

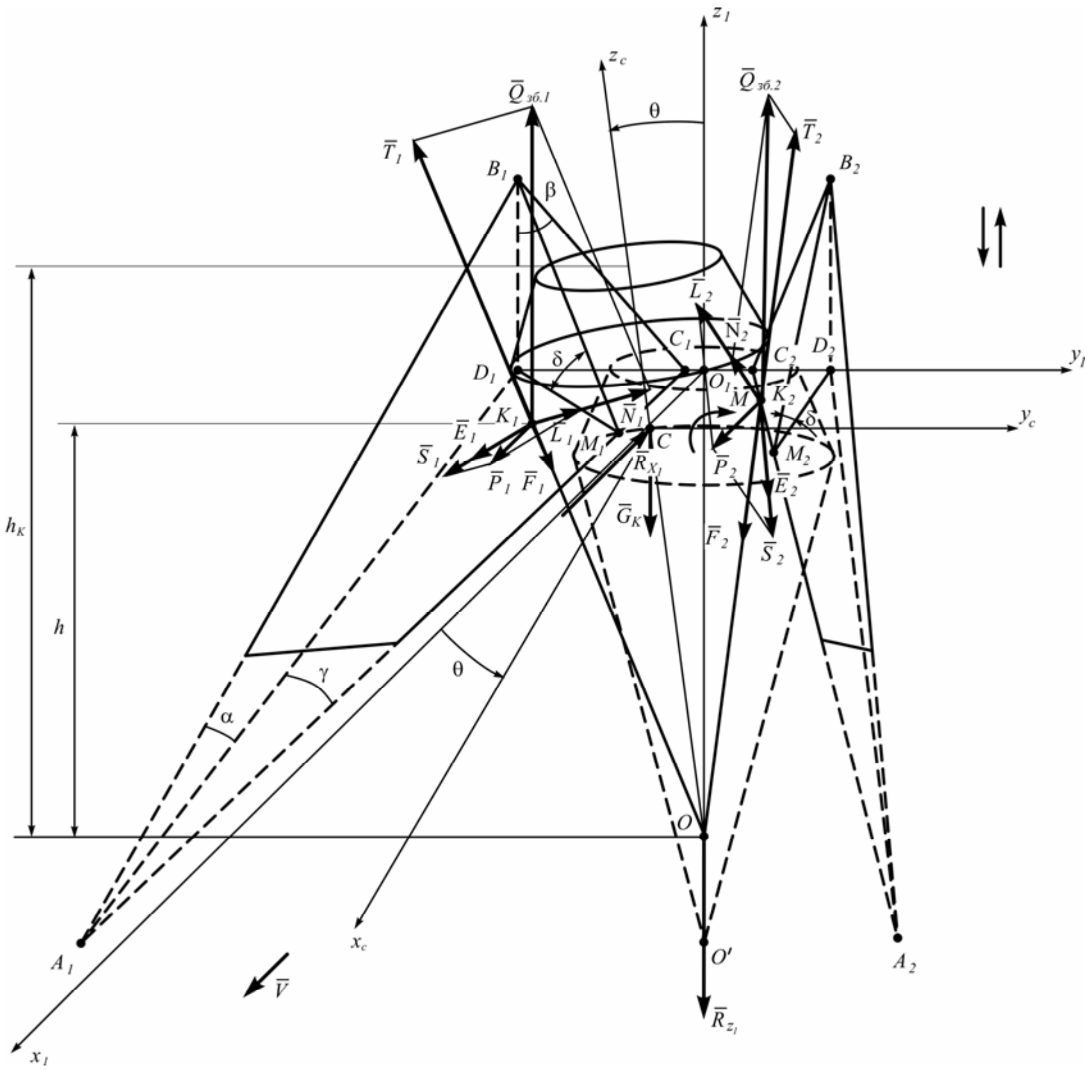

Figure The equivalent scheme of a sugar beet root crop vibration extraction out from a soil

This force plays the basic role during loosening a soil in the digger working channel zone and the root crop extraction. Specified disturbing force $\overline{Q}_{tr}$ is applied to a root crop from its two sides and on the scheme it is presented by two compounds $\overline{Q}_{tr.1}$ and $\overline{Q}_{tr.2}$. These forces are applied accordingly in points K_1 and K_2 on distance h from conditional fixing point O and they cause the root crop oscillations in longitudinal-vertical planes which destroy connections of the root crop with a soil and create for the root crop required conditions of extraction out from a soil.

As a capture of the root crop is symmetric it is obvious, that there will be a following correlation:

$$Q_{tr.1} = Q_{tr.2} = \frac{1}{2} H \sin \omega t \qquad (2)$$

Let's decompose given forces into normal $\overline{N}_1$ and $\overline{N}_2$ and tangents compounds $\overline{T}_1$ and $\overline{T}_2$, as it is shown on figure. As vibration digger moves forward in a direction of an axis O_1x_1 according to a root crop which is fixed in a soil and during the moment of capture of a root crop by the end-effector in the direction of an axis O_1x_1 motive forces $\overline{P}_1$ and $\overline{P}_2$ operate also. Let's decompose the forces $\overline{P}_1$ and $\overline{P}_2$ in two compounds: normal $\overline{L}_1$ and $\overline{L}_2$ and tangents $\overline{S}_1$ and $\overline{S}_2$ to surfaces $A_1B_1C_1$ and $A_2B_2C_2$ accordingly.

Besides in points of contact K_1 and K_2 forces of friction $\overline{F}_{K1}$ and $\overline{F}_{K2}$ act accordingly which counteract to a root crop sliding on a working surface of wedges $A_1B_1C_1$ and $A_2B_2C_2$ during its capture by vibration end-effector. Vectors of these forces are directed opposite to a vector of relative speed of a root crop sliding on a surface of wedges.

A root crop sliding on a surface of wedges can occur in a direction of forces $\overline{T}_1$, $\overline{T}_2$ action (parallel lines B_1M_1 and B_2M_2) and in a direction, opposite to the action of forces $\overline{S}_1$, $\overline{S}_2$, due to motion resistance force of a soil.

The vector of relative speed of root crop sliding on a surface of wedges can be decomposed into the compounds in the directions specified above. So, force of friction $\overline{F}_{K1}$ also can be decomposed in two compounds: $\overline{F}_1$ in a direction, opposite to vector $\overline{T}_1$, and $\overline{E}_1$ – in a direction of the vector $\overline{S}_1$.

Similarly, force of friction $\overline{F}_{K2}$ also can be decomposed in two compounds: $\overline{F}_2$ – in a direction, opposite to vector $\overline{T}_2$, and $\overline{E}_2$ – in a direction of the vector $\overline{S}_2$.

It is obvious, that $F_1 = F_2$, $E_1 = E_2$.

In the center of a root crop mass (point C) force of the root crop mass operates $\overline{G}_k$. Forces of resistance of loose soil at the root crop movement in a working channel of digger in a direction of axes O_1x_1 and O_1z_1 are designated through $\overline{R}_{x1}$ and $\overline{R}_{z1}$ accordingly.

At direct root crop extraction out from a soil the rotation of the root crop around its center of mass (point C) will be carried out under the action of pair of resistance forces of the loosened soil. We shall designate the moment of this pair of forces as M.

At direct root crop extraction it is possible to consider forces of resistance of the loosened soil dependent on speed of the root crop movement in the loosened soil or as a first approximation – simply constants. Therefore for simplification of mathematical model we shall consider the forces $\overline{R}_{x1}$, $\overline{R}_{z1}$ and the moment of pair M as constants.

Let's make at first the differential equations of movement of the center of a root crop mass (point C), i.e. forward movement of a root crop along axes O_1x_1 and O_1z_1. Considering the given above scheme of forces, the differential equation of movement of the root crop mass centre in the vector form at its direct extraction will be of the form:

$$m_k\overline{a} = \overline{N}_1 + \overline{N}_2 + \overline{L}_1 + \overline{L}_2 + \overline{F}_1 + \overline{F}_2 + \overline{E}_1 + \overline{E}_2 + \overline{G}_k + \overline{R}_{z1} + \overline{R}_{x1}$$

where $\overline{a}$ – acceleration of movement of the root crop mass center.

As the process of extraction as it has been specified above, occurs at symmetric capture of a root crop by end-effector, so the root crop movement along a working channel of the digger occurs actually in longitudinal-vertical planes (planes $x_1O_1z_1$) that is why the vector equation (3) is reduced to set of two equations in projections to axes Ox_1 and Oz_1.

After the definition of values of all forces which enter into the vector equation (3), and their projections to axes Ox_1 and Oz_1 we shall receive two following sets of differential equations:

$$\left.\begin{aligned}
\ddot{x}_1 &= \frac{1}{m_k}\left[\frac{\cos\delta\, tg\gamma}{\sqrt{tg^2\gamma + 1 + tg^2\beta}} + f\cos^2\delta\,\sin\left(\gamma + \frac{\alpha_{K1\max}}{2}\right)\sin\gamma + \right. \\
&\left. + f\cos\delta\cos\left(\gamma + \frac{\alpha_{K1\max}}{2}\right)\cos\gamma\right]H\sin\omega t + \frac{2}{m_k}\times \\
&\times\left[\frac{\sin\gamma\, tg\gamma}{\sqrt{tg^2\gamma + 1 + tg^2\beta}} + f\sin^2\gamma\,\sin\left(\gamma + \frac{\alpha_{K1\max}}{2}\right)\cos\delta + \right. \\
&\left. + f\sin\gamma\,\cos\gamma\,\cos\left(\gamma + \frac{\alpha_{K1\max}}{2}\right)\right]P_1 - \frac{R_{x1}}{m_k}, \\
\ddot{z}_1 &= \frac{1}{m_k}\left[\frac{\cos\delta\, tg\beta}{\sqrt{tg^2\gamma + 1 + tg^2\beta}} - f\cos\delta\,\sin\left(\gamma + \frac{\alpha_{K_1\max}}{2}\right)\sin\delta\right]H\sin\omega t + \\
&\frac{2}{m_k}\left[\frac{\sin\gamma\, tg\beta}{\sqrt{tg^2\gamma + 1 + tg^2\beta}} - f\sin\gamma\,\sin\left(\gamma + \frac{\alpha_{K_1\max}}{2}\right)\sin\delta\right]P_1 - \frac{R_{z_1}}{m_k} - g, \\
&\omega t \in \left[2k\pi, 2(k+1)\pi\right],\ k = 0, 1, 2, ...
\end{aligned}\right\} \qquad (4)$$

$$\left.\begin{aligned} m_k\ddot{x}_1 &= \frac{2P_1\sin\gamma\, tg\gamma}{\sqrt{tg^2\gamma+1+tg^2\beta}} + 2fP_1\sin^3\gamma\cos\delta + fP_1\sin 2\gamma\cos\gamma - R_{x1}, \\ m_k\ddot{z}_1 &= \frac{2P_1\sin\gamma\, tg\beta}{\sqrt{tg^2\gamma+1+tg^2\beta}} - 2fP_1\sin^2\gamma\sin\delta - G_k - R_{z1}, \end{aligned}\right\} \tag{5}$$

$$\omega t \in \left[(2k-1)\pi,\ 2k\pi,\ \right],\ k = 1, 2,...$$

Thus the set of differential equations (4) describes the process of direct vibration extraction of a sugar beet root crop out from a soil (i.e. a length on which a periodic disturbing force acts on a root crop), and the set of differential equations (5) describes the process of the root crop extraction out from a soil when it is not acted by a disturbing force. I.e. the same vibration digging up end-effector in the different time intervals can realize the process of the root crop digging up as usual share digger.

Let's solve the received sets of differential equations.

For the given sets of differential equations (4), (5) initial conditions will be the following: at t = 0:

$$\dot{x}_1 = 0, \qquad \dot{z}_1 = 0$$

$$x_1 = x_{10}, \qquad z_1 = -\frac{1}{3}h_k$$

The set of differential equations (4) is the set of linear differential equations of the second order. As it is known, it is solved in quadratures. For the simplification of the record set of differential equations (4) let's designate:

$$\frac{1}{m_k}\left[\frac{\cos\delta\, tg\gamma}{\sqrt{tg^2\gamma+1+tg^2\beta}} + f\cos^2\delta\sin\left(\gamma+\frac{\alpha_{K1\max}}{2}\right)\sin\gamma + \right.$$
$$\left. + f\cos\delta\cos\left(\gamma+\frac{\alpha_{K1\max}}{2}\right)\cos\gamma\right] = \phi_1, \tag{8}$$

$$\frac{2}{m_k}\left[\frac{\sin\gamma\, tg\gamma}{\sqrt{tg^2\gamma+1+tg^2\beta}} + f\sin^2\gamma\sin\left(\gamma+\frac{\alpha_{K1\max}}{2}\right)\cos\delta + \right.$$
$$\left. + f\sin\gamma\cos\gamma\cos\left(\gamma+\frac{\alpha_{K1\max}}{2}\right)\right] = \psi_1, \tag{9}$$

$$\frac{1}{m_k}\left[\frac{\cos\delta\, tg\beta}{\sqrt{tg^2\gamma+1+tg^2\beta}} - f\cos\delta\sin\left(\gamma+\frac{\alpha_{K1\max}}{2}\right)\sin\delta\right] = \phi_2, \tag{10}$$

$$\frac{2}{m_k}\left[\frac{\sin\gamma\, tg\beta}{\sqrt{tg^2\gamma+1+tg^2\beta}} - f\sin\gamma\sin\left(\gamma+\frac{\alpha_{K1\max}}{2}\right)\sin\delta\right] = \psi_2. \tag{11}$$

Considering expressions (8) – (11), the set of differential equations (4) will get the form:

$$\left.\begin{aligned} \ddot{x}_1 &= \phi_1 H\sin\omega t + \psi_1 P_1 - \frac{R_{x1}}{m_k}, \\ \ddot{z}_1 &= \phi_2 H\sin\omega t + \psi_2 P_1 - \frac{R_{z1}}{m_k} - g. \end{aligned}\right\} \tag{12}$$

Let's integrate the set of differential equations (12). After twofold integration and finding of any arbitrary constants we receive the following solutions of differential equations (4) in a final form:

$$\left.\begin{aligned} \dot{x}_1 &= -\frac{\phi_1 H}{\omega}\cos\omega t + \psi_1 P_1 t - \frac{R_{x1}t}{m_k} + \frac{\phi_1 H}{\omega}, \\ \dot{z}_1 &= -\frac{\phi_2 H}{\omega}\cos\omega t + \psi_2 P_1 t - \frac{R_{z1}t}{m_k} - gt + \frac{\phi_2 H}{\omega}. \end{aligned}\right\} \tag{13}$$

$$\left.\begin{aligned} x_1 &= -\frac{\phi_1 H}{\omega^2}\sin\omega t + \frac{\psi_1 P_1 t^2}{2} - \frac{R_{x1}t^2}{2m_k} + \frac{\phi_1 Ht}{\omega} + x_{10}, \\ z_1 &= -\frac{\phi_2 H}{\omega^2}\sin\omega t + \frac{\psi_2 P_1 t^2}{2} - \frac{R_{z1}t^2}{2m_k} - \frac{gt^2}{2} + \frac{\phi_2 Ht}{\omega} - \frac{1}{3}h_k. \end{aligned}\right\} \tag{14}$$

Sets of equations (13) and (14) describe the laws of the speed change and the moving of the root crop mass centre during its direct extraction out from a soil. From the second equation of set (14) it is possible to define the time t of the root crop direct extraction out from a soil. For this purpose it is necessary to substitute in the left part of the specified equation the value $z_1 = 0$ and to solve the received equation according to t. As the equation is transcendental to receive analytical expression for definition t is impossible, nevertheless it can be solved on computer by means of known numerical methods. The calculated mean t_1 can be applied to the definition of the unit productivity for root crops digging up by vibration end-effectors.

Let's solve the set of differential equations (5). For the simplification of the given set record let's designate:

$$\frac{1}{m_k}\left(\frac{2\sin\gamma\, tg\gamma}{\sqrt{tg^2\gamma+1+tg^2\beta}}+2f\sin^3\gamma\cos\delta+f\sin 2\gamma\cos\gamma\right)=\psi_1', \tag{15}$$

$$\frac{1}{m_k}\left(\frac{2\sin\gamma\, tg\beta}{\sqrt{tg^2\gamma+1+tg^2\beta}}-2f\sin^2\gamma\sin\delta\right)=\psi_2'. \tag{16}$$

In view of expressions (15), (16) the set of differential equations (5) will get the form:

$$\left.\begin{aligned}\ddot{x}_1&=\psi_1' P_1-\frac{R_{x_1}}{m_k},\\ \ddot{z}_1&=\psi_2' P_1-\frac{G_k}{m_k}-\frac{R_{z_1}}{m_k},\end{aligned}\right\} \tag{17}$$

$$\omega t\in\left[(2k-1)\pi,\ 2k\pi,\ \right],\ k=1,2,...$$

After twofold integration of set of equations (17) and a finding of any arbitrary constants we shall receive denouement set of the differential equations (5) in a final form:

$$\left.\begin{aligned}\dot{x}_1&=\psi_1' P_1 t-\frac{R_{x_1}}{m_k}t,\\ \dot{z}_1&=\psi_2' P_1 t-\frac{G_k}{m_k}t-\frac{R_{z_1}}{m_k}t,\end{aligned}\right\} \tag{18}$$

$$\omega t\in\left[(2k-1)\pi,\ 2k\pi,\ \right],\ k=1,2,...$$

$$\left.\begin{aligned}x_1&=\psi_1' P_1\frac{t^2}{2}-\frac{R_{x_1}t^2}{2m_k}+x_{10},\\ z_1&=\psi_2' P_1\frac{t^2}{2}-\frac{G_k t^2}{2m_k}-\frac{R_{z_1}t^2}{2m_k}-\frac{1}{3}h_k,\end{aligned}\right\} \tag{19}$$

$$\omega t\in\left[(2k-1)\pi,\ 2k\pi,\ \right],\ k=1,2,...$$

Sets of equations (18) and (19) accordingly describe the laws of the speed change and moving of the root crop mass center during its direct extraction out from a soil at the absence of disturbing force action.

Let's set up the differential equation of the root crop turn around of its center of mass, or around of a conditional axis Cy_c which passes through the center of mass (point C) in parallel axis O_1y_1. According to [Butenin et al. 1985], the specified equation in a general view will be of the form:

$$I_{y_c}\frac{d^2\theta}{dt^2}=M_{y_c}^e, \tag{20}$$

where θ – an angle of the root crop turn around axis Cy_c; I_{yc} – the moment of inertia of a root crop concerning an axis Cy_c; $M_{y_c}^e$ – the rotary moment around of an axis Cy_c (the sum of the moments of all external forces which act on a root crop, concerning an axis Cy_c).

The moment of inertia I_{yc} of a root crop concerning an axis Cy_c is defined according to [Butenin et al. 1985] of such expression:

$$I_{y_c}=\left(\frac{3}{80}+\frac{3}{20}tg^2\varepsilon\right)m_k h_k^2. \tag{21}$$

Substituting expressions (2), (21) in the differential equation (20) and carrying out the necessary transformations we shall receive the (201) (20) differential equation of turn of a root crop around axis Cy_c at direct vibrating extraction out from a soil (i.e. at the action of disturbing force on it) which has the form:

$$\left(\frac{3}{80}+\frac{3}{20}tg^2\varepsilon\right)m_k h_k^2\frac{d^2\theta}{dt^2}=-H\left(-h_k+h-z_1\right)\sin\theta\sin\omega t+2P_1\cos\theta\left(-h_k+h-z_1\right)+$$
$$+2\left(\frac{1}{2}fH\cos\delta\sin\omega t+fP_1\sin\gamma\right)\sin\left(\gamma+\alpha_{K1\ \max}\sin\omega t\right)\cos\varepsilon\left(-h_k+h-z_1\right)\sin\theta+$$
$$+2\left(\frac{1}{2}fH\cos\delta\sin\omega t+fP_1\sin\gamma\right)\cos\left(\gamma+\alpha_{K1\ \max}\sin\omega t\right)\cos\gamma\left(-h_k+h-z_1\right)\cos\theta- \tag{22}$$
$$-M,$$
$$\omega t\in\left[2k\pi,\ (2k+1)\pi\right],\quad k=0,1,2,...$$

The differential equation of the root crop turn around axis Cy_c at usual extraction (i.e. at the absence of disturbing force), has the form:

$$\left(\frac{3}{80}+\frac{3}{20}tg^2\varepsilon\right)m_k h_k^2\frac{d^2\theta}{dt^2}=2P_1\cos\theta\left(-h_k+h-z_1\right)+2fP_1\sin^2\gamma\times$$
$$\times\cos\varepsilon\left(-h_k+h-z_1\right)\sin\theta+fP_1\sin2\gamma\cos\gamma\left(-h_k+h-z_1\right)\cos\theta-M, \tag{23}$$

$$\omega t\in\left[(2k-1)\pi,\ 2k\pi\right],\qquad k=1,2,...$$

Let's analyze the received differential equations (22) and (23). The differential equation (22) is nonlinear. It is possible to solve it by the approached numerical methods with application of computer, and for each step of application of numerical algorithm it is necessary to find magnitude z_1 from the second equation of set (14) for the corresponding moment of time t_k. The differential equation (23) which includes variable quantity z_1, is also nonlinear, and for each moment of time t_k the magnitude z_1 is necessary to define from the second equation of set (19).

Thus, it is finally possible to consider, that the mathematical model of the process of a sugar beet root crop direct extraction out from a soil at its vibration digging up is developed. The received results enable to define kinematic modes of root crops vibration digging up at the conditions of inviolate and constructive parameters of vibration digging up end-effectors.

Conclusion

1. Two sets of differential equations which describe plane-parallel motion of a root crop in a soil at its direct extraction realized under act of vertical disturbing force which is transmitted a root crop from vibrating digging up end-effector, and tractive effort which arises owing to translation movement of digger.

2. Solution given differential equations give an opportunity to find out the law of a root crop movement in longitudinal-vertical plane at direct extraction out from a soil.

3. The received results enable also to define kinematic modes of root crops vibration digging up reasoning from conditions not damage of root and to find rational constructive parameters of vibration digging up end-effectors.

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LOWERING NOISE LEVEL IN THE COMBINE HARVESTER

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The design process of the combine harvester's cabin should include acoustic criteria with regards to the standard based noise level on the driver's station. The paper presents the selection of insulation structures of acoustic panels for the prevalent sources of noise in the cabin. The proprietary concept of insulation structures of the absorption-reflexive panels certified for the distribution of relative acoustic insulation power has been proposed. The selection of insulation structures should be implemented exclusively with regards to the results of panels certification in the acoustic chambers.

Keywords: combine harvester cabin, acoustic insulation power, noise level

Introduction

The noise level in the combine harvester's cabin under fieldworks, measured on the operator's station, depends on the engine power produced, operating parameters and technical condition of the functional assemblies of the combine. The results of the published measurements of noise in the combine harvester's cabin are diversified within the range 82-95dB.

The application of individual noise suppression protections in the form of noise suppressing earlaps or elastomer inserts hermetically locking the hearing ducts is not successful. Such protections are slightly suitable in the course of fieldworks due to the necessity of hearing contact of the operator with the ambience and the necessity of recognizing the sound-based symptoms of combine operation.

The active methods of lowering the noise level include all the methods of reducing noise source emissivity. These measures force the modification of the combine harvester's design, which is a remedial action with regards to the errors committed in the phase of the criteria evaluation of the technical means designed. Therefore, the passive measures are undertaken, covering the introduction of sound-insulating structures, reducing the spread of sound waves. The measures are focused on the scope of designing the noise-absorptive-insulation cabins, adjusted to the capability of embedment thereof on the load-bearing structure of the combine harvester. These measures should be implemented with the comprehensive coverage for such issues as ventilation and air-conditioning of the cabin as the application of practices of opening the roof in the course of fieldworks simply frustrates and comprimises the results of all silencing measures [Cieślikowski 1995]. Taking into consideration the state of exceeding the allowable noise levels on the combine operator's station, the objective of the report has been put precisely, aimed at analysis of the amplitude-frequency spectrum of noise for the prevalent zones of emission in the cabin. The next step of works includes performing the acoustic calculations and the selection of insulation structures for the emission surfaces of the cabin.

Sound absorption issues in the cabins

In most cases, the combine harvester cabins may be qualified for the group of sound-absorptive developments, partly open. Usually, fragmentary silencing of the zone of the separation wall of the cabin and the combine engine compartment occurs. Also the level of noise penetrating into the cabin from outside through the tampered, thin layer cabin glasses is essential. The sound-absorptive structures applied should show a diversified character due to the necessity of using significant glazed surfaces of the cabin. The introduction of flat glasses deteriorates the cabin's acoustic climate through providing higher reflexiveness to the planes frequently parallel to one another. The activation of intense airflow in the ventilation ducts of the cabin deteriorates the image of efficiency of silencing measures in the cabin. Small volume of the cabin with relation to the space dedicated for operator's work is the essential difficulty in the process of arriving at the proper selection of the cabin's sound-absorptive structures and adopting the proper assumptions for elaboration of the acoustic design.

Acoustic parameters

In the first sequence, the measurements of noise level in the Z-058 combine operator's cabin applied to the determination of the emissivity of prevalent resources. These measurements were performed in the so-called close proximity zone of the source by means of making frequency analysis. It has been shown that the prevalent sources of noise is the zone of separation wall of the cabin in relation to the compartment of engine and transmission. The spectrum evaluation regarded the levels in the individual octave bands. The frequency analysis of the time runs of the acoustic pressure was performed with the use of the following apparatus: NABRA IV-SJ measuring tape recorder, Bruell-Kjaer BK 2133 analyzer, PC and printer. The BK 2133 analyzer is the frequency analyzer with constant bandwidth from the level of octave to 1/24 of octave. The analyzer includes the digital filters allowing real time analysis of signals with frequencies up to 22.4kHz. The spectrum analysis of noise for the zone described has been presented in the figure 1, while the time runs of the change to the sound level A have been shown in the figure 2, with the adoption of sampling time equal to 0,05s, frequency range 25Hz – 20kHz with the unitary record of 200 samples.

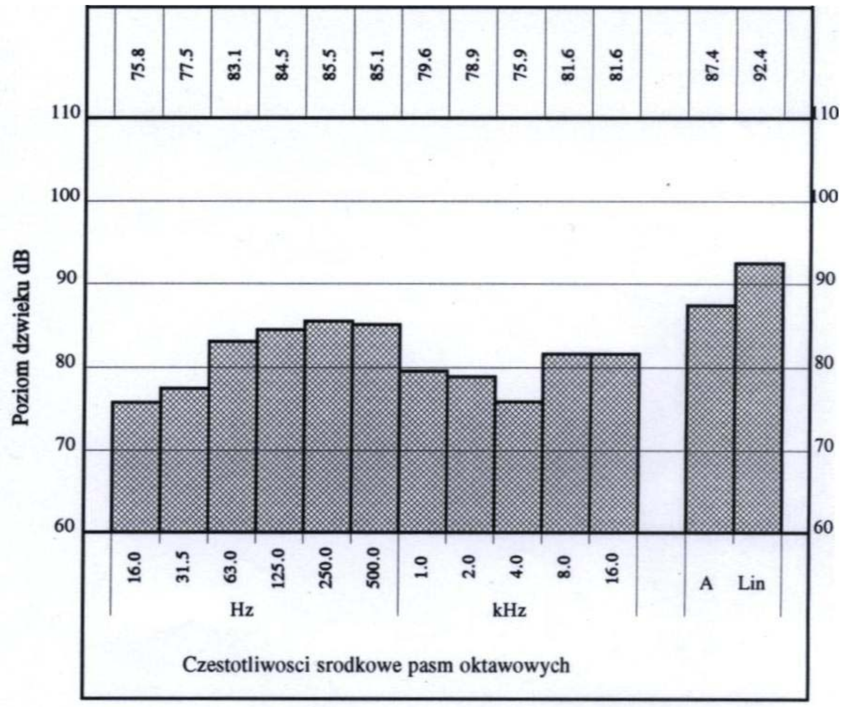


Fig. 1 Measuring sheet of the noise spectrum distribution in the zone close to the separation wall of the cabin and the engine chamber
Poziom dźwięku – sound level, częstotliwości środkowe pasm oktawowych – Central frequencies of octave bands

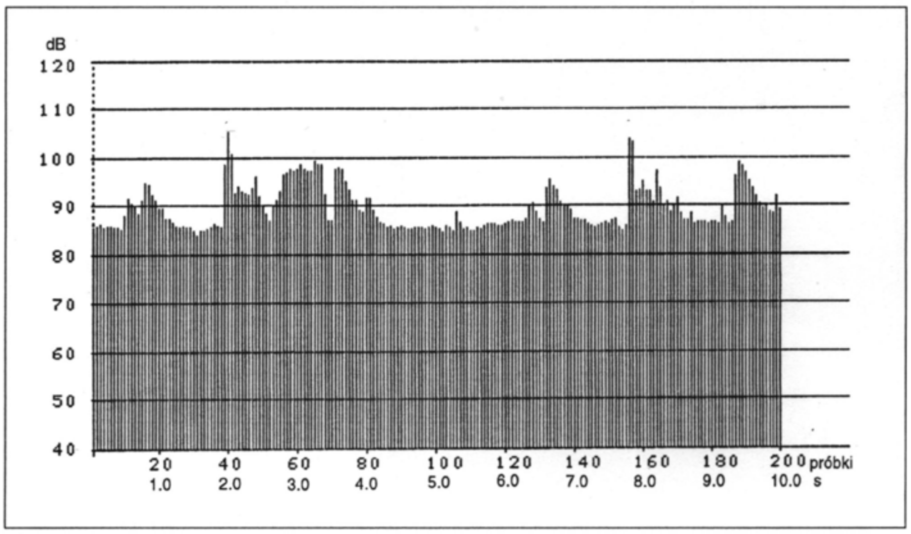


Fig.2 Changes of the sound level A in the function of sampling time
Próbki - samples

Acoustic calculations

Acoustic calculations have been performed due to the necessity of selecting the structures of a panel dedicated for installation on the separation wall, on the side of the engine compartment. The assumption was pertinent to the introduction of two structures of panels: noise absorptive and noise suppressive. The preliminarily scheduled criteria of the selection of the panels structures showed the necessity of achieving the big absorption factor α= 0.7-0.9 with multi-layer construction and non-flammability of materials.

Assuming the reference level as the average level of acoustic pressure, as determined by measurements in accordance with PN-84/N-01332, the required distribution of the average acoustic pressure in octave bands Lm1 corresponding to the noise level of 87.4dB(A), was obtained. This value was subsequently referenced to the level of acoustic pressure Lm2 in octave bands for the frequency corresponding to the standard-based level of sound A equal to 75dB in accordance with PN-84/N-01307.

The enclosure efficiency measure is the value of acoustic insulation power of the enclosure Dob determined in dependence on frequencies in octave bands:

$$D_{ob} = L_{m1} - L_{m2} + 5 \qquad (1)$$

The specific acoustic insulation power Rsw of the cabin walls was determined from the following equation:

$$R_{sw} = D_{ob} + 10\log\frac{S_{ob}}{S_{źr}}\ , \qquad (2)$$

where: Sob – enclosure area [m2],

Sźr –area of the prevalent source of sound emission [m2].

The acoustic insulation power of the silenced enclosure walls was arrived at with the use of the following formula:

$$R_{ob} = D_{ob} + 10\log\frac{S_{ob}}{A_{ob}}\ , \qquad (3)$$

The sound absorption Aob was adopted for the volume of the combine harvester cabin at the level of 4.35m2 [Engel 1993]. Taking into consideration the average sound absorption factor α=0,47 determined for the roof lining and the walls and floor of the cabin, we get Rob less than Dob by 3.4dB within the range of octave bands under analysis. The results of calculations have been presented in table 1.

Tab. 1. The results of calculations of relative sound absorption power of the panel Rsw p

f [Hz]	63	125	250	500	1000	2000	4000	8000
L_{m1} [dB]	83.1	84.5	85.5	85.1	79.6	78.9	75.9	81.6
L_{m2} [dB]	90	82	77	75	70	68	66	64
D_{ob} [dB]	-1.9	7.5	13.5	15.1	14.6	15.9	14.9	22.6
R_{sw}	7.2	16.6	22.6	24.2	23.7	25.0	24.0	31.7
$R_{sw\ p}$	12.5	18.9	32.2	42.1	46.0	49.0	47.7	43.4
ΔR_{sw}	5.3	2.3	9.6	17.9	22.3	24.0	23.7	11.7

Verification of calculations

The cabin partly locked shows the reduction of operator's protection efficiency from the noise. Therefore, it is beneficial to seal the zones of noise emission to the maximum extent possible by means of the floor panels and to replace the tempered glass with the VSG6.4mm safety glass with known distribution of acoustic insulation power in octave bands [Cieślikowski 2007]. The acoustic insulation power of the cabin, the necessary slots in adjusting the cabin to receive the passes for driving system, power hydraulics and braking system being preserved, may be arrived at from the following equation 1990]:

$$D_{ob} = 10\log\frac{F_C}{F_O} \qquad (4)$$

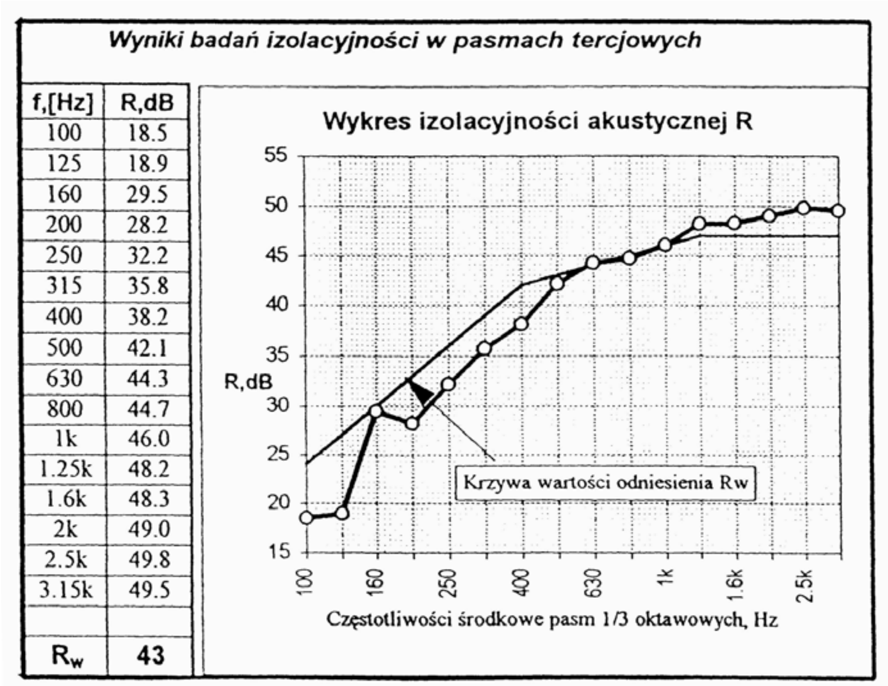
where: Fc – total area of cabin walls, including floor and roof [m2],

Fo – area of passes [m2]

Following inserting into the equation, the acoustic insulation power for the partly locked cabin under analysis was arrived at and is equal to 14,2dB. This value determines the efficiency of the cabin acoustic insulation with relation to the catalogue based insulation power of the structures applied.

Insulation structures selection

The selection of acoustic panels for the zone of the separation wall has been performed based upon the proprietary, material kit of panels previously subjected to certification in the acoustic chambers of the Vibration Acoustics Faculty of



f,[Hz]	R,dB
100	18.5
125	18.9
160	29.5
200	28.2
250	32.2
315	35.8
400	38.2
500	42.1
630	44.3
800	44.7
1k	46.0
1.25k	48.2
1.6k	48.3
2k	49.0
2.5k	49.8
3.15k	49.5
R_w	43

Fig.3. Catalogue sheet of the certification of insulation structure of the acoustic panel [Cieślikowski 1993].
Wyniki badan izolacyjności w pasmach tercjowych – Results of research into insulation power in third bands
Wykres izolacyjności akustycznej – Acoustic insulation power diagram
Krzywa wartości odniesienia – Reference value curve
Częstotliwości środkowe pasm 1/3 oktawowych – Central frequencies of 1/3 octave bands

AGH University of Science and Technology [Cieślikowski 1993]. The selection of the panel determines the necessity of obtaining the positive values of ΔRsw for each octave band.

The AR-40 absorptive-reflexive panel has been selected, with thickness 40mm, whose structure is as follows: perforated sheet (27.5% of solid sheet) on the side of the noise source, mineral wool ρ=120kg/m3, reticular absorbing agent, Keller slab, solid sheet on the side of the cabin interior. The distribution of the specific acoustic insulation power of the selected panel has been presented in the figure 3.

The slight surplus of acoustic insulation power of the panel Rsw panel with relation to the required insulation power of the enclosure Rsw encl is found for levels of frequency in the order of 63 Hz, difficult for suppression. In the remaining bands, the values of ΔRsw explicitly grow, which confirms the proper selection of the insulation structure.

Conclusions

1. The possibility of improving the acoustic climate in the driver's cabin of the Z-056 combine harvester has been shown, through adding the extra acoustic panel to the design of the separation wall of the cabin on the side of the engine compartment.
2. The selected insulation structures of the panel, complemented with the glazing from VSG safety glass (the subject of a separate report) provide for the standard based conditions of combine harvester operator with reference to the standard based levels of sound.
3. The cabin under analysis requires the essential design additions and verification of the design criteria adopted.

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CONSTRUCTION SOLUTION OF THE OUTRIGGER FOR THE LIFT TRUCK

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In the contribution there is described construction solution of the support outrigger intended for the lift truck D35. There is carried out strength and stiffness analysis for the proposed welded construction of the out digger. The results of the analysis serve as the background for the final selection of the solution of the outrigger.

Introduction

We will consider the lift truck which is depicted in the figure1. We will focus on the problem of the design of the outrigger for this lift truck. The outrigger is intended for manipulation with weldments in metal workroom. The manipulation includes various transportation during manufacture process and is terminated by operation of taking away the finished product from the workroom and placing it on the truck trailer or body of the lorry.

The outrigger is slipped over the fork arms of the truck. Set-out of the arm of the outrigger was required to reach 3 meters and maximum weight of the burden was required up to 350 kilograms.

There was made use of fork arm lift truck D 35 which is produced by DESTA factory which enables the load up to 3 tons as is shown on the figure Fig. 1.

This lifting truck was originally established mainly for universal manipulation with paletted material. There serves 45 kW power Compression Ignition engine (Diesel engine) as the Driving unit for the truck. Both The travel of the drive and operational hydraulic system of the truck is implemented by compact driving unit power plant which consists of combustion engine, hydrodynamic transducer, DESTAMATIC planetary reversal gear box of the type Power shift and powered axle with differential gear and break.

Fig. 1 Lift truck

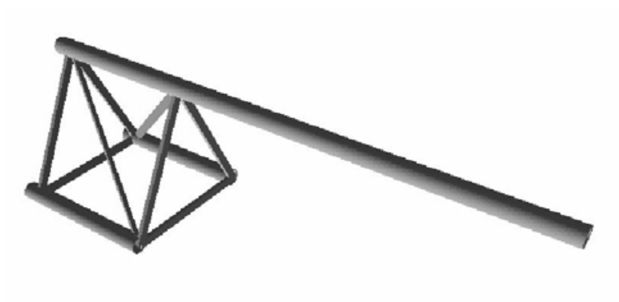

Fig. 2 Laid down adapter

2 Material and Methods

Adapter alternative 1 as is shown at figure 3 is welded from 3 tubes and 7 rod bar reinforcement pieces. The lower two tubes which serve for slipping over the fork arms have circular shape cross section (profile) with diameter D=127 mm. The thickness is t = 5 mm. The upper tube is thick-walled and has the diameter D=127 mm and thickness t = 20 mm. The reinforcement pieces are made of closed rectangular (dimensions 60 mm and 40 mm) hollow profile. The thickness of the reinforcements is t = 5 mm. The lengths of the parts of the construction is given on Fig. 2. The parts are made of steel σ_{Pt}= 360 MPa σ_{Kt}= 235 MPa.

There was required to perform the checkout firmness and stiffness calculation of proposed construction of the adapter for given values. The checkout calculation was performed with the help of computer software IDA Nexis. Fig. 3 shows the scheme of computer model and dimensions of the parts of the construction.

Next figure Fig. 4 shows the results of strength analysis. There are also depicted normal tensions. It can be seen from Fig. 5 that maximum value of normal tension is achieved in the upper tube (σ = 60 MPa). The values of tangent tension are very small in comparison with normal tensions (τ_{max} = 2,8 MPa) and can be omitted.

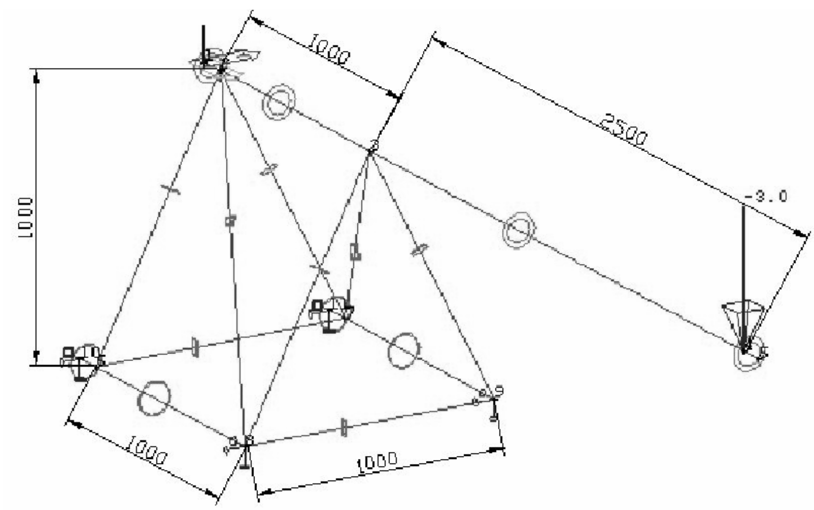

Fig. 3 Scheme of the adapter with dimensions

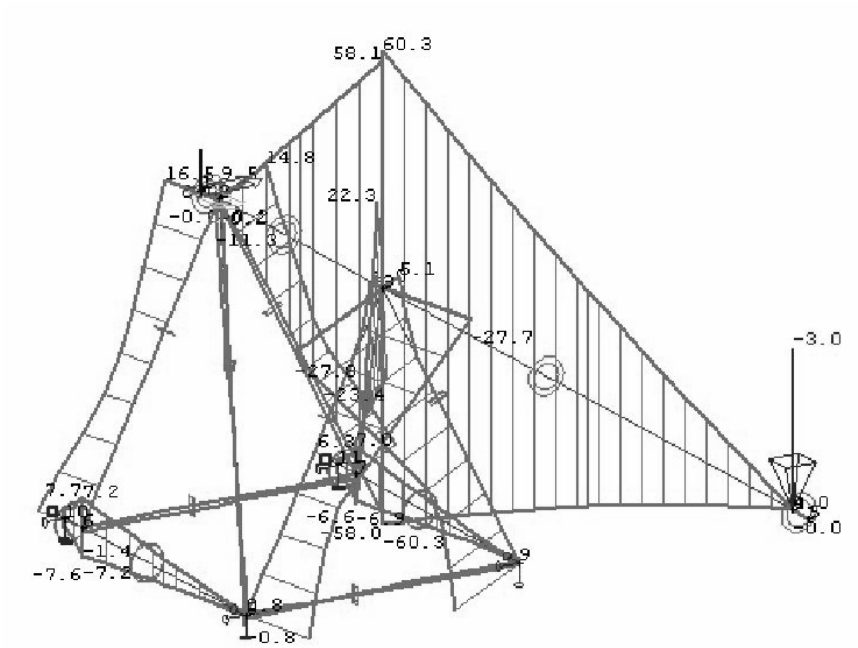

Fig. 4 The results of the strength analysis of normal tension of the parts of the adapter (The tension in MPa) –alternative 1

In the course of solution of above mentioned problem there was considered one more construction variant. This variant enabled to lower strength in the upper tube of the adapter. This construction possibility (variant 2) is displayed on figure Fig. 5. Following Fig. 6 shows strength analysis for this construction. There was lowered the value of normal tension to one half (σ = 30 MPa) in this variant.

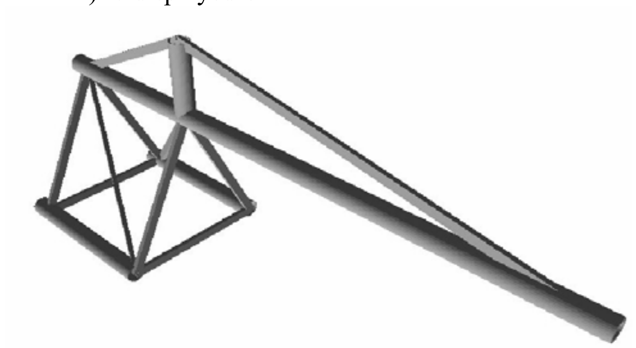

Fig. 5 Computer model for construction variant 2

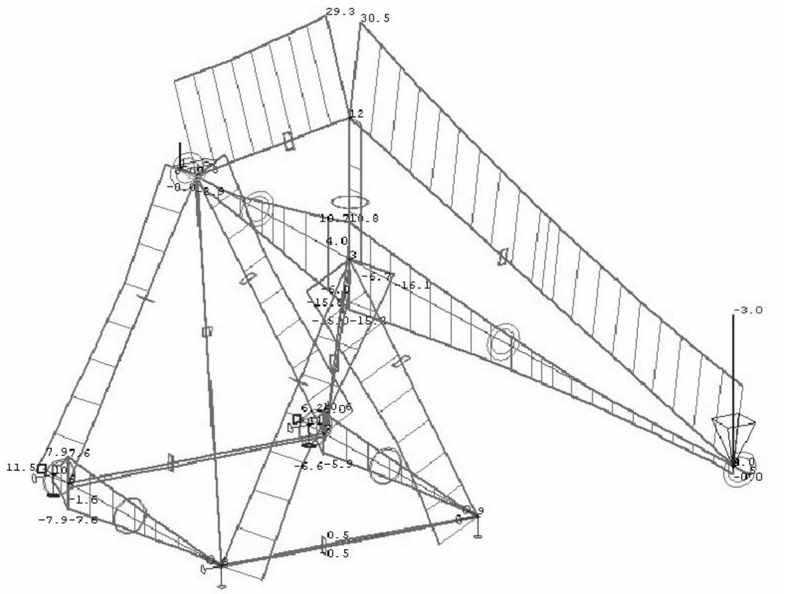

Fig. 6 The results of the strength analysis of normal tension of the parts of the adapter (variant 2). The tension is in MPa.

Fig. 7 Lifting truck with the adapter–alternative 1

4 Discussion and conclusion

The was decided to choose construction variant 1 for the production of the initial model as there were included and considered other mainly technological and operating reasons (Fig. 7). Strength and stiffness analysis carried out with the help of the program IDA NEXIS is adequate from the point of view of strength sufficiency. It was fully proved by compliance tests. Designed and installed device can be well managed and device also fulfils operating conditions for weldments production and manipulations with weldments in the hall with limited range of built in lifted technology. The designed device is sufficiently mobile and after finishing required work it can be simply placed to designated place.

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ALTERNATIVE AND RENEWABLE FUELS FOR ENGINES

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Development of engines is not only question of technical and power parameters. It is also problem of fuels development. On engine fuels are posed not only energetical and economical requirements, but also environment protection requirements. Demands on quality of engine fuels increase from ecology standpoint, general safeness, mainly fire safety, reliability and safety during service life of engines etc. New strict legislative emission standards of internal combustion engines require conformation and monitoring of qualities of engine fuels. The reserves of fossil fuels or crude oil and natural gas are exhaustible. Replacing existing conventional sources of energy or fuels for combustion engines becomes an urgent task. Unconventional power sources are mostly ecologically clean, reproducable power sources offer CO_2 neutral fuels. Renewable energy sources become object of a great intrest. Therefore it is purposeful enlarging the exploitation of renewable energy sources as a supplement of classical power sources.

Key words: fossil fuel, alternate fuel, combustion engine, environment

1 Introduction

Crude oil is exhaustible and limited source. Any kind of engine fuel is not nowadays and in foreseeable time available in quantity which could compete with crude oil. Sustainable development must ensure the crude oil will be available for the next generations, therefore there are searched further sources of fuel for drive engine vehicles. For utilize other power sources are demanded technical changes, which in some cases may be made relatively easily. Requirements on fuels depend on energetic, economic and ecological standpionts.

The possibility of replacing by classical fuels at the combustion engines by alternative fuels begins with using of combustion engines from the beginning of development and design. Reason, why alternative fuel was examinated was different in each period for example - economic - solve substitute classical fuel by cheaper fuel, source - replacement of classical fuels in country which has not their own crude-oil production in period of petrolic crisis, ecological - decreasing production of harmful emission, etc.

2 Review of internal combustion engine technology

Engines are designed to change chemical energy on mechanical energy. The reactants and endproduct mixture of an engine work directly with the piston. The reciprocating piston is in the cylinder and turns a crankshaft. The crankshaft delivers the power via flywheel and an output shaft to the load.

There are two basic types of engines used, the spark ignition and the compression ignition engines. Compression engines have more energy efficiency than spark ignition engines, they generally provide higher torque output and operate over limited engine speed.

In spark ignition engines the fuel and air mixed and then ducted in the engines cylinder. In the cylinder, the fuel/air mixture is compressed by pistons upward motion toward top dead center. The compressed fuel/air mixture is ignited by an external spark or spark plug. Burning, the chemical energy stored in the fuel realises.

In compression engines ingest only air ito the cylinders. The air is compressed to a high pressure and temperature in the cylinder by the piston. The fuel is injected directly into the high pressure and hot air inside the cylinder where it ignites and burns as it mixes with the air. No external spark is required for engine operation.

Engine parameters of interest are engine rpm, torque, power, specific fuel consumption. and mean effective pressure, The power output of an engine depends on the amount of energy in the form of a fuel, which can be changed by cylindres. The quantity of fuel that can be burned in the cylinder is limited by the mass of air that can be introduced.

Power boost accessories such as mechanical superchargers and turbochargers are frequently used on engines to provide a better balance betwen power and fuel economy. Supercharging can be used also to modify the torque characteristic. Supercharging and turbocharging greatly increase the power output of engine. Superchargers and turbochargers increase the effective volumetric efficiency and decrease the specific fuel consumption.

3 Fuels and their combustion

Commonly used fuels constitute accumulated solar energy whether solid fuel, liquid fuel or gaseous fuel. For example natural crude oil or natural gas, or fuels obtained by crude oil refining e.g. petrol and Diesel fuel. According to age they are fossil fuels, which come into definite geological stage e.g. crude oil, natural gas, transient fuels e.g. peat, and fuels all the time created by the help of solar energy it is biomass.

The combustion process consists in combining chemically oxygen from the air with carbon and hydrogen in the fuel. During combustion carbon and hydrogen burn to CO_2 and H_2O, generated heat and pressure increase. By imperfect combustion carbon burns to CO. The spark ignitron engine and the compression ignition engine produce the same emissions.

Properties required for petrol or gasoline fuel are - specific gravity, octane numer, anti-knock index, initial boiling point, final boiling point, volatility, vapour lock, ice formation, destillation, vapor pressure, sulphur content, gum content, heating valeus etc.

Properties required for Diesel fuel are - cetane numer, cetane index, heating values, volatility, viskosity, carbon residue, flash point, pour piont, cloud point, cold filter plugging point, waxing tendency, sulphur content, ash content etc.

Table 1 shows sales of selected engine fuels in Czech Republic, thous of tons.

4 Alternative fuels

Alternative fuels are fuels that can be derived from non crude oil or non petroleum resources. Alternative fuels can be produced from domestic resources and generally reduce engine emissions. Each of alternative fuels has advantages and disadvantages such as cost, compatibility with the engine, availability, vehicle modification, safety, storage, environmental impact, customer acceptance etc.

Problems of alternative fuels have been discussed for many years already. European Union supports using alternative fuels direction 2003/30/ES. Action programme of European committee shows strategy, how to achieve substitution of classical engine fuels (petrol and Diesel fuel) by the alternative fuels into of the year 2020.

Table 2 shows energetic share consumption of each fuel type for motor vehicles.

Motivational factors for formation of these initiatives are environment improvement, cut-down CO particular matters content in atmosphere, safeness of energy supplies or independence on crude oil. Significant arguments are the longer lifetime of natural gas reserves compared to crude oil and equable stock lay-out of gas fields in world.

Table 1 Sales of selected engine fuels in Czech Republic, thous of tons

Indicator	Trade name	2001	2002	2003	2004	2005
Diesel fuel		2 668	2 660	3 046	3 487	3 673
Unleaded petrol	Special OČ 91	316	221	193	180	149
Unleaded petrol	BA91D Normal	131	77	64	57	55
Unleaded petrol	BA95D Natural	1501	1658	1876	2004	1 893
Unleaded petrol	BA98+ Euro Super	25	20	25	26	19
Biofuel		207	225	219	145	9,8 x)

Biofuel – defined as fuel that is at least 90 % biodegradable in 21 days, where the fraction of acid methylesters must correspond to over 30 % of all substances contained in the biofuel.

x) Sales only within the period from 1. 7. to 31. 12. 2005. Between 1. 5. 2004 and 30. 6. 2005 Biofuel was not traded on domestic market due to unfinished legislation after accession to the EU.

Table 2 Energetic share consumption of each fuel type for motor vehicles

Year	Biofuels	Natural gas	Hydrogen
2005	2		
2010	6	2	
2015	7	5	2
2020	8	10	5

5 Fossil gas fuels

Gaseous fuels compared with liquid fuels they have some benefits:

- easily create homogenous fuel/air mixture with air, which burns better and uniformlier
- during the work, the deposits are smaller, the engine lubrication oil does not come to thin and the engine service life increases
- soft combustion lowers total engine-noise level
- after outflow do not pollute soil not even waters
- longer service life of engine and oil

5. 1 Liquifield petroleum gas

Although the LPG propulsion is price and ecological favourable, we can not expect that would get dominant position as combustion engines fuel.

Table 3 shows comparison of methane, propane and butane.

5. 2 Compressed natural gas

From ecological and price reasons natural gas as an alternative fuel is favoured, it is also necessary to have in mind the fact that, its world's reserves outmatch reserves crude oil.

Table 4 shows comparison of LPG and CNG with petrol.

6 Boimass liquid fuels

Problems of biofuels have been discussed for years already, especially in relationship with energy yield, it has still the bigger attention. Transportation and stocking of fuels with addition of biofuels brings problms, which result from different characters of fossil fuel and of biological substance.

Benefits of obtaining engine fuels from biomass are for example:

- renewability and possibility of different utilization
- technology utilize are mostly generally known and investment is not very exacting
- ecological contribution, lower gaseous emission of harmfull pollutants and particles, noise, biological degradation of escaped fuels into environmental etc.

6. 1 Vegetable oils and their esters

Basis for production of fuels are plant oils. According to geographical position for these purposes are used oils pressed from seeds rape, soya, sunflower, maize etc. Modified, then are mixed with diesel oil, and the mixed fuel or biodiesel is done.

Table 5 shows comparison of rape oil and his methyl ester with diesel fuel.

Table 3 Comparison of methane, propane and butane

Parameter	Methane	Propane	Butane
Boiling point, ^{0}C	-161,5	- 42,1	- 0,6
Research octane number	above 150	112	96
Motor octane number	above 150	96	90

Table 4 Comparison of LPG and CNG with petrol

Parameter	LPG	CNG	Petrol
Density, kg . m^{-3}	540	140	750
Heating value, MJ . kg^{-1}	46,1	47,7	43,7
Overpressure in tank, MPa	0,4	20	0

Table 5 Comparison of rape oil and his methyl ester with diesel fuel

Parameter	Rape oil	Methyl Ester Rape Oil	Diesel fuel
Boiling point, ^{0}C	311	347	191
Cetane number	42,6	61,2	46
Heating value, MJ . kg^{-1}	40,4	40,6	44,5
Density, kg . m^{-3}	906,6	880,2	845,9

6. 2 Ethanol and methanol

Alcohols can be produced either from fossil fuels or by processing biomass, mostly crops e. g. corn, maize, potatoes, sugar beet, fruit, vegetables, wood or cellulose. Process of production of alcohol is known as fermentation on solutions of sugar. Liquid bio-fuel obtained by distillation then.

Table 6 shows comparison of alcohols with classic fuels.

7 Hydrogen

Utilization of hydrogen as combustion engines fuel also today inheres in axperimental phase. It is the cleanest and the most exacting fuel. While using as fuel it is impossibled impugn its contribution in particular in field of environment. In context with hydrogen propulsion its fuel cell, where electric energy is produced. Hydrogen can be also burnt directly in engine. Hydrogen can be produced by several methods. Exacting is the storage and transportation of hydrogen. Benefits of using hydrogen in engine vehicles have ecological character, because waste product is mainly water vapour. Fuel cell no-burden environment by heavy metal. Wide utilize of fuel cell is up to now obtained by economic costingness of production of hydrogen.

8 Environment and engine fuels

Internal combustion engine are in now a days one of dominant contaminator of environment. Gaseous emission and noise are barrier for provision well-being and healthy environment on many places. New synthetic engine fuels from organic material - crops and waste - are contribution from standpoint of environment protection. By using organic fuels which do not contain sulphur acid rains formation is limited. Preventing breakdown of organic material decreases production of greenhouse gases. Biofuels do not produce more carbon dioxide during combustion than it is content in plant used to thein production. Further development of engine fuels is question of broad discussion of workers in branch of engines or motor vehicles, engine fuels, environment, agriculture etc. Using of natural gas for vehicle propulsion can significantly no contribute to environment improvement, especially in towns. During operation on natural gas emissions of particular matters and carcinogenic matters are reduced. Using of natural gas is profitable in buses of public transport, delivery vehicles, traffic service, post, taxi service etc .

Table 7 shows trends of emission standards for gas engines CNG.

9 Conclusion

Energy resources are step by step going exhausted and demand on emission levels keeps on beeing strict. Increasing exploitation of renewable power sources, together with saving energy, is an important aim in the area of energetics and ecology. Which alternative fuel will obtain superiority is difficult to estimate today.

The effectiveness of different energetic sources for propulsion of engine remains inclined on the behoof of conventional fossil fuels. Liquid fuels are highly concentrated form of chemical energy storage. Replacing of classical engine fuels on base crude oil by alternative fuels to solve the problem in continuity with exhaustibility. Replacing of classical engine fuels other fuels means in most cases solving bigger or smaller technical and organizational problems. Replacing present engine fuels in next years should three technology - in present term horizon used biofuels, in medium term horizon natural gas, in log term horizon hydrogen and fuel cell.

Table 6 Comparison of alcohols with classic fuels

Parameter	Methanol	Ethanol	Petrol	Diesel fuel
Boiling point, ^{0}C	78,3	64,5	99,2	150
Heating value, MJ . kg^{-1}	26,9	21,3	43,7	42,5
Research octane number	106	105	79-98	

Table 7 Trends of emission standards for gas engines CNG

EURO/substance/unit	CO	NmHC	CH	NO_x	PM
	g . kW^{-1}.h^{-1}	g . kW^{-1}.h^{-1}	g . kW^{-1}.h^{-1}	g . kW^{-1}.h^{-1}	g . kW^{-1}.h^{-1}
EURO 3	5,45	0,78	1,6	5,0	0,16
EURO 4	4.0	0,55	1,1	3,5	0,03
EURO 5	4,0	0,55	1,1	2,0	0,02
Limits EEV	3,0	0,40	0,65	2,0	0,02

EEV – Enhanced Environmentally Friendly Vehicle
NmHC – nomethane hydrocarbons

In last years in connection with economic and ecological requirements endeavours to solving the problem not only in the area fuels, but also in area of transmission of power, hybrid propulsion and vehicles with fuel cell get more intensive. Direct combustion of hydrogen in engines for considerable complication with storage and refuelling liquid hydrogen will be in evident opposit in to former presumption, shifted on later period.

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REGIONAL MODELING OF GLOBAL SOLAR RADIATION DYNAMICS AS A FUNCTION OF GEOGRAPHICAL AND METEOROLOGICAL DATA OVER TURKEY

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A total of 96 empirical models in linear, quadratic, cubic, logarithmic, exponential and hybrid forms using geographical and meteorological data were compared to estimate monthly average daily global solar radiation on a horizontal surface for 159 weather stations in Turkey. As a function of sunshine duration only, Jin et al. (2005) model provided most robust performance based on the error statistics of the coefficient of determination (R^2), the mean percentage error (MPE), the mean bias error (MBE), and the root mean square error (RMSE). As a function of mean air temperature, precipitation, and sunshine duration, Chen et al. (2006) model gave best results. A comparison of observed and predicted monthly average daily global solar radiation for 35 sites typical of the major climate zones of Turkey had high R^2 values. Spatial variability in mean annual global solar radiation observed was mapped using universal (co-)kriging with the spherical semi-variogram model. Cross-validation statistics indicated that universal (co-)kriging was sufficiently reliable in prediction of spatial variability in global solar radiation across the country, particularly, in areas with a lack of incident solar radiation data.

Keywords: Global solar radiation; Empirical models; Universal kriging; Spatio-temporal modeling; Turkey

1 Introduction

Global solar radiation is the principal energy source that drives physical, biological and chemical processes such as snow melt, photosynthesis, evapotranspiration, and plant development as well as solar energy applications such as solar furnaces, solar collectors, photovoltaics, and interior illumination of buildings (Meza and Var 2000; Ulgen and Hepbasli 2002). Global solar radiation data are not readily available over vast and complex terrains due to mountainous nature and high maintenance cost of solar measurement devices despite spatial and temporal data needs of numerous users ranging from architects to ecologists. The amount of global solar radiation received by a given surface is a function of the geometry of the earth, atmospheric transmittance, geographical location, sun elevation angle, surface slope, aspect and elevation (Allen et al., 2006). Many empirical models have been developed to predict temporal and spatial variability in global solar radiation using single or multiple explanatory variables and parameters. Global solar radiation models constructed with multiple explanatory variables, therefore, may be inconvenient to use due to the lack of readily available data for variables required for the models to run. Stochastic geostatistical interpolation techniques (e.g., kriging, and co-kriging) create surfaces from measured points using their mathematical and statistical properties such as the extent of similarity, the degree of smoothing, the statistical distribution and the spatial correlation among the point data (Webster and Oliver, 2001). Such interpolation methods may be used to add a spatial dimension to the temporal dynamics of global solar radiation models.

The objectives of this study were to (1) compare and validate models selected to estimate monthly average daily global solar radiation on a horizontal surface; and (2) validate the models selected using an independent dataset of 35 stations typical of the major climate zones of Turkey; and (3) map spatial variability in observed global solar radiation by universal kriging based on 159 weather stations.

2 Data and methods

Daily global solar radiation on a horizontal surface is measured with actinographs at only 163 major weather stations across the entire area of Turkey of 780,580 km^2 by the Turkish State Meteorological Service (DMI) (Aksoy, 1997). The statistical quality control of monthly climate data from 163 weather stations between 1968 and 2004 for the empirical models was conducted based on the exploratory data analyses of Gaussian distribution, outliers, and missing values. Out of the

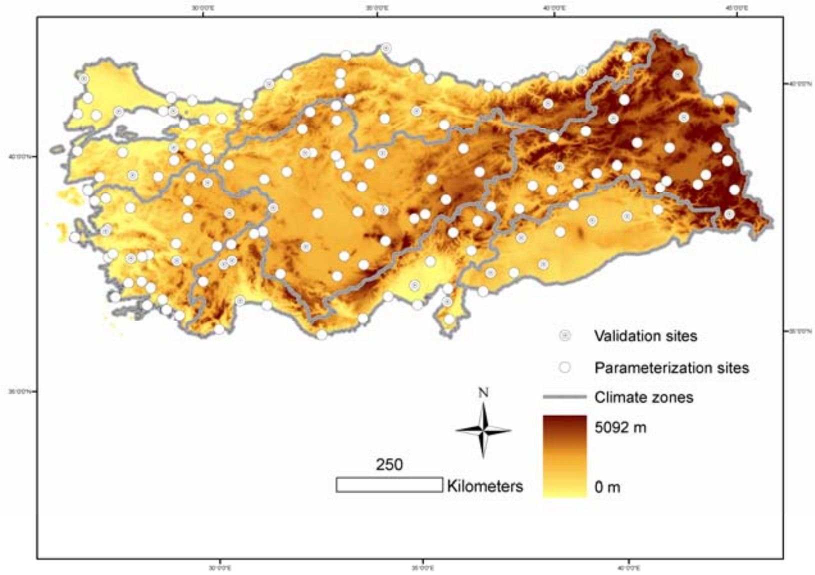

Fig. 1. Spatial distribution according to the climate zones of Turkey of major 159 weather stations used in the empirical models and universal kriging. Parameterization dataset of 124 stations was used to construct the models, and validation dataset of 35 stations was used to test the models.

163 weather stations, the geo-referenced datasets of the 159 locations were thus used in the temporal and spatial interpolations of global solar radiation. The assumptions of spatial autocorrelation and stationarity (fixed mean structure throughout the study region) were verified before the implementation of geostatistical interpolation by the exploratory data analyses of Moran's Index (I), and trend analyses, respectively. Only 159 weather stations have both global radiation and sunshine duration data between 1968 and 2004 and were used to estimate and map global solar radiation (Fig. 1).

A total of 18 models as a function of only sunshine duration and 78 models using a differential combination of 17 variables were selected from the literature and are presented in order of the linear, quadratic, cubic, power, exponential and hybrid forms (Ertekin and Evrendilek, 2007; Evrendilek and Ertekin, 2007). Explanatory variables embedded in the models include maximum possible sunshine duration, mean, minimum and maximum air temperature, soil temperature, mean and maximum relative humidity, precipitation, cloudiness, evapotranspiration, extraterrestrial radiation, day length, declination angle, day of the year, latitude, longitude, and altitude. The monthly average daily extraterrestrial solar radiation on a horizontal surface was calculated from the following equation (Duffie and Beckman, 1991):

$$H_o = \frac{24}{\pi} I_{gs}\, f \left[\cos\lambda\cos\delta\sin w_s + \frac{\pi}{180} w_s \sin\lambda\ \sin\delta\right] \quad (1)$$

where H_o is monthly average daily extraterrestrial solar radiation on a horizontal surface (MJ m^{-2} day^{-1}), I_{gs} the solar constant (1367 W/m^2), f the eccentricity correction factor, λ the latitude of the site, δ the solar declination, and w_s the mean sunrise hour angle for a given month. The eccentricity correction factor, solar declination and sunrise hour angle can be computed by Eqs. (2) to (4), respectively (Duffie and Beckman, 1991):

$$f = 1 + 0.033\left[\cos\left(\frac{360\, n}{365}\right)\right] \quad (2)$$

$$\delta = 23.45\sin\left[\frac{360(284+n)}{365}\right] \quad (3)$$

$$w_s = \cos^{-1}\left(-\tan\lambda\tan\delta\right) \quad (4)$$

where n is the number of day of the year starting from first of January. For a given month, the maximum possible sunshine duration (S_0) can be calculated using the following equation (Duffie and Beckman, 1991):

$$S_o = \frac{2}{15} w_s \quad (5)$$

The spatial variability maps of global solar radiation were generated on a 500 m x 500 m grid for 18 models using only sunshine duration and 5 km x 5 km grid for 78 models using 17 different variables using 159 weather stations using the ArcGIS geostatistical analyst module 9.1 (ESRI Inc., 2002).

Site-specific parameters of the empirical models were estimated using a parameterization dataset of 124 weather stations, while an independent dataset of 35 stations (22% of the entire dataset) typical of the major climate zones of Turkey was used for validation of the models according to Jackknifing procedure. The degree of model accuracy was quantified using the following six statistical indicators of (1) coefficient of determination (R^2, %); (2) the adjusted coefficient of determination (R^2_{adj}, %); (3) the mean percentage error (ME, %); (4) the mean bias error (MBE, MJ m^{-2} day^{-1}); (5) the root mean square error (RMSE, MJ m^{-2} day^{-1}); and (6) the relative percentage error (e), summed to calculate the MPE values, as follows (El-Metwally 2004; Almorox et al. 2005; Ertekin and Evrendilek 2007):

$$\mathrm{ME} = \frac{1}{N}\sum_{i=1}^{N}\left(\frac{H_{ip}-H_{io}}{H_{io}}x100\right) \quad (6)$$

$$\mathrm{MBE} = \frac{1}{N}\sum_{i=1}^{N}\left(H_{ip}-H_{io}\right) \quad (7)$$

$$\mathrm{RMSE} = \sqrt{\frac{1}{N}\sum_{i=1}^{N}\left(H_{oi}-H_{pi}\right)^2} \quad (8)$$

$$e = \left[\left(H_{ip}-H_{io}\right)/H_{io}\right]100 \quad (9)$$

where H_{io} is the ith observed value, H_{ip} is the ith predicted value, and N is the total number of observations. The MBE reveals whether a given model has a tendency to under- or over-predict, with the MBE values closest to zero being desirable. The RMSE provides a term-by-term comparison of the actual deviation between the predicted and observed values, with the lower RMSE values reflecting a better model in terms of its absolute deviation (Togrul and Togrul, 2002; Ulgen and Hepbasli, 2002).

The best-fit variogram model was chosen based on leave-one-out cross-validation and evaluated using the six error statistics of (1) the mean prediction error (MPE), (2) the root mean square prediction error (RMSPE), (3) the average kriging standard error (AKSE), (4) the mean standardized prediction error (MSPE), (5) the root mean square standardized prediction error (RMSSPE), and (6) R^2 as follows:

$$\mathrm{MPE} = \frac{1}{N}\sum_{k=1}^{N}\left(z_{ok}-z_{pk}\right) \quad (10)$$

$$\mathrm{RMSPE} = \sqrt{\frac{1}{N}\sum_{k=1}^{N}\left(z_{ok}-z_{pk}\right)^2} \quad (11)$$

$$\mathrm{AKSE} = \sqrt{\frac{1}{N}\sum_{k=1}^{N}\sigma(k)} \quad (12)$$

$$\mathrm{MSPE} = \frac{1}{N}\sum_{k=1}^{N}\frac{\left(z_{ok}-z_{pk}\right)}{\sigma(k)} \quad (13)$$

$$\mathrm{RMSSPE} = \sqrt{\frac{1}{N}\sum_{k=1}^{N}\left(\frac{\left(z_{ok}-z_{pk}\right)}{\sigma(k)}\right)^2} \quad (14)$$

where z_{ok} is the observed value at location k, z_{pk} is the predicted value at k through the ordinary kriging method, N is the number of pairs of observed and predicted values, and σ(k) is the prediction standard error for location k. Spatial cross-validation conducted assisted in the assessment of model accuracy by regressing observed versus predicted values. The MPE and MSPE indicate the degree of bias in model prediction and should be close to zero. The RMSPE and AKSE reveal the precision of prediction and should be equal to one another, with AKSE > and < RMSPE showing overestimation and underestimation, respectively. The RMSSPE compares the error variance with kriging variance and should be close to unity, with the RMSSPE values > and < unity indicating underestimation and overestimation, respectively.

3. Results and discussion

Exploratory data analysis showed that the observed data of global solar radiation for Turkey followed the Gaussian statistical distribution, with minimum and maximum values of 9.8 and 19.3 MJ m^{-2} d^{-1}, respectively.

The 18 models using only sunshine duration had ME of -10.1 to 64.9%, MBE of -0.1 to 9.0 MJ m^{-2} d^{-1}, RMSE of 1.4 to 10.0 MJ m^{-2} d^{-1}, $R^2_{adj.}$ of 92.0 to 94.2%, R^2 of 89.6 to 95.1% for validation, and e of -100 to 119%. Other 78 models had $R^2_{adj.}$ values of 22.7 to 96.5% based on the parameterization dataset. The error statistics of the empirical models for the validation were in the ranges of -14.1 to 0.3 MJ m^{-2} d^{-1} for MBE, -2.7 to 99.7% for ME, 1.4 to 15.3 MJ m^{-2} d^{-1} for RMSE, 0 to 99.8% for minimum e, 32.8 to 292% for maximum e, and 62.2 to 95.1% for R^2.

According to the sunshine based models, there were no significant difference in the error statistics and performance along the transition from linear to exponential empirical models except for the cubic models. The cubic models performed worst in terms of the ME, MBE, RMSE and e values ($P < 0.05$). Among the 78 models, the quadratic and cubic models performed best in terms of the MBE, RMSE, $R^2_{adj.}$, R^2, and minimum and maximum e values ($P > 0.05$).

The best performance of sunshine based models was achieved by Jin et al. model based on their error statistics and validation for the 35 stations typical of the major climate zones of Turkey. This model estimated monthly average daily global solar radiation values with relative errors less than about ± 25% of the observed values in 98% of the data points (n = 420). Our results revealed that Jin et al. model resulted in the best estimation of the monthly average daily global solar radiation on a horizontal surface for Turkey and can be used to reasonably estimate global solar radiation in areas with a lack of ground measurements.

According to the validation results of the 78 empirical global solar radiation models, the best performance was achieved Chen et al model in the estimation of the monthly average daily global solar radiation on a horizontal surface for Turkey.

The spatial distribution of long-term mean monthly global solar radiation in Turkey clearly revealed a strong latitudinal dependence, with the northern parts receiving less radiation than the southern parts. Spatial variability in mean annual global solar radiation was mapped using the spherical variogram model of universal kriging on a spatial scale of 500 m x 500 m grids for the entire Turkey. The range (*a*), sill ($c + c_0$) and nugget effect (c_0) values of the variogram parameters were 5.6 km, 2.49, and 1.67 for observed global solar radiation. The nugget effect of 1.67 for the variogram indicated the magnitude of local influences at short distances and uncertainty in interpolated values. The variogram anisotropy of global solar radiation showed a spatial correlation in the west-southwest to east-northeast direction with a specific angle of 250^o. Global solar radiation maps clearly indicate the locations of lows and highs over the long-term mean annual values in Turkey (Fig. 2).

The interpolated global solar radiation values were compared with the observed values at the station locations in order to quantify how accurate a randomly selected grid-point value was. The error of estimate (difference between estimated and measured values) for long-term mean annual values varied from -3.2 to 3.1. The errors greater than $\pm$ 3.0 occurred at six stations with a mean elevation of 1196 $\pm$ 644 m, higher than the mean elevation of the 159 stations of 707 $\pm$ 575 m. The relative percentage error (*e*) was less than 20% of the observed values at any randomly selected grid-point in 95% of the data points. The resulting cross-validation error statistics were -0.086 for ME, 1.48 for RMSPE, 1.49 for AKSE, -0.061 for MSPE, 1.00 for RMSSPE, and 36.7% for R^2 ($P < 0.001$) for the mean annual values observed. The low cross-validation errors reveal the significance of coupling the empirical global solar radiation models with geographical information systems (GIS) for accurate spatio-temporal estimations of global solar radiation over large territories with complex topography. However, a multitude of interacting factors other than sunshine hours, altitude, latitude, and longitude are involved in and need to be taken into account to quantify spatio-temporal dynamics of global solar radiation in complex terrains like Turkey (Baigorria et al., 2004).

To satisfy stationarity assumption (a homogeneous behavior on the structure of spatial correlation), the first order of trend removal was carried out for global solar radiation and elevation (the co-variable) before the implementation of universal co-kriging. The trends removed before the construction of the best-fit variogram models were added back to more accurately make actual predictions. The anisotropic spherical variogram model of universal co-kriging was selected as the best model to map spatial variability in mean annual global solar radiation on a grid resolution of 5 km x 5 km for the entire Turkey (Fig. 3).

As result of the spatial cross-validation, the interpolated global solar radiation values were compared with the observed values at the station locations in order to quantify how accurate a randomly selected grid-point value was. The MPE and MSPE values being close to zero indicate that the universal co-kriging prediction errors are

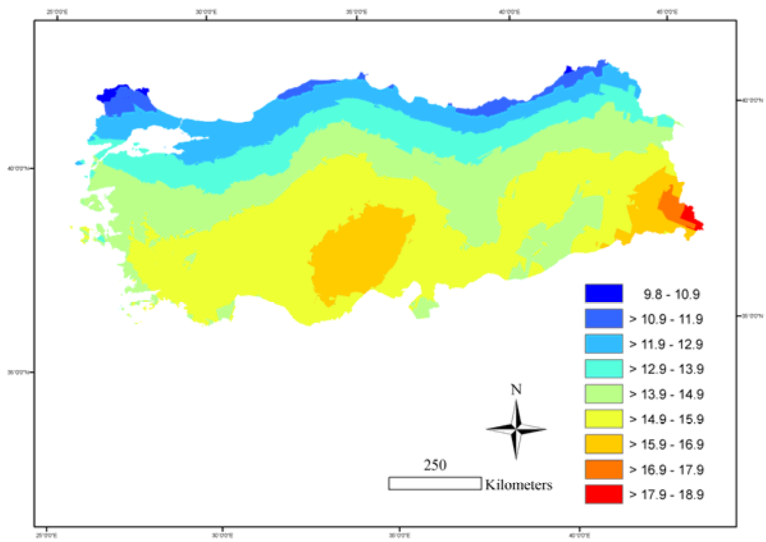

Fig. 2. Map of observed mean annual global solar radiation (MJ m^{-2} d^{-1}) based on the interpolation method of universal kriging on a 500 m x 500 m grid.

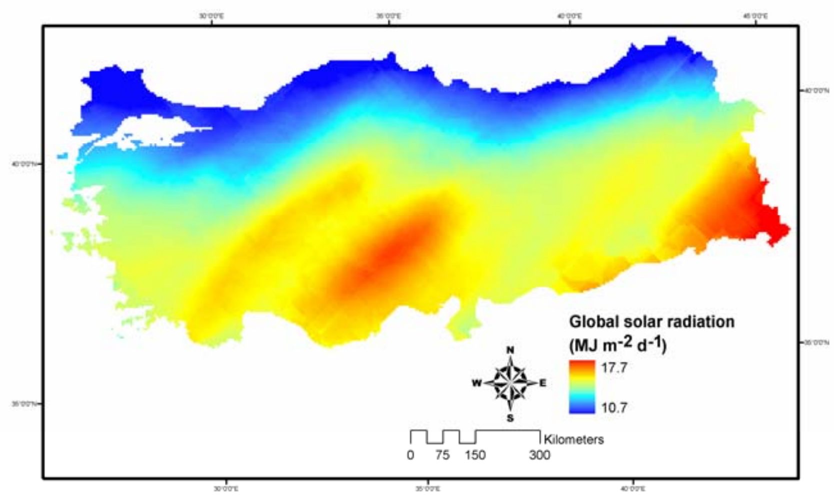

Fig. 3. Spatial interpolation of mean annual global solar radiation on a horizontal surface based on universal co-kriging, with a grid resolution of 5 km x 5 km

unbiased. The small RMSPE value points to the closeness of the predicted values by the universal co-kriging interpolator to the observed values. The similar values of AKSE (1.48) and RMSPE (1.43), and the RMSSPE of 0.97 being close to unity reveal the robustness of assessing the variability of the predictions from the observed values, with a slight indication of overestimation. Spatio-temporal coupling of the empirical and spatial interpolation models appears to be promising for accurate estimations of global solar radiation dynamics over large territories with complex topography.

4. Conclusions

Global solar radiation is one of the most important driving variables used in many mechanistic and empirical models and needs to be estimated indirectly from more commonly measured meteorological variables since these data are not readily available from most climate stations.

Given the low errors and robust performance in the validation, Jin et al. model using sunshine hours, altitude and latitude and Chen et al. model using maximum possible sunshine hours, extraterrestrial solar radiation, mean temperature, and precipitation reasonably estimated monthly changes in global solar radiation across Turkey..

Anisotropic spherical semi-variogram model of universal (co-)kriging was found to provide the best performance for the estimation of spatial changes latent in the dataset of mean annual global solar radiation over Turkey, a vast range of complex terrain, based on the low spatial cross-validation errors.

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DESIGNING THE MICROCLIMATE IN BUILDINGS FOR CATTLE

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A classical method is applied in designing the microclimate in inventory buildings. Its principle is based on the thermal balance in animal's compartments. It revealed a variety of both analytical and graphical methods. Thermal Properties Indicator (TPI) used in Poland is also its improvement. All those methods can be counted to a single group that uses a static model of heat exchange within the building. The model assumes a constant temperature of outer and inner air as well as heat exchange according to assumed conditions. In fact, all elements of heat balance are variable in time and heat exchange is according to unstable conditions. Method for designing the microclimate based on static-dynamic model as well as assumption of the method applying dynamic model of heat exchange was worked out at University of Agriculture in Lublin.

Keywords: expert system, preparation, fodder, beef cattle.

Introduction

The inventory building along with the animals and the outer environment is a complex dynamic system of elements bounded and changing in time. Microclimate resulting from the heat exchange processes between outer environment and a building, technological processes associated with animal maintenance, physiological processes as well as ventilation system operation is formed in halls for animals [Głuski T., 1999]. Microclimate is a resultant of such factors as air temperature and moisture content, content of hazardous gases in air, velocity of air movements as well as light. Complexity of that system makes that the problem of building designing from a point of view of microclimate shaping in animal's halls is a difficult and complex issue, and taking into account all elements, including on their variability in time, is almost impossible.

Elements influencing the microclimate in a building

Except from building's geometry, most of elements influencing on microclimate in animal's hall is characterized by changing in time. That variability may be relatively little and be of character similar to linear, e.g. daily gains of animal's body weight. It may also be of cyclic and curvilinear character, such as daily milk efficiency, which depends on lactation stage. However, changes of outer climate factors depending on daytime, season, and weather, are the most difficult to take into account.

Factors shaping the microclimate in animal's hall result from a continuous interaction of the following elements:

- **outer climate** consisting of air temperature and moisture content, but also wind force and direction as well as insulation is very important. These elements are changeable in time depending on a season, daytime, and current weather [Siarkowski Z., Głuski T. 2000]. It is not possible to estimate them with properly large time in advance, because even short-time weather forecasts are not always relevant, and referring to a particular building localization – even impossible.
- **livestock density** determining the quantity of heat, water vapor, and carbon dioxide emitted. The amount of heat emitted by animals depends on body weight, daily milk production, fodder caloric value, and air temperature in animal's hall. Cow's body weight increases up to reaching the total weight of adult age; milk efficiency depends on lactation stage of a dairy cow; temperature of animal's hall depends, among others, on the amount of heat emitted by animals.
- **inventory building** determining the loss of heat by penetration, which depend on functional and constructional solutions, existence of attic with litter and forage reserves as well as thermal properties of building barrier. Materials, the barriers are made of, are of great importance, because besides heat penetration coefficient value, it affects the heat capacity of building elements, thermal stability of animal's hall, and danger of water vapor condensation in barriers.
- **ventilation system** determining the loss of heat by ventilation. Solution of that system is a principal factor determining the amount of ventilation air, thus microclimate quality in animal's hall. In a case of gravitational

ventilation, the quantity of exchanged air is determined by the surface of inlet and outlet holes, difference of heights between them, difference of inner and outer air temperatures, wind force and direction, as well as regulation of hole's size using a sprocket.

Methods for microclimate designing

Methods of thermal sizing of inventory buildings [Wolski L. 1988] can be divided into prognostic-assumption and final. The former ones allow for estimating the inventory building's thermal status during making the technical documentation and help to set approximate initial data for designing.

– **Petit and Debruyckere's method** is a graphical mean that uses plots and nomograms presenting particular components of heat balance of classical method.
– **Bournas, Forget and Jonguoy's method** allows for initial estimation of heat amount that should be supplied to heated inventory building as well as to define the thermal isolation of outer barriers.
– **Wajdzik's method** is a graphical technique and plots make possible to evaluate the heat losses during ventilation depending on outer air temperature.
– **Method of inventory building's thermal shaping** was worked out by Wolski and it enables to determine the thermal characteristics of a building as well as to calculate average heat penetration coefficient for all outer barriers taking into account the building's shape.
– **Method of optimum self-heating course** was also worked out by Wolski. It considers building, technological, and thermal associations, which makes possible to programming the self-heating phenomenon before beginning of technical designing of an object.

Final methods provide making calculations of thermal sizing of inventory buildings both at the designing stage and during building's exploitation. These methods are based on the assumption of a constant heat exchange, which makes possible to compare the supplying and disposing heat streams.

- **Classical method** is a basic method that describes thermal processes in an inventory building assuming constant heat exchange. The principle is the equation of heat balance that compares the heat losses with the amount of heat supplied to a building. That balance equation reflects the thermal processes occurring in an inventory building.
- **WWT method (Thermal Properties Index)** was worked out by Wolski and it is the improvement of classical method. If heat surplus occurs during heat balancing process, a building reaches self-heating effect; if there are heat deficiencies, their ratio to total heat gains is important then. This problem was solved by defining the index of relative heat deficiency.
- **Simplified WWT method**, that is the modification of WWT itself. The simplification consists in quitting the calculations of heat losses due to ventilation by introducing the term of disposed heat. It is thermal energy stream that 1 DJP may dispose for covering the heat losses by penetration in a building.

Above methods present varied attempts to microclimate designing issue; they take into account different factors influencing on the microclimate, but use of the general dependence from classical method that compares heat gains and losses is their common feature [Głuski T. 2003]. All methods accept the assumption that heat exchange is in accordance to constant conditions, and tables, plots, and nomograms are used in order to simplify the calculations. Calculations are usually made for accepted outer air temperature (depending on the climatic zone) and accepted inner air temperature (depending on animal types).

The aim of study

The study was aimed at building the system for designing the microclimate in inventory buildings for cattle that would describe processes occurring in analyzed object as similar to the real ones under any environmental conditions as possible. The system takes into account the functionality of a building and air temperature in all its halls is determined for variable environmental conditions.

Method for calculating the temperature in a hall

The inventory building is a complex thermodynamic system of connected elements and air temperatures in its particular fragments continuously vary, which results from the tendency of the system to achieve the thermal balance due to changing environmental conditions. Above considerations reveal that heat balance and air temperature can be determined for a given moment for any compartment assuming that separate system tends to the balance, i.e. heat balance tends to zero.

General description of the system:

1. Accepting the values of parameters that describe building's outer climate taking into account daily oscillations. It refers mainly to air temperature and moisture content, wind force

and direction, insulation intensity, and any combination of these factors.

2. Accepting the time interval, the whole calculation cycle will be made for.
3. Setting predicted herd size and structure in analyzed calculation interval on a base of existing livestock density in a farm and its planned development, performance direction, purchase of a new material, etc.
4. Calculating air temperatures in all closed spaces of a building on a base of heat balance in those compartments.
5. Calculating the air temperature and moisture content in animal hall for every time interval on a base of heat balance taking into account the following:
   - Predicted variable parameters of outer air;
   - Designed herd size and structure as well as dairy production and body weight gains of particular animals;
   - Amount of ventilation air depended on parameters of inner and outer climate as well as type and geometric dimensions of ventilation devices.

Verification of the method

In order to verify the method, air temperatures measured in real object and calculated using worked out method were compared. Building for cattle localized in Niewęglosz was selected to study. It is free-stand cow-house with hall construction with no utility attic and natural ventilation system with crest gap. Temperature measurements have been made in all building's compartments as well as outside the building since 24.12.2002 till 13.01.2003. Measurements were made using temperature recorders programmed to record simultaneous measurements in 15-minute intervals.

Summary

The method for calculating the air temperature in particular parts of an inventory building was worked out. It enables to simulate the building's behavior from a point of view of microclimate in animal's hall for any environmental conditions and is a basis of a new attempt to design microclimate in buildings for cattle. Calculations make possible to take into account the air temperature in auxiliary rooms on a base of heat balance and taking into account the heat sources contained, namely the heat produced during milk cooling.

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A CONTROL SYSTEM TO ACHIEVE OPTIMUM SOIL WATER CONDITIONS FOR PLANT GROWTH

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In this paper, a drip irrigation control system based on measurements of soil water content has been presented. In order to achieve optimum soil water conditions, we have to place a moisture sensor within the zone of soil volume saturated by average soil water content. Concerning the deep root plants, the solution of installing two or more sensors, has been decided. The core of the control system is the unit IRCO-19. The control loop of embedded software is continually repeated, collecting new input values. In every measured value deviation from the requested limits of minimum (LVAL) and maximum (HVAL) soil water content, the control unit regulates on the electric valves of the drip irrigation system. The experimental validation of control instrumentation IRCO-19 was done in the area of Larissa (Greece) during the summer time of the years 2005 and 2006.

Keywords: Irrigation automation, soil moisture sensor, drip irrigation system.

1 Introduction

The relationship between crop production and the amount of irrigation water applied to the plants is very important. The aim of irrigation control is to avoid the detrimental effects of water stress on the plants and save water. Of course, the measurements of soil water content and the capability to control it, in order to achieve optimum water conditions for plant growth, is not a new idea. It is known and made more researchers to develop automated irrigation systems.

Since 1960 there is a continuous improvement in the efficiency of water use, which is accomplished by scheduling of the irrigation on basis of climate parameters, plant water potential and measured soil water content. Waugh and Corey (1963) and Painter (1966) describe different systems by which the plants could be grown at constant soil water content. Fischbach et al. (1970) developed an irrigation control system using tensiometers. One of the disadvantages of tensiometer is that it cannot follow rapidly changing soil water conditions. Phene et al. (1973) developed control for an automatic irrigation system with soil matric potential sensor that operates on the principle of heat dissipation rate in a porous block. Cuming (1990) developed an irrigation control system, which includes a soil moisture sensor that controls the common lines of various irrigation systems. A timer is activated whenever the soil moisture sensor placed in the root zone allows it to be watered. Frankovitch and Sarich (1991) developed an automatic plant watering system consisted of an electronic switching system that controls pumping time. The flow rate of water is controlled by a valve system. Stenitzer (1993) presented recommendations for irrigation scheduling with gypsum blocks. A pilot block placed 20-40 cm deep indicates the need for irrigation. A second control block, at a depth of 60-70 cm, signals percolation losses as a result of too high irrigation applications. Gypsum blocks have small sphere of influence and so give soil water measures in one spot. Malicki and Skierucha (1989) described the principle of operation of a simple, manually controlled Time Domain Reflectometer (TDR) for soil water measurements, which operates with needle pulse of 300 ps rise–time. Lukangu et al. (1999) obtained laboratory and field measurements of soil water content using a frequency-domain reflectrometry (FDR) sensor to predict the start and termination of irrigation.

The term "automated" irrigation applies to any irrigation system that is controlled by something other than the direct actions of a person. Typically it means any irrigation system where irrigation is initiated by a control system using operator settings and measured environmental conditions. Two general types of automated irrigation systems are used: i) open control loop systems and ii) closed control loop systems. Open control loop systems are constructed in such a way that an irrigation timer is used to start/stop irrigation. Operator makes the decision of the amount of water and the time that it should be applied. The first devices were composed of clocks that were converted to timers that controlled the electric valves. Today, several designs are commercially available with many different features and over a wide range of costs (Zazueta et al., 2002). The closed control loop systems have feedback for sensing equipments, make decisions and apply them to the irrigation systems. The general strategy is defined once by the operator and the control system takes detailed decisions on how much water to apply and when. The early generation of programmable controllers was complex and bulky. The most outstanding progress in the last decades occurred by the incorporation of integrated circuits (IC), which increased the capabilities of automation and reduced the cost. Programmable Logic Controllers (PLC) and industrial microcomputers replaced the early generation of controllers (Sne, 2005).

Numerous soil moisture-sensing instruments based on different techniques have been commercialised. Classical soil monitoring devices such as tensiometers and modified gypsum blocks are available along. The soil moisture neutron probe, based on neutron scattering by the hydrogen atoms of water, was developed about 40 years ago. However, due to the mounting pressure against the utilisation of any radioactive source, it is becoming increasingly difficult and expensive to use the neutron probe. More recently, non-radioactiv devices have been developed, including time domain reflectometry (TDR) and capacitance probes (CP). Both devices measure the dielectric capacity of moist soil in situ.

The objectives of this paper is to test whether the control system can achieve optimum soil water conditions for plant growth and close to a set point for a long period and within an acceptable range of the targeted values.

2 Materials and methods

The control system is based on data acquisition of environmental parameters, such as, soil water content and solar radiation. Therefore, this type of system requires feedback loop for sensing equipments (sensors). Depending on the feedback of the sensors, the irrigation decisions are made and actions are carried out if they are considered to be necessary. The decisions based on the comparison between the direct measurements of soil water content and a desired state. Figure 1 shows the block diagram of the automated control system, each of the hardware elements is described below.

The prototype of specially designed unit IRCO-19 that is solely dedicated to control task and is evolution of the device IRCO-09 is presented in Figure 2 (Gravalos, 2003). The core of the control unit is an Intel's microcontroller. It is a single CMOS 8 bits microcontroller with 128x8 RAM and 32 programmable I/O lines. Two other circuits, an address register and an external memory EPROM support the microcontroller. The control unit has 8 analog inputs and outputs for the connection of sensors and actuators respectively. Since, microcontroller works internally with digits, the analog output resulting from each soil water sensor must be converted to digital data. This is done through Analog to Digital (A/D) converter. The user can input the desired operation parameters by an array of 4 DIP switches. In those parameters, the minimum soil water limit (LVAL), the maximum soil water limit (HVAL), the solar radiation limit (INZL) and the maximum irrigation time (TZ) (defined at 6 hours) are included. If, by error, we define the minimum soil water limit larger than maximum, the right-hand decimal point on the led display automatic starts lighting. On the led display

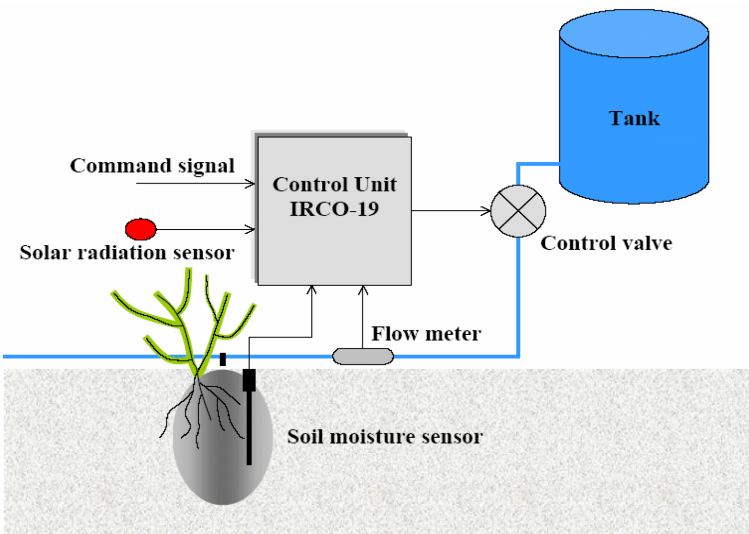

Figure 1 - Block diagram of automated control system

of control unit the measured values are depicted. It consists of four 7-segment units. The choice of the above electronic components was done exclusively with the criteria of the wide experimental capabilities and the low cost of the prototype device IRCO-19.

A great number of soil moisture sensors have been developed the last decades. However, the information with regard to their performance is limited, while the comparative studies that have been realised are not despite minimal. The type of soil moisture sensor, which used in this study, was Virrib (Fig. 3). The Virrib sensor selection was done between six other dielectric sensors (ECH_2O, Aquaflex, SM200, Gro-Point, Virrib και Acclima), according to their technical characteristics, the satisfactory precision of their measurements and the possibility of easy interface with electronic systems and the low cost (Gravalos, 2006). The Virrib soil moisture sensor consists of two stainless steel concentric circular rings (electrodes of diameters 28 and 20 cm). Measurements of soil water content using the Virrib sensor are made by means of an electro-magnetic wave between these two electrodes. The sensor produces an output between 5 and 55 mA, which corresponds to a soil water content range from 5 to 55 % v/v. Soil moisture measurements using the Virrib sensor are reported to be independent of the soil's chemical properties. Due to the diameter of the outer electrode and the layer thickness over which the sensor output responds (approximately 12 cm when installed parallel), the sensor provides average soil moisture measurements for a 20 l volume of soil.

Avoid the irrigation during summer cloudless days (mainly in midday hours) using a solar radiation sensor. The radiation was measured 1 m above the canopy. Solar radiation sensor was designed and constructed to be able to measure within predefined range. It is based on general-purpose photodiode IPL10020BW and its photocurrent conditions by an operational amplifier and other compensating and filtering elements. The using photodiode is not the ideal sensor but is suitable for orientation measurements and has low cost.

This control system can automatically collect, record and control the soil water content in the root zone of plants in real time. It is also possible to be connected with other devices such as flow meter and pressure transducer to perform technical diagnosis of irrigation system.

3 Results and discussion

Effective irrigation management requires soi1 water content data to ensure higher water use efficiencies and to achieve better yields. Thus, the

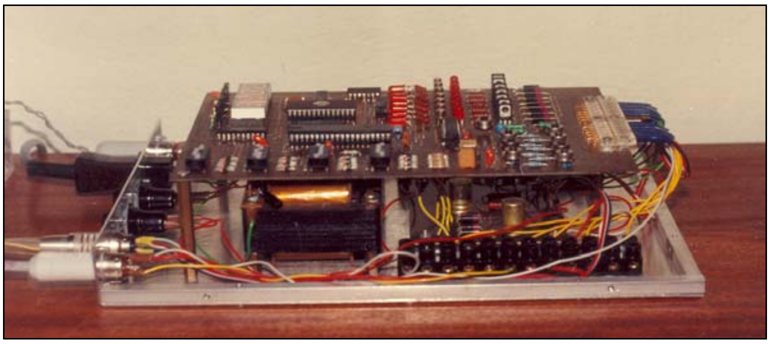

Figure 2 - The prototype of specially designed control unit (IRCO-19)

Figure 3 - Soil moisture sensor Virrib under laboratory conditions

sensing equipment should measure soil water quickly and accurately. In order to verify the accuracy and repeatability of commercially available soil water Virrib sensors, we have tested the ability of these sensors to provide reliable results for different soil types and water salinity levels. The experiments were conducted under controlled laboratory conditions and over more drying cycles for water contents decreasing from FC to PWP by volume. Therefore, sensors were set up in plastic boxes with soil of known physical and hydrological properties. The Virrib sensors were installed horizontally. Soil was wetted up to saturation and allowed to drain to FC and weighed periodically to determine the gravimetric water contents. Afterwards, calculated volumetric soil water contents were compared with values obtained from the sensors. Figure 4 illustrates the Virrib readings as function of calculated volumetric content. Each data point represents the mean value of the measurements from the sensor. Virrib sensors respond to soil water content variations and gave very accurate results in the 12 to 20 % range.

The soil water sensors were placed into the root zone of plants in depth at 20 cm. The DIP switches of the control unit IRCO-19 were put into the limits of minimum soil water (LVAL) and the maximum soil water (HVAL) according to the soil type, while the measurement values are depicted on led display. The experimental validation of control system was done in the area of Larissa (Greece) during the summer time of the years 2005 and 2006. For the experiments, two different soil types were used, one with low and the other with high infiltration (table 1). The measurement recordings were done in predefined time intervals and the results are processed by diagrams (fig. 5, 6, 7).

From the following diagrams it is clear that soil water content was always into the desired values of LVAL and HVAL, which composes fraction of available water. At the soil B, due to high infiltration, the falling of soil water is faster in relation with the other soil type A, which is smoother. The user must give special care for the determination of operation parameters (LVAL, HVAL). The method of these parameters determination is experimental. For monitoring the soil water content in deep root zone plants two sensors were used. The first was placed at a depth of 20 cm and the second at 60 cm. By placing one soil moisture sensor in the root zone (across) and another sensor below (parallel), we have maintained crops at optimal hydration and monitor excess irrigation. The soil water in the superficial layers at depth 20 cm has high excitation due to disturbances, in contrast with deeper layers at 60 cm, when the soil water content is more stable.

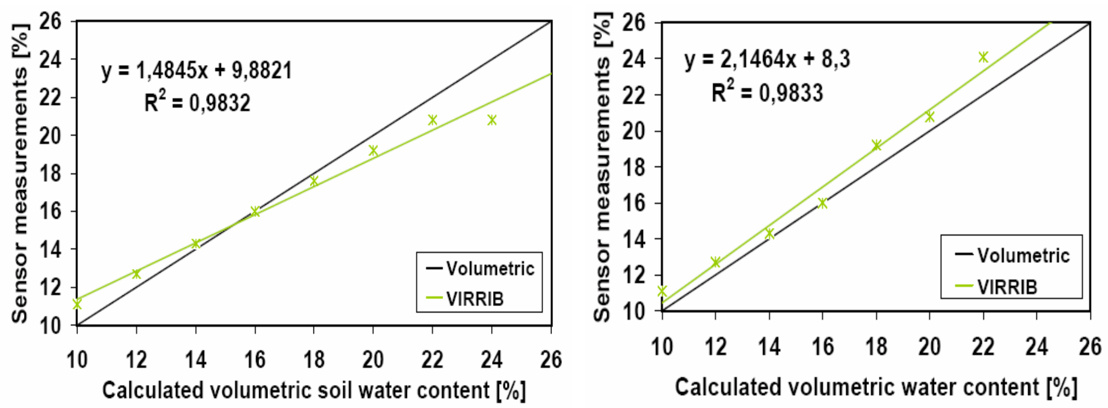

Figure 4 - Comparison of volumetric soil water content as determined by Virrib Sensor and from calculated volumetric content: a) in loam and b) in sandy loam

Table 1- Physical and hydrological properties of soil types

Soil type	Sand [%]	Silt [%]	Clay [%]	Bulk density [g/cm^3]	Field capacity [% Vol.]	Permanent Wilting point [% Vol.]
A	44	40	16	1.35	24	10
B	69	22	9	1.50	18	7

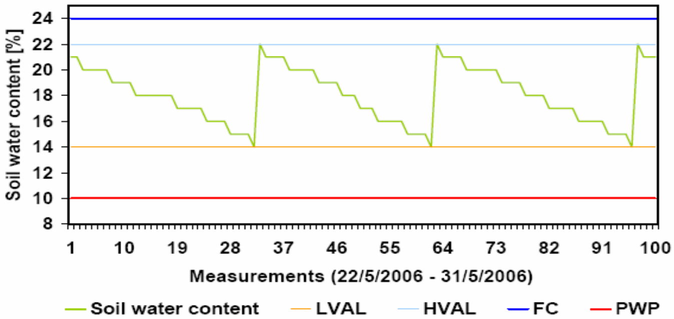

Figure 5 - The soil water change at soil type A in depth 20 cm and its regulation by control system

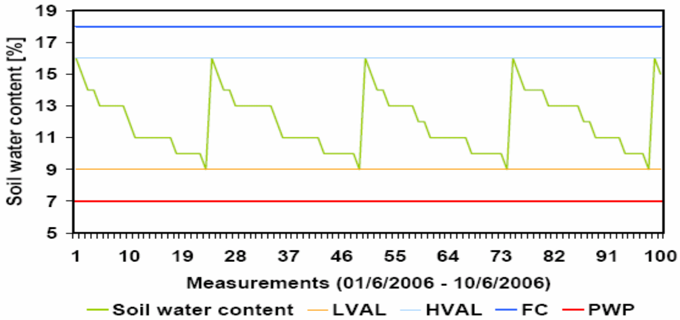

Figure 6 - The soil water change at soil type B in depth 20 cm and its regulation by control system

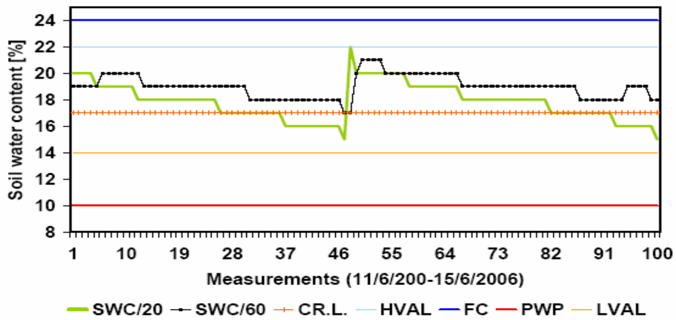

Figure 7 - The soil water changes at soil type A in depth 20 cm and 60 cm and their regulation by the control system

4 Conclusions

This paper presents a feedback irrigation control system in real time. From the experimental validation of the control system, it is obvious that it is possible to create optimum conditions for the plant growth, despite the changes of wind velocity, temperature and relative humidity of the environment. The measurements and the regulation of soil water were done automatically. The normal growth of plants confirms that there are not dry periods in the root zone during the summer hot days in Larissa (Greece), while the water consumption was limited. The major water consumption was observed during the months of July and August.

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A SOFTWARE TOOL TO COMPUTE AUTONOMOUS PHOTOVOLTAIC WATER PUMPING SYSTEMS

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The applications of photovoltaic systems (PVS) have been increased rapidly in the last years. The water pumping systems are included in between the photovoltaic applications. This paper describes the features of a software tool, which computes an autonomous PV water pumping system. First, this tool calculates the power needed for pumping water considering effects of crop and climatologically parameters, the size of the area to be irrigated, pipeline friction losses and so on. Consequently, this tool enables the user to estimate the monthly or daily output power of PV array, the number of PV panels needed and the required PV array size, the total capacity and the number of batteries, the number of days of autonomy and finally the volume of water tank. The development software tool can be utilized in designing the real water pumping systems as well as in research and educational processes.

Keywords: Photovoltaic system, software tool, water pumping.

1 Introduction

Photovoltaic (PV) power system can convert sunlight directly into electricity. The basic building block of PV system is the solar cell. There are different materials suitable for making PV cells, like crystalline silicon, poly-crystalline silicon, amorphous silicon, cadmium telluride, etc. For a typical solar cell the most common structure is a semiconductor material into which a p-n junction, has been formed. The electric current flows in one direction, and thus the electricity generated is termed direct current (DC). In case that the DC current cannot be used directly, other system components will be needed. These may include battery charge controllers, batteries, inverters, and wiring with appropriate safety devices. Today's commercial PV systems can convert from 7% to 17% of sunlight into electricity. Users of PV power systems appreciate their quiet, low maintenance, pollution-free, safe and reliable operation. Last years, their cost has dropped and PV modules now cost around 5 Euro per Watt (Gustafson and Morgan, 2004).

The three typical configurations of PV power systems are: autonomy, hybrid and grid-connection. Autonomous power systems are not connected to the main utility grid and are used in remote areas. They may incorporate batteries, which store energy from the PV modules during the day, for use at night or in periods of low solar radiation. Alternatively, they may provide the application entirely, with no need for batteries. A hybrid system is a good option for larger systems that need a steady power supply, when there is not enough sunshine at certain period of the year. Usually, a hybrid system consists of PV modules and a fuel-fired generator. A grid-connected system generates its own electricity and feeds its excess power into the utility grid for later use (Natural Resources Canada, 2002).

In agricultural applications, where a small amount of energy in remote locations is needed, the autonomous PV power systems are a good solution. Today, several thousands hectares of remote cultivating land are not being used due to the high costs of pumping water by conventional methods. Therefore, solar pumping systems are widespread. They can be used to pump drinking water from wells or water for irrigation in agriculture. The demand for water is greater when the weather is hot and dry, precisely when the most solar energy is available. Simple non-storage types of PV power systems are ideal for many irrigation applications. However, the difficulty is predicting the performance of a direct-coupled PV pumping system. The relationship between pumping rate and the radiation is a non-linear. At high radiation levels, the rate of increase of the pumping rate with increasing radiation is smaller than at intermediate radiation levels. Both the existence of a radiation threshold and the non-linear dependence of flow on radiation level complicate the prediction of direct-coupled PV pumping system performance (Kou et al., 1998). In this case, water is pumped when the sun shines and is stored directly in a tank that is installed at a higher level for later use by gravity feed. It makes PV powered irrigation systems economically attractive. Normally, the excess energy generated in autonomous PV systems during sunny periods is stored in batteries. The batteries then provide electricity at night or when there is not enough solar radiation. For these applications, the number of watts in the array and the capacity of the batteries is carefully sized to give optimum performance (Poulek and Libra, 2006).

This paper describes a user-friendly software tool to compute autonomous photovoltaic water pumping systems and presents some examples to demonstrate how it can be applied.

2 Materials and Methods

Theory

A computer program has been developed to simulate the irrigation performance of the PV systems under different climate conditions. The program is based on mathematical models in order to properly size the system components: the PV array and pumping subsystem.

Step 1-Determination of water pumping power: According to Royer et al. (1998) the daily hydraulic energy demand E_h [J/day] corresponding to lifting water to a height h_o [m] with a daily volume Q [m^3/day] is:

$$E_h = \rho \times g \times Q \times h_o \quad (1)$$

Where g is the acceleration of gravity (9,81 m/s^2), ρ the density of water (1000 kg/m^3). This hydraulic energy converts into an electrical energy requirement:

$$P = \frac{E_h}{PT \times PTF \times \eta_a} \quad (2)$$

Where P [kW] is the power needed for pumping water, PT [h/day] is the pumping time, PTF is the pumping time factor and η_a is the pump system efficiency.

Step 2-Tilt angle selection of PV array: PV collectors can be fixed, adjustable or tracing. Adjustable collector allows the tilt angle to be varied manually throughout the year to maximize output year round. The tilt angle β of each PV collector is determined by formulas $\beta=\varphi\pm15^o$ or $\beta=\varphi$, where φ is the geographic latitude. In practice, it has been found that the tilt angle $\beta=\varphi-15^o$ is better for summer months.

Step 3-Determination of the average daily solar radiation falling on the PV array for each month: In base of tilt angle of PV array calculated the average daily value of solar radiation energy gain G_t [kWh/m^2/day]:

$$G_t = \frac{k_c \times I_{hs} \times 10^3}{d \times 3600} \quad (3)$$

Where I_{hs} [MJ/m^2] is the average monthly radiation on horizontal surface, k_c is conversion factor and d [days] is days per month.

Step 4-Determination of day autonomy: If the daily radiation or the minimum peak sun hours (PSH) over the period of operation of the load is known for a location, the numbers of days of autonomy can be estimated by the following equations (Messenger and Ventre, 2004):

$$D_{crit} = -1{,}9 \times PSH_{min} + 18{,}3 \quad (4)$$

$$D_{non\text{-}crit} = -0{,}48 \times PSH_{min} + 4{,}58 \quad (5)$$

Where D represents the number of storage days required, either for critical or non-critical storage.

Step 5-Selection of PV module characteristics: The next step is to select an appropriate module that gives a maximum power point voltage as close as possible to the voltage at which the subsystem attains maximum operating efficiency. In case that the DC current cannot be used directly, it is necessary to choose other balance of the system components.

Step 6-Determination of electrical power losses: When designing a PV system it is necessary to determine the electrical power losses in the other system components (wiring, MPPT, inverter, etc.). For example wire cross-sections should be selected to limit resistive losses to less than 5%.

Step 7-Determination of peak PV output: The determination of the peak PV output P_{PV} [kW/day] is easily performed according to the following equation (Wenham et al., 2007):

$$P_{PV} = \frac{E'_h}{(PSH)_{min}} \quad (6)$$

Where E_h' [kWh/day] shows the increase in E_h due to the losses of PVS and $(PSH)_{min}$ is the minimum value of peak sun hours (equivalent number of hours per day when solar irradiance averages 1 kW/m^2).

Step 8-The effect of temperature on the maximum power output: The ambient air temperature, determines the operating temperature of a solar cell (Wenham et al., 2007). The specific parameters of PV module (I_{sc}, V_{oc}, P_m, FF) have been measured under standard test conditions. However, in practice they can be operated in different conditions. In nominal operating cell temperature (NOCT) (approximately 45 ºC), the temperature of PV modules (T_c) [ºC] will be different compared to the temperature of 25 ºC, in which the parameters have been initially measured.

$$T_c = T_a + \frac{(NOCT - 20)}{0{,}8} \times I_t \quad (7)$$

Where T_a [ºC] is the mean daily ambient air temperature, I_t [kW/m^2] is the solar radiation on PVS surface and NOCT [ºC] is the nominal operating cell temperature. The temperature dependency of V_{oc} is approximated by the following equation:

$$V_{oc} = V_{oc(initial)} - n_s \times 0{,}0023 \times (T_c - 25) \qquad (8)$$

Where n_s is the number of solar cell that are encapsulated in the PV module. The effect of temperature on the maximum power output P_m [W] is as follows:

$$P_m = I_{sc} \times V_{oc} \times FF \qquad (9)$$

Where I_{sc} [A] is the short circuit current, V_{oc} [V] is the open circuit voltage and FF is the fill factor.

Step 9-Photovoltaic system sizing: The total number of modules is the product of the number in parallel and the number in series. The number of modules in parallel is determined by dividing the derated array current by the rated module current. The number of modules in series is determined by dividing the nominal system voltage by the lowest anticipated module voltage of a module supplying power to the system (Messenger and Ventre, 2004).

Step 10-Determination of area of the PV station: The PV panels should be mounted facing due south in a location where they receive maximum sunlight throughout the year. The area of PV station S_{PV} [m^2] is given by:

$$S_{PV} = \frac{c}{b \times cos\beta} \times S_{CS} \qquad (10)$$

Where c [m] is the distance between rows of PV panels, b [m] is the width of PV panel, β [º] is the tilt angle and S_{CS} [m^2] is the cross section of the total area of the PV array.

Step 11-Battery selection: The energy generated by PV modules can be used immediately or stored in batteries for later use. The required battery capacity C_b [Ah] can be estimated:

$$C_b = \frac{Q \times d}{V_{DC}} \qquad (11)$$

Where Q [Wh/day] is the total daily load, d [days] are days of storage and V_{DC} [V] is the voltage output of PV generator. The following expressions are used to determine the number of the batteries needed:

$$N_{bs} = V_{DC} / V_b \qquad (12)$$

$$N_{bp} = C_b / C_n \times DOD \qquad (13)$$

$$N_b = N_{bs} \times N_{bp} \qquad (14)$$

Where N_{bs} is the number of batteries connected in series, N_{bp} is the number of batteries connected in parallel, V_b [V] is the battery voltage, C_n [Ah] is the nominal capacity and DOD is the depth of discharge. If more than four batteries are required in parallel, it is generally better to consider higher capacity batteries to reduce the umber of parallel batteries to provide for better balance of battery currents. For these applications the number of watts in the PV array E_{PV} [kWh] and the capacity of the batteries E_b [kWh] must be carefully sized to give optimum performance.

$$E_{PV} = P_{PV} \times PSH \times d \qquad (15)$$

$$E_b = N_{bp} \times \left(N_{bs} \times V_b \times \left(C_n \times DOD \right) \right) \qquad (16)$$

$$E_b > E_{PV} \qquad (17)$$

It means that energy delivered by batteries will cover the energy demands of the water pumping system for long time (autonomy in days).

Step 12-Determination of the tank volume: When the sun shines the water is pumped and it is stored in a tank for later use. This is economically attractive for autonomous PV water pumping systems. The volume V [m^3] of the tank is defined by:

$$V = Q_t \times T \times d \qquad (18)$$

Where Q_t [m^3/h] is the pumping system flow per hour, T [h] is the pumping time and d [days] is the autonomy in days of the system.

Software

This software tool allows the user to rapidly compute autonomous photovoltaic water pumping systems. It is a Microsoft Windows Multiple Document Interface application written in Microsoft Visual Basic. Multiple screens can be displayed simultaneously, allowing different sets of parameters to be selected and the results to be displayed. At the moment, it has been prepared only the Greek version. The English version will be prepared in the future.

3 Results and Discussion

The evaluated software is a unique tool developed by the Department of Agricultural Machinery & Irrigation team at Technological Educational Institute of Larissa (TEI/L) to assist in the design of autonomous PV water pumping systems. In this section, we show the results obtained by the above software tool. Each worksheet case includes inputs and results. Values that the evaluated software calculates based on the values of other input variables. When the results are consistent with the inputs, the results are complete. When the results are not consistent with the inputs, the results are pending.

Figure 1 presents an example worksheet of system crop and climatic parameters setting. Several additional worksheets are associated with this to set soil and irrigation parameters, pipelines friction losses (Fig. 2) and technical parameters of PV modules and batteries. This worksheet consists of a menu bar and parameters setting pane. In parameters setting pane the brown background indicates the calculated and pre-defined values and the green background indicates the new parameters setting. In the right upper side, it displays a basic help system that provides simple instructions. Action buttons in the menu bar determine what worksheet appears in the next active case. In the taskbar, click the Excel button to create an Excel file containing the data show in the data table. This feature allows the use of external spreadsheets. Both import values from spreadsheets and export values use the result of a spreadsheet calculation for the value of one variable that depends on the value of other variables.

Figure 3 presents the results summary table for an area in Larissa (Greece). It consists of menu pane, results and data pane, and results management tool bar. The color of actions buttons and text box backgrounds provides you, with information about the contents of the worksheet. The green background color of text boxes saws about the results and the violet background color provides you with the IS units.

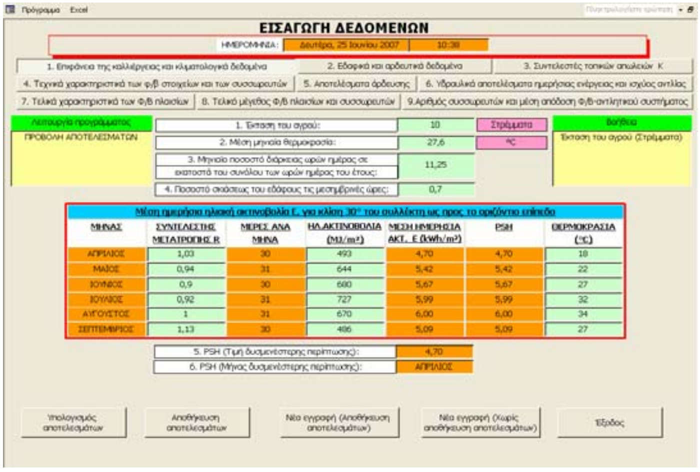

Figure 1 - System parameters setting

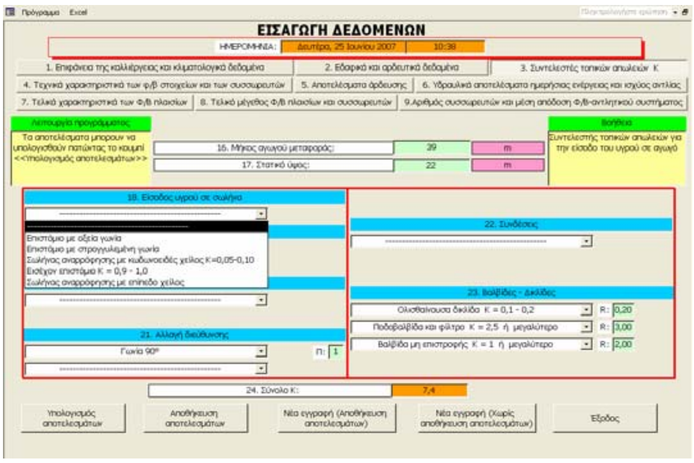

Figure 2 - Worksheet to set pipelines friction losses

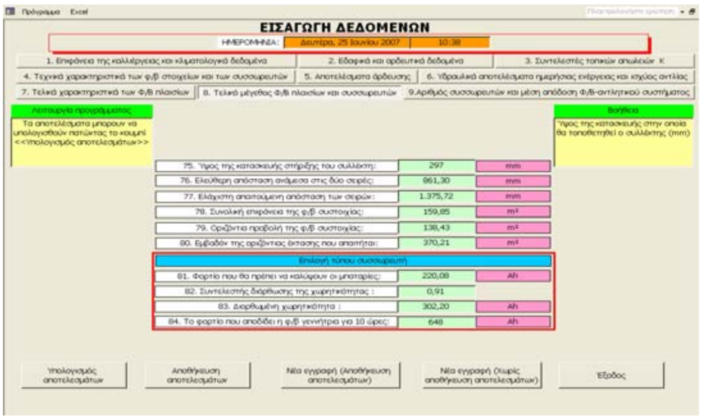

Figure 3 - Overview of the results summary for an area in Larissa (Greece)

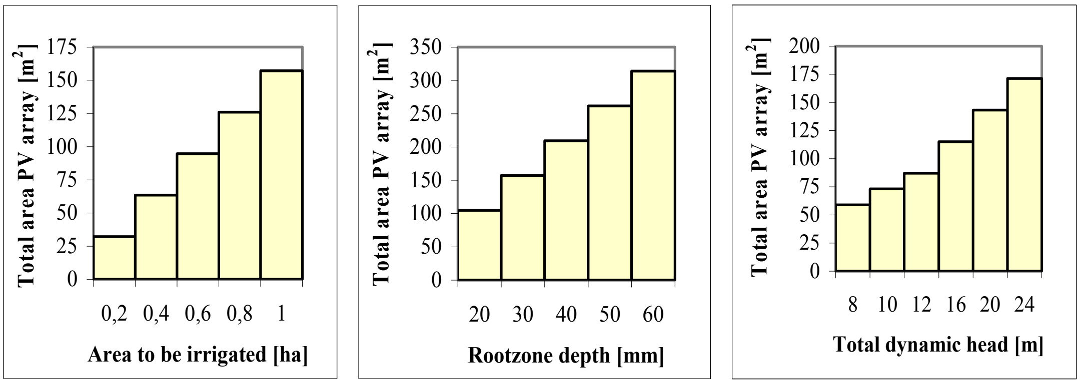

Figure 4. - The total surface of PV array predicted for different areas to be irrigated, rootzone depths and total dynamic heads

By insertion different variables as areas to be irrigated, rootzone depths and total dynamic heads, verified the evaluated software tool (Fig. 4). In any case, the predicted total surface of PV array increasing according the variables growing. Furthermore, the total surface of PV array is more affected by the growing of rootzone depth.

4 Conclusions

The evaluated software is a user-friendly tool that provides computation of autonomous photovoltaic water pumping systems and how this changes the PV generator characteristics according to the size of the area to be irrigated, the rootzone depth and the total dynamic head. Detailed analyses have shown that the software tool gives reasonable estimation of the total surface of PV array or the total number of modules. This means that the developed software tool can be used with confidence in designing the real water pumping systems as well as in research and educational processes.

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SIMULATION PROGRAM FOR NATURAL VENTILATION CONTROL IN LAYING HEN HOUSES

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This article is concerned to introduce a specialty developed stimulating program used for natural ventilation control in laying hen houses. These are placed in local conditions in Northern part of Turkey, Samsun. The program is developed especially to observe and following analysis of required values obtained during natural ventilation. It means a ventilation by the windows, doors and other inlets and outlets, in other words without any other ventilation initiators.

By the measuring are checked and recorded air temperature and relative air humidity. These are measured inside of the laying hen houses as well as outside them. Final values of measurements are statistically analyzed and graphically demonstrated.

According to the results, it's seen that the laying hens were exposed to higher relative humidity values and lower air velocities in the afternoon section. Thus, supplemental ventilation or cooling is needed in this time period of the day. Since the relative humidity values were high enough for the laying hens it wouldn't be suitable to use evaporative cooling system in the poultry house. Only ventilating the poultry house with high air velocities (2 $m.s^{-1}$) is recommended when the air relative humidity exceeds 75 %.

The aim of work is to give practical results to designers and farmers. These conclusions may lead to ventilation improvements in laying hen houses with an option of total process automation there.

Keywords: natural ventilation, laying hen, wind, air temperature, simulation program

1 Introduction

Generally, ventilation is described as exchanging the fresh air with the respired and ambient air mixed with noxious gases by using natural and mechanical methods (1). Natural ventilation is the movement of air through specified building openings by the use of natural forces produced by wind and temperature difference (2, 3). The ventilation rate depends on the wind speed and direction, interference of nearby obstructions such as hill or buildings and the size, design and location of outlet and inlet openings. Natural ventilation is the oldest form of ventilation and has been used for as long as housing has been provided for animals. Low initial cost and low energy costs are primary factors that make it the most common type of ventilation. This type of ventilation is dependent on natural forces and consequently has numerous limitations. These include such factors as the nature of the climate, geographic area, terrain, obstructions to the wind, environmental requirements and others that must be considered in the design of a natural ventilation system and its subsequent management (3, 4). Besides, factors which effect the performance of natural ventilation systems are: animal heat, production, orientation of structure, roof slop, eave openings, ridge openings, side wall openings, side wall height, insulation and other structural details. In this study, a simulation program was developed for controlling the natural ventilation rates in laying hen houses in Samsun conditions.

2 Material and Method

The research was carried out in laying houses of Ondokuz Mayıs University Agricultural Faculty in Samsun.

Measurements of air temperature, air relative humidity and air velocities were recorded by TESTO 400 data logger. The data collected with TESTO 400 were transferred to computer.

The computer program, which was developed to determine the natural ventilation rates in laying hen houses, was done in MS Visual Basic programming language.

Determination of natural ventilation rates realized by wind forces and thermal buoyancy was done by using the methods below. The methods were explained as follows:

Natural Ventilation by Wind Forces

On a building three different pressure zones occur due to wind forces (5). These are;

- Positive pressure that pushes the outside air into the building through the air inlets,
- Negative pressure that pulls the inside air from the building through air outlets and,
- Neutral pressure where there is no air flow between the building and the outside air.

The value of the static pressure on the structure occurred by wind forces changes upon geometric shape of the structure, resistance of the cracks and openings and also the direction and the velocity of the wind. Velocity pressure effecting the structure at given wind velocity is as follows (2):

$$P_v = \frac{1}{2}\rho.v^2 = 0{,}6.v^2 \qquad (1)$$

where;

P_v : Wind pressure (Pa)

ρ : Density of air ($kg.m^{-3}$)

v : Wind velocity ($m.s^{-1}$)'dir

The average wind velocity, dominant wind direction, seasonal and daily changes in velocity and direction of the wind and the obstructions (building, hill, tree, etc) that will effect the wind are taken in consideration in predicting the effect of wind. These factors can effect on the pressure zones formed by the wind on the structure.

It's not possible to determine precisely the natural ventilation rates. Therefore, the empirical equation below is recommended in predicting ventilation rates formed by the wind forces (2, 6);

$$Q = EAv \qquad (2)$$

where;

Q : Ventilation rate ($m^3.s^{-1}$)

A : Area of air inlets (m^2)

v : Wind velocity ($m.s^{-1}$)

E : Efficiency of air openings ( )

For the wind blowing perpendicular to air openings; E=0.50.....0.60 and for the non-perpendicular blowing wind E=0.25 to 0.35 is recommended. The wind rarely blows perpendicular to agricultural structures and for this reason (E=0.35) is recommended for the agricultural structures (2, 6).

Natural Ventilation by Thermal Buoyancy

When the air temperature inside the building is different from the outside air temperature pressure gradients occurs between the structure and outside air depending on density difference. The inside air with low density rises upwards when the inside air is hotter than the outside air. The rise realizes with the buoyancy effect equal to mass of outside air entering into building. This is called chimney effect. The inside air rising upwards in the building is removed outside while the outside air enters into the building. The ventilation rate formed by thermal buoyancy has direct proportion with the vertical distance between the air inlets and outlets, and with pressure difference. The velocity of the air, which is moved by the temperature difference of inside and outside air, is calculated by the equation below depending on ideal gas laws;

$$v = \theta\sqrt{2g\Delta h\frac{T_i - T_o}{T_i}} \qquad (3)$$

where;

v : Air velocity at air outlet ($m.s^{-1}$)

θ : Efficiency of air openings ( )

Δh : Vertical distance between air inlets and air outlets (m)

T_i Inside air temperature (K)

T_o : Outside air temperature (K)

g : Gravity ($m.s^{-2}$)

Opening efficiency is taken into consideration due to air friction at inside surfaces of air outlet and also for the reduction in air velocity due to cooling down of the air while passing through the air outlet. Barre and Sammet have recommended (θ = 0.3....0.5) value for this factor. Similarly, 0.65 value is recommended at sharp edged orifices (4), but there is no suggestion for the friction losses. For the wide air outlets with square, rectangle or circle cross section and with heat insulation at outer surface (θ = 0.6....0.7) value is recommended by many researches.

The air velocity is determined at air inlets or at outlets then this value is multiplied by opening area for the prediction of ventilation rate. However, the ventilation rate for the animal houses can be easily calculated by the energy and mass balance equations. Air inlet and outlet areas for providing the required ventilation rate can be calculated as follows;

$$\left(\frac{Q}{A}\right)^2 = \theta^2.2g\Delta h\frac{(T_i - T_o)}{T_i} \qquad (4)$$

$$A = \left(\frac{Q}{\theta}\right)\sqrt{\frac{T_i}{2g\Delta h(T_i - T_o)}} \qquad (5)$$

If air inlet area is equal to outlet area the ventilation rate is calculated by the equation (5). Otherwise the calculated value must be corrected according to Figure 1.

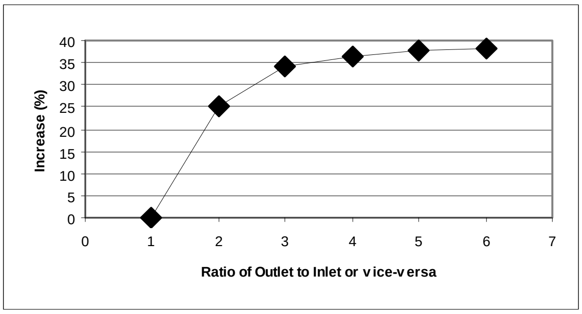

Figure 1 Ventilation rate depending on the ratio of outlet to inlet (2)

Combined Effect of Wind Forces and Thermal Buoyancy

As mentioned before the natural ventilation rate in the buildings depends on combined effect of wind forces and air temperature differences of inside and outside air. One of them can be dominant on other at some conditions. The sum of ventilation rates provided by each factor is not equal to the ventilation rate obtained by the combined effect of these factors. Although some researches reported that the combined ventilation rate of these two factors is equal to square root of the sum of ventilation rates of each factor, the total ventilation rate can be found from a graph (Figure 2) (4).

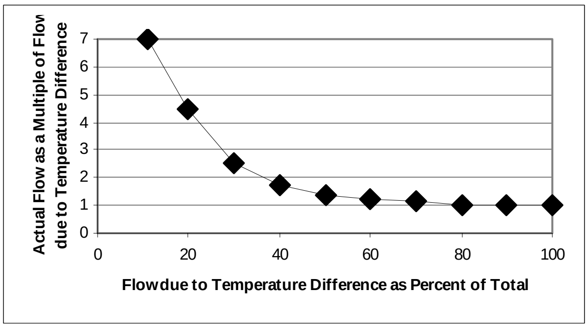

Figure 2 Natural ventilation rate depending on combined effect of wind forces and thermal buoyancy (2)

In this method, the ventilation rates depending on the two factors are found by the equations above. Then the proportion of the ventilation rate due to temperature differences to the ventilation rate due to wind forces is calculated and the total ventilation rate is found from the graph.

In this computer program natural ventilation rate due to thermal buoyancy is calculated by the inside and outside air densities which are obtained by the inside and outside air temperature and relative humidity values and concerning total static pressure balance (7).

$$M_v = \mu_i . S_i . \sqrt{2.pi.\rho_e} \quad (6)$$

$$p = p_i + p_o \quad (7)$$

$$\mu_i . S_i . \sqrt{2.(p - p_o).\rho_e} = \mu_o . S_o . \sqrt{2.p_o.\rho_i} \quad (8)$$

$$V_e = \frac{M_v}{\rho_e} \quad (9)$$

where;

M_v : Mass flow of ventilation air (kg. s^{-1})
V_e : Volume flow of ventilation air (m^3. s^{-1})
μ_i : Correction factor for air inlets
μ_o : Correction factor for air outlets
S_i : Area of air inlets (m^2)
S_o : Area of air outlets (m^2)
ρ_i : Density of inside air (kg. m^{-3})
ρ_e : Density of outside air (kg. m^{-3})
p : Total static pressure (Pa)
p_i : Inside static pressure (Pa)
p_o : Outside static pressure (Pa)
h : Vertical distance between air inlet and outlet (m)

Calculation of air density according to air temperature and relative humidity is given below (8):

$$\ln(p_{ws}) = \frac{-7511.52}{T} + 89.63121 + 0.023998970T - 1.1654551x10^{-5}T^2$$
$$-1.2810336x10^{-8}T^3 + 2.0998405x10^{-11}T^4 - 12.150799\ln(T)$$
$$\ldots \quad (10)$$

$$W = 0.62198\frac{p_w}{P - p_w} \quad (11)$$

$$p_w = \frac{P \cdot W}{0.62198 + W} \quad (12)$$

$$v_h = \frac{R \cdot T}{P}(1 + 1.6078W) \quad (13)$$

$$\rho = \frac{1}{v_h} \quad (14)$$

where;

p_{ws} : Water vapor saturation pressure (kPa)
p_w : Water vapor pressure (kPa)
W : Humidity ratio
R : Gas constant (J.kg^{-1}.K^{-1})
T : Temperature (K),
P : Total pressure (kPa),
v_h : Specific volume (m^3.kg^{-1})
ρ : Air density (kg. m^{-3})

3. Result and Discussion

The measurements were mainly done in August because the August is the hottest month in Samsun region according to the last 30 years weather records (5). Inside and outside air temperature and relative humidity values were recorded regularly. The measurements at air inlets were taken from both sides of the poultry house, and inside the house at bird level, at 1.5m above the ground and at air outlets. The results of the measurements are given as graphs (Figure 3 to 6).

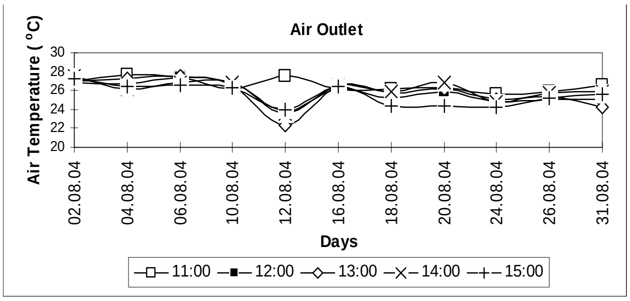

Figure 3

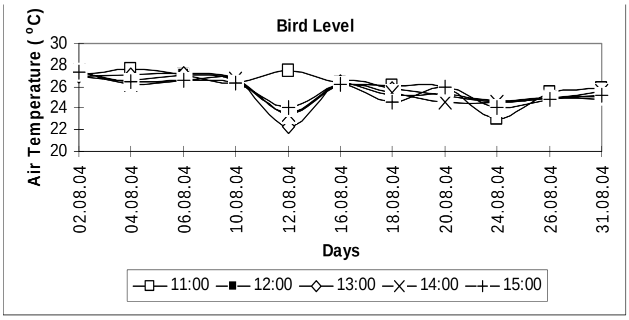

Figure 4

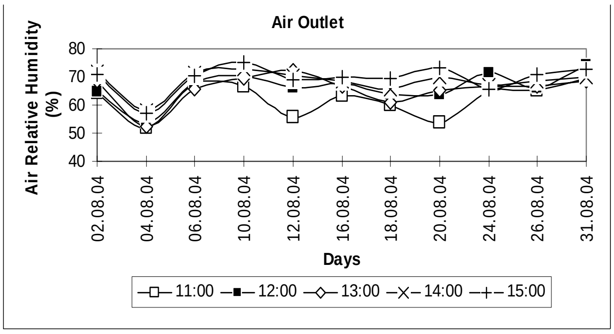

Figure 5

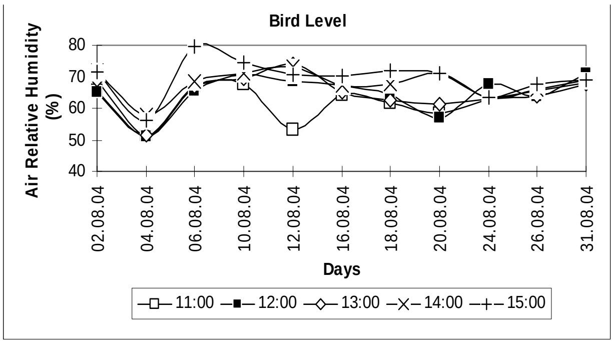

Figure 6

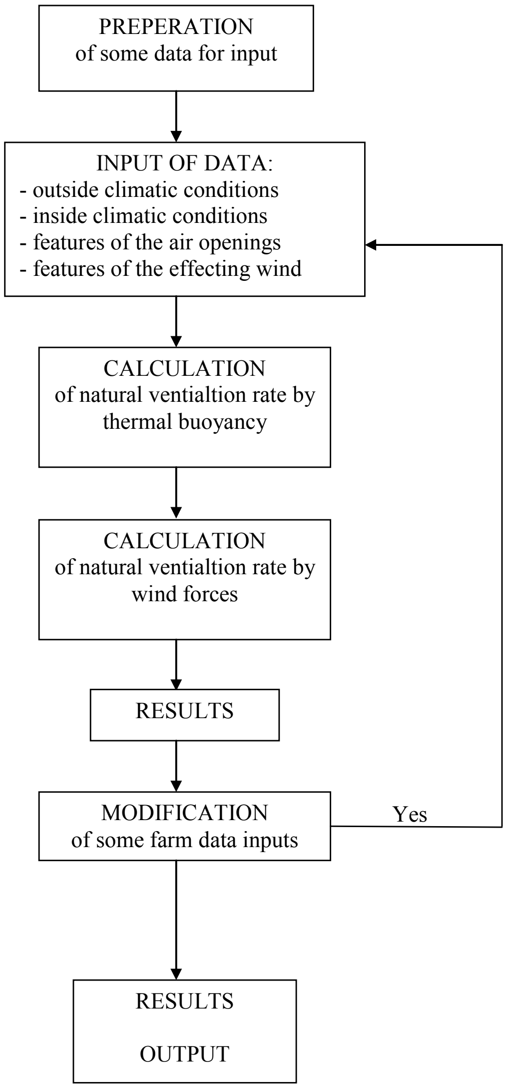

Figure 7 Algorithm of the program

A computer program was developed by MS Visual Basic 6.0 programming language. Algorithm of the program is given in Figure 7. The outside and inside air conditions, features of the air openings and features of the blowing wind effecting the laying hen house are defined. Then the program calculates the natural ventilation rates by thermal buoyancy, by wind forces and the total natural ventilation rate occurred in the laying hen house.

According to the results, it's seen that the laying hens were exposed to higher relative humidity values and lower air velocities in the afternoon section. Thus, supplemental ventilation or cooling is needed in this time period of the day. Since the relative humidity values were high enough for the laying hens it wouldn't be suitable to use evaporative cooling system in the poultry house. Only ventilating the poultry house with high air velocities (2 m.s^{-1}) is recommended when the air relative humidity exceeds 75 %.

The aim of this program is to give practical solutions to designers and farmers in the design and operation of the animal house. This program can also be used for the automation of the laying hen house when it's combined with the appropriate sensors.

Acknowledgment:

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THE STUDY OF COMPRESSIVE LOADING ON MECHANICAL PROPERTIES OF SOYBEAN KERNEL

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Agricultural product in the process of collecting, planting, handling and producing is affected under static and dynamic forces. In most cases, these forces cause damage to the product, so far optimizing to the energy consumption, in the different process, especially in designing and making of different machines, agricultural equipments, information of mechanical specification is a significant importance.

To determine the physical and mechanical properties of soybean ,we choose three varieties common in Iran including : Lindarin , Hill and Davis at three level of moisture content : (11-13) , (14-16) and(17-19) percent on the base of wetness under the single axis compressive loading . In three direction , the compressive loading L(length) , W(width) ,H(height) was studied . In this research , the dimension of the kernels were examined under the test , sizing at the basis of that the cavities coefficient was calculated whereas compressive forces in the different producing process have the most influences , thus for compressing test under statical loading , the effect of variety and kernel moisture content and loading direction , the least ruptured force , the least ruptured energy will be calculated for rupture point , displacement , the apparent strain coefficient and the most tangential stress as criterion assessment are calculated. According to conclusion , it was determined that the most required forces for rupturing pertaind to Hill variety and for loading the direction of (L) and exposure of (14-16%) equal to 340.2 Newton force and the least required forces for rupturing pertained to Lindarin variety in the direction of (L) and (17-19%) humidity equal to 65.43 Newton force , and so , the most required energy for rupturing , respect to Davis variety in the direction of (L) and (14-16%) humidity , equal to 260.40 milijoule , and the least variety of that respect to the same variety in the direction of (W) and (11-13%) equal to 35.60 milijoule was calculated . According to conclusions it is determined ,midlingly the most strain rating in the direction of (L) by the least value in (W) direction . Also by incrematation of humidity, the strain rating will be increased in three directions. Considering with this consequences, we can make a result that by humidity incrementation the kernel's elasticity is going to reduce, and the viscoelasticity of that will be increased.

So on the humidity surfaces from (17-19%) the most viscoelasticity will be seen. On the basis of the study , the most strain coefficient related to Davis variety in the humidity (11-13%) was equal to 2150.1 Mpa , and the least quantity pertain to Lindarin variety at the humidity (17-19%) equal to 201.5 Mpa was calculated . on the otherside , the most side placement at the rupture point pertain to Lindarin variety in the direction of (L) in the (17-19%) humidity , equal to 1.7mm and the least displacement , pertain to Lindarin variety in the direction of (H) in the (11-13%) equal to 0.21mm was calculated. Meanwhile the most tangential stress pertains to Davis variety in the (11-13%) and the least quantity of that pertains to Lindarin variety in the (17-19%) humidity was attained. Meanwhile at the basis of attained result, the Davis variety on the surface probably (α = %1) did a lot of effect on the required forces to failure, displacement in the failed point and necessary energy for failure. So that for breaking the corn, in the direction of (H), we need the maximum forces and in the direction of (L) we need the minimum forces. On the other hand it was determined that adding to humidity of the kernel, the force percent for cracking and displacement, in the failed point, and required energy for rupturing would increase, but coefficient ant tangential stress would be decreased.

Introduction

Soybean as a valuable nutrient is used for both human and animal consumption. In regard with the increasing need of the countries for the soybean, studies have been conducted to reduce the lose of product in all stages of cultivation, harvesting, handling, storing and processing. These loses may have originated from the influence of different forces on the soybean body in that stages. So in the process of making devices for actions such as pulverization , crushing and pressing of the soybeans, the determination of the maximum and minimum forces could be necessary . In general, mechanical properties are including stiffness, compressive strength, and impact and shear resistance, and since in different stages, compressive forces have the most influential power, so, there is a need to study compressive resistance in the soybean. The main objectives of this study are to determine the influencing factors such as corn variety , moisture content and loading direction in compressive test under static loading and to determine the minimum rupture force , the minimum rupture energy , the rate of deformation at the rupture point and apparent elastic coefficient ,and maximum contact stress as compressive resistance assessment indexes .

Allen & Watts have conducted the compressive and crashing tests on the cowpeas. In the compressive loading test, cowpeas with 11% and 15% of moisture content have been loaded. The findings show that with the increase of moisture content from 11% to 15%, the average force at the rupture point and elastic module coefficient, and the contact stress decreased but at the same time the average deformity at the rupture point and the average of absorbed rupture energy increased. Paulsen, et al conducted the breakage susceptibility and compressive loading tests on two corn varieties and reported the drying influence on corn rupture resistance. Their findings show that: 1) the increase of drying rate and temperature may cause to linear increase of breakage susceptibility.2) the increase of drying rate may cause to the increase of ruptured kernels. 3) The increase in corn drying rate may cause to decrease of the absorbed energy for the kernel rupture.

To determine the required kernel rupture energy, Zoerb and Hall made a measurement device and reported that; whit the high level of moisture content, more rupture energy would be needed. They also reported that with the increase of moisture content, the required energy for destroying of corn kernel may increase.

Materials and Methods

For the purpose of this study, three soybean varieties namely Hill, Davis and Lindarin have been selected. In this test, each soybean variety 100g samples were randomized and selected. To determine moisture content of each soybean variety, 100g samples were put in the drying oven for 3 hours in 103^{0}c .The moisture degree was assessed on the basis of standard weight technique. To obtain the required kernel moisture, in the time of each test, 100g samples of each variety was selected and to gain the balance moisture, after 72 h, calculated water rates were added to each sample. In order to prevention of soybeans germination, all samples were stores at less than 4^{0}c. Levels of moisture contents selected in this study were (11%-13%), (14%-16%), (17%-19%). In order to uniaxial compressive loading a pull-press device was used. All of soybean varieties with different moisture levels in three orientations length (L), width (W), and height (H) – were put under uniaxial compressive loading. In concern with the use of three different soybean varieties, altogether 270 soybeans were put under compressive loading. Concurrent with the compressive loading force-deformity curves were drawn. With calculation of subcurves levels up to the rupture point, the required energy for the kernel rupture was calculated. Concerning with the heterogeneous shape of the soybeans, the direct use of contact stress equations is impossible. So, in order to determine quantities such as apparent modules of elasticity and the maximum compressive contact stress, uniaxial density tests on the basis of hertz theory can be used *(Arnold & Robert, 1969. Arnold & Mohsenin, 1971).* In order to calculation of the apparent modules of elasticity and the maximum compressive contact stress , the soybeans were put between two flat surfaces in the H direction and were put under uniaxial compressive loading with a regular rate . With the use of below equations apparent modules of elasticity was calculated.

$$E=\frac{0.338k^{3/2}F(1-\mu)^2}{D^{\frac{3}{2}}}\left[\ {}^{1}\!/\!_{R_1} + {}^{1}\!/\!_{R_1'}\right]^{\frac{1}{2}}$$

$$R_1 \approx \frac{H}{2} \quad , \quad R_2 \approx \frac{H^2+\frac{L^2}{4}}{2H} \quad , \quad \delta_{max}=\frac{1.5F}{\pi ab}$$

In these equations K is the geometric characteristics of two contact bodies , D is deformity point , F is the level of force , R& R' are the great and small curvature radius of the convex corn surface , a & b are half oval diagonals , δ_{max} is the maximum compressive contact stress . At the end of the test, data collected were separated in different files with EXCEL software and then conclusions and statistic analysis were conducted with MSTATC software. The analysis conducted were including variance analysis. Before variance analysis data normalization conducted.

Conclusion and discussion

Primary findings show that like other biologic materials, soybean has a S-shape force-deformity curve and in the most cases the linear part, subordinate point and breakage point of the soybean could be easily recognized. In some cases subordinate point could not be recognized. But in samples with high level of moisture content this reorganization is easier. In this study with the increase of kernel moisture content no change was observed in the kernel dimensions of all varieties. Because of heterogeneous nature of the selected soybean kernels, determination of moisture influence was not possible. on the basis of conducted measurements in the kernel moisture level of 11-19% , the rate of roundness was 64% .In the uniaxial compressive loading test , calculated mechanical parameters of force-deformity curve are including ; required kernel breakage force , the rate of deformation at breakage . point , maximum contact stress and apparent elasticity modules .on

the basis of average rates of measured parameters , it was cleared that the maximum required force for breakage of the Hill variety and for loading at the H direction in 14-16% of moisture content equal to 340.2 Newton force and the minimum required force for rupturing to Lindarin variety in the direction of (L) and 17-19% of moisture content equal to 65.43 Newton force , and so , the maximum required energy for rupturing concerning with the Hill variety in the direction of (L) and with 14-16% of moisture , equal to 260.40 mili joule , and the least variety of that respect to the same variety in the direction of (W) and 11-13% of moisture equal to 35.60 milijoule was calculated.

Concerning with the heterogeneous dimensions of soybean kernel, the strain rate at different directions and at different level of moistures was assessed. On the basis of this study, the maximum strain rate at the (L) direction and the minimum strain rate at (W) direction were observed. With the increase in moisture content, the rate of strain in all three directions would be increase. With the increase of moisture, the elastic characteristics decreased and kernel viscoelasticity increased. In the moisture level of 17-19% the most viscoelastic characteristics observed.concerning with these observations, the most elastic modules was belong to Davis variety with the 11-13% of moisture content equal to 2150.1Mps and the least elastic modules was belong to Lindarin variety with 17-19% of moisture content equal to 201.5Mps .on the basis of this study the most contact stresses was belong to Davis at 11-13 % moisture content and the least contact stresses was belong to Lindarin variety with the moisture of 17-19%.

Table 1-variance analysis of required rupture force

F	MS	SS	df	Source of variable
1.2944	2691.35	24222.2	9	Repetition
0.731	1521.6	3043.2	2	Variety
97.42**	202555.6	405111.2	2	direction
4.955**	10303.82	41215.3	4	Variety * direction
197.96**	411605.6	823211.2	2	Moisture
1.147	2386.82	9547.3	4	Moisture * Variety
2.673	5557.8	22231.2	4	Moisture * direction
1.525	3170.83	25366.7	8	Variety* direction* Moisture
	2079.15	486523.2	234	error

Table2-variance analysis of required rupture energy

F	MS	SS	df	Source of variable
0.5838	1058.13	9523.2	9	Repetition
0.1517	275.05	550.1	2	Variety
30.317**	54941	109882	2	Direction
0.758	1375.02	5500.1	4	Variety * direction
11.105**	20125.05	40250.1	2	Moisture
0.4609	835.3	5341.2	4	Moisture * Variety
7.5496**	13681.3	54725.2	4	Moisture * direction
0.8450	1531.38	12251.1	8	Variety* direction* Moisture
	1812.18	424051.1	234	error

Table3-variance analysis of elasticity modulug

F	MS	SS	df	Source of variable
0.7256	261171.91	2350547.2	9	Repetition
56.714**	20412666.6	40825333.2	2	Moisture
3.822**	1375701.1	2751402.2	2	Variety
1.636	588842.8	2355371.2	4	Moisture * Variety
	359921.14	25914322.2	72	error

Table4-variance analysis of deformation at the rupture point

F	MS	SS	df	Source of variable
0.7	0.091	0.82	9	Repetition
2.307	0.3	0.60	2	Variety
358.46**	46.6	93.2	2	direction
5.192**	0.675	2.7	4	Variety * direction
74.230**	9.65	19.3	2	Moisture
1.630	0.212	0.85	4	Moisture * Variety
10.769	1.4	5.6	4	Moisture * direction
4.615	0.6	4.8	8	Variety* direction* Moisture
	0.13	30.5	234	error

Table5-variance analysis of maximum contact stress

F	MS	SS	df	Source of variable
	17.8	160.2	9	Repetition
255.48**	2561.15	5122.3	2	Moisture
11.603**	113.6	227.2	2	Variety
6.901**	67.57	270.3	4	Moisture * Variety
	9.79	705.40	72	error

Conclusions

1 – With the increase of moisture from 11 up to 17 percent, the required rupture force decreased and deformation at the rupture point increased.
2 – The most deformity at the rupture point and the maximum required energy for the kernel breakage were belong to loading at (L) direction and the most required rupture force was belong to breakage at the (H) direction .
3 – With the increase of kernel moisture content, the apparent modulus coefficient and the most contact stress decreased. The maximum and minimum contact stresses were belonging to Davis and Lindarin varieties, respectively.
4- On the basis of these information, the Davis variety has the best physical characteristic.

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THE EVALUATION OF GROUND BASED REMOTE SENSING SYSTEMS FOR CANOPY NITROGEN MANAGEMENT IN WINTER WHEAT: ENVIRONMENTAL BENEFITS

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Nitrogen management is a crucial issue in terms of environmental and economical efficiency for winter wheat husbandry. Precision Agriculture in particular Remote Sensing, has been used to determine the variability of the crop. Satellite, airborne and ground based platforms are possible to use. The most common passive ground based remote sensing system in Europe is the Yara N sensor. Active sensors, using their own energy sources, are now available in the market e.g. the Crop Circle (Holland Scientific) and the Yara N sensor ALS. This paper reviews environmental analyses of two sub-experiments conducted in 2006. One in Wilstead (UK), with the objective to evaluate application of active and passive ground based remote sensing systems in field management of winter wheat. The field experiment carried out in Oponice (Slovakia) assessed three different management strategies (the real time, near real time and traditional nitrogen management). The application of Nitrogen using these sensors in the UK saved 15kg N/ha (UK). The nitrogen saved in Slovakia was small (1.5 kg/ha). Use of the sensors enabled a reduction in nitrogen without a negative influence on yield, which increased the Nitrogen use efficiency. In addition to this there were potential environmental benefits through a 52% reduction of the residual Nitrogen in the soil in the UK. In Slovakia there was no significant overall reduction in the total nitrogen used; however, a different application rates was applied to 80% of the field.

Introduction

The management of nitrogen fertiliser is an essential issue for winter wheat husbandry. Nitrogen deficiency is characterized in winter wheat by leaf chlorosis, reduced net assimilation and relative growth rates, lower leaf area, phytomass and grain yield (Alley et al., 1996). Over-application can lead to the lodging of the crop and negative environmental impact, *e.g.* leaching or diffuse pollution of excess nitrogen. The characterisation of crop canopies for nitrogen management has, therefore, received much attention (Ložek, 1998; Alley et al., 1996; HGCA, 1997; HGCA, 2000; Godwin et al., 2003).

The management of the spatial and temporal variability of the crop canopy characteristics is a key factor for improving grain yield. The crop requirements or Nitrogen have to be matched as closely as possible by the nitrogen rates and the time between crop data acquisition and management decision making has to be as short as possible. These issues are not only important from an economical point of view, but environmental considerations must also be taken into account. Effort to apply only the necessary amount of fertilisers and chemicals has to be considered. So the accuracy of determining the requirements of the crop plays an important role in site –specific nitrogen management.

To gather the required information it is possible to use satellite, airborne and ground based platforms. Despite the presence of some commercial applications of the satellite and airborne techniques (eg. Griffin, 2007), ground based systems offer advantages in terms of ease of availability. The most common passive ground based remote sensing system in Europe is the Yara N sensor which has limitations in poor light conditions. Active sensors, using their own energy sources, are now available in the market e.g. the Crop Circle (Holland Scientific) and the Yara N sensor ALS. The ability of both, the Crop Circle and the N sensor Field Scan sensors, to determine the variability of crop nitrogen requirements as well as shoot density was proved in the previous work (Havránková – Godwin – Wood, 2006; Havránková, 2007). The NDVI output data can be calibrated by these crop characteristics or real time application is possible. The environmental considerations of the two sensors in nitrogen management are described in this paper, where the sensors were assessed in practical field conditions compared to uniform nitrogen management.

Methods

The field experiments were conducted in two experimental winter wheat (Triticum aestivum) fields. The experiments were scheduled for the dates of nitrogen fertilisation, used in winter wheat husbandry.

A. Wilstead (22 ha) (lat 52.854444, long 0.448055), Bedfordshire, UK;

Strip design was used to apply nitrogen in these experiments. All other procedures (seeding, application of chemicals) in this field were controlled by the farmer attempting to apply in a uniform manner. Conventional farm machinery was used to apply nitrogen along the 24 wide strips with three nitrogen treatments based on:

a) the variation in the estimated tiller density from the active sensor Crop Circle - CC,

b) the uniform treatment - agronomist's best practice rates,

c) the variation in the estimated tiller density from the passive sensor Field Scan - FS.

This strategy was designed so, the uniform treatment is in the middle of the variable treatments and the paired comparison can be done. This pattern was repeated for the whole field. To apply nitrogen all fields were scanned with both sensors simultaneously, NDVI data were calibrated based on methodology proposed by Wood et al. (2003a). Afterwards the field was divided into strips (where the width of strips was given by the tramline spacing) allocating the CC, UNIFORM and FS based methods to each strip alternately. Each strip was divided along its length into zones of different tiller densities – different NDVI values (above, under and on target) after Godwin et al. (2003). To calculate the nitrogen rates for each zone HGCA methodology (HGCA, 1997) was used.

Yield was used as an indicator of variable nitrogen management effects. The field was harvested with a combine harvester Massey Ferguson 7276 equipped with a yield monitoring system. Nitrogen efficiency and nitrogen residuals in soil were analysed.

B. Oponice (38 ha) (lat 48.475697; long 18.155478) Slovakia. Strip design was used in these experiments to apply nitrogen; all other procedures at these fields were controlled by the farmer. 18 m wide strips were treated based on the following pattern throughout the whole field:

a) Using passive sensor with real time variable application (SENSOR)

b) Farmer's best practice - uniform treatment – (UNIFORM)

c) NDVI obtained from passive sensor and N applied with standard machinery in zones – near real time application (ZONAL)

In this situation all field was scanned with the passive sensor, the values of "index biomass" obtained were calibrated following the methodology after Wood et al. (2003a), the field was divided into strips based on the principle above – SENSOR, UNIFORM, ZONAL, the ZONAL strips were divided into zones on the same principle as in the experiment in Wilstead. Nitrogen application was conducted twice – for main dose (April) and for late application (June). The equipment comprised N sensor, the control computer of the N sensor, GPS receiver, sprayer equipped with control computer. Application rates were estimated based on the farmer's best practice used in Slovakia, which were supported by the information from plant analyses, and the dose was estimated based on a methodology used in Slovakia after Ložek (1998). The dose was limited by legislative restrictions a maximum limit of 60 kg $N.ha^{-1}$ for one application (Bielek, 2005). As there was no yield monitoring system available for the combine harvesters on the farm, the yield was estimated on the base of yield hand samples taken from 152 x $1m^2$ quadrates. Sampling locations were targeted at the centre of each application rate zone along the variable strips. Where uniform rates were applied, the sampling location was at the centre of each zone of similar biomass.

Results

A. WILSTEAD

The field was scanned on 5th May 2006 by both the Crop Circle and the Field Scan simultaneously. The NDVI data obtained from both sensors were ground calibrated by numbers of shoots, following the methodology after Havrankova (2007) and introduced by Wood et al. (2003a). The equations of linear regression for this relationship were $y=1012x+112.24$ with $R^2=0.59$ for the Crop Circle sensor and $y=1748x-756.23$ with $R^2=0.52$ for the Field Scan sensor. The threshold values and nitrogen rates (Table 1) were estimated based on Practical guidelines "Precision farming of cereals" (Godwin et al., 2003) and personal communication with agronomist (Parrish, 2006). Crop density of below 600 / m^2 was considered as below target, 600 – 750 shoots on target and above 750 - above target. However, estimation of the threshold values is critical as the areas of above, on and below the target may change and so the design of the fertiliser application map. This could have significant influence to the overall efficiency of the sensors performance.

Table 1 Parameters and total amounts used during the experiment at Wilstead

Tiller density	<600 tillers per m^2		600 – 750 tillers per m^2		>750 tillers per m^2	
N rate	150 kg.ha^{-1}		115 kg.ha^{-1}		80 kg.ha^{-1}	
Method \ area	%	ha	%	ha	%	ha
Crop Circle	5	0.38	46	3.29	49	3.54
Uniform	-	-	100	6.16	-	-
Field Scan	-	-	55	3.42	45	2.75

Table 2 Saving on nitrogen during the experiment in Wilstead

	Crop Circle	Field Scan
Saving on nitrogen for all field, kg	110	96
Saving on nitrogen/kg.ha^{-1}	15.3	15.6

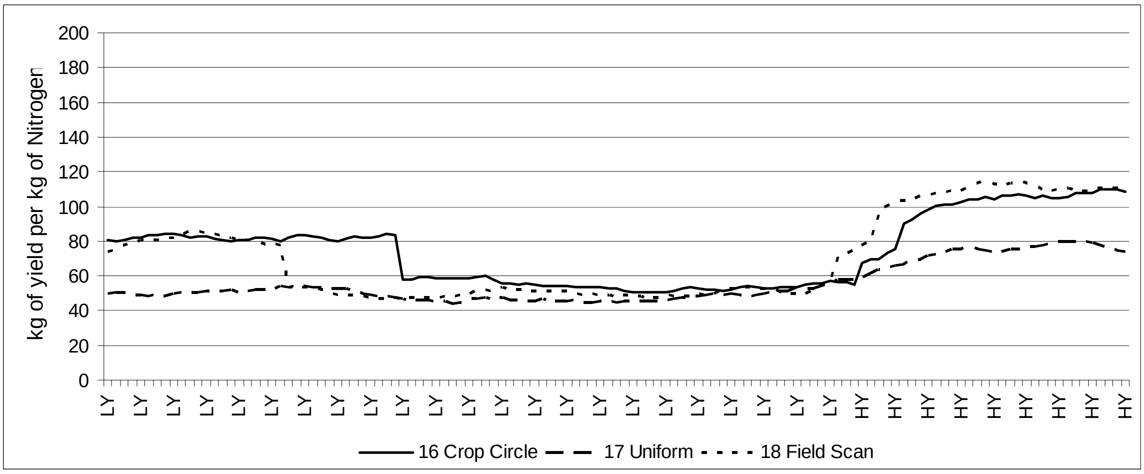

Figure 1 Nitrogen utilisation along tramlines number 16, 17 and 18 in higher and lower yielding zone

The Nitrogen rates were determined for each category of tiller density and the fertilising scenario was design applied using Extran 37% N (Yara). The total amounts of fertiliser applied are indicated in Table 1.

On the base of the experiment conducted, it can be concluded that both the Crop Circle and Fied Scan system saved on nitrogen, compared to the UNIFORM practice. Lower rates of nitrogen were applied on 49% and 45% of the area of the active and passive-based strips (Table 1), respectively; higher nitrogen rates were applied on 5% of the area using active system. Savings of 15 kgN.ha^{-1} were obtained with variable nitrogen management (Table 2). Resulting from the analyses, it could be concluded that variable application of nitrogen brought more precise targeting of nitrogen application, using the sensor approach lower nitrogen rates were applied at almost half of the field area.

The yield obtained at a particular location was divided by the amount of Nitrogen applied to obtain an N utilisation value – *i.e.* kilogram of yield per kilogram of N. Nitrogen utilisation was also assessed along the strips. As example tramlines from the area where both zones are represented are given in Figure 1.

The spatial pattern of N utilisation corresponds closely to the historical yield information. The poorest utilisation of N is in the area with low yield. From the Figure 1 it is obvious that reducing the dose based on the ground based remote sensing system brought a benefit in Nitrogen use efficiency at the beginning and the end of the tramline. The mid tramline zone has a poorer utilisation as for the CC and FS an extra nitrogen has been applied to stimulate the crop development which failed to be utilised. This suggests that the problems with the soil in this zone are not due to nitrogen but other fertility issues, which the lack of time prevented from the detailed investigation. From which it could be concluded that the yield overall was influenced by soil conditions (belonging to production zones). However, the efficiency of Nitrogen use is increased using the precision farming methods.

From the environmental point of view it is essential to apply nitrogen in the way that it does not negatively impact on ground water quality through leaching of excess, unused fertiliser. Therefore, the amount of residual nitrogen is important. To understand the N balance, five soil samples were taken at the beginning of the season. The soil samples were taken at the field in order to estimate the level of Nitrogen available form soil.

The laboratory analyses showed the average nitrogen level available for the field was 6 kg/ha. This amount did not influence the amount of nitrogen applied. The average amounts of applied Nitrogen are given in Table 3. The uniform treatment resulted in nitrogen residuals of 36.15 kg/ha whereas the variable applications CC and FS only 17.5 and 23.5 kg/ha assuming that each tonne of winter wheat grain together with equivalent of straw will take off 25 kg of N (Fecenko & Ložek, 2000).

On the basis of these analyses it can be concluded that the variable application of nitrogen, which is based on the crop status, enables a reduction of nitrogen residuals comparing to uniform treatment of 36 – 52%, which is a potentially significant environmental benefit.

B. Results

The application was performed in April and in June. Reference rate for the N sensor in April was 42 kg N.ha^{-1}, the minimum dose for N sensor was set up as 37 and maximum 46 kg N.ha^{-1}. The difference between the minimum and the uniform rate was low because of very poor status of the crop, caused by poor climate conditions in the spring of 2006. The nitrogen rates for UNIFORM application (farmers' best practice) for main dose application were 42 kg N.ha^{-1}. The nitrogen rates for ZONAL application were 37, 42 and 46 kg N.ha^{-1}. Because there were problems with fertiliser during the application of Nitrogen at the bottom tramlines, the last two tramlines were excluded from this experiment. This gives the number of 17 tramlines used for analyses. The headlands were not considered as well. Based on the analyses conducted after the application the average rate applied with passive sensor was 44 kgN. ha^{-1} and for ZONAL application 42 kg N.ha^{-1}.

More nitrogen was applied over 47% of the area, less nitrogen was applied over 30% of the area and 23% of the area received the UNIFORM nitrogen rate using ZONAL application (Table 4). It has to be stressed that the crop was very poor after winter and that laboratory analyses showed that there was need for a maximum rate across almost all over the field. From these results it is evident that almost approximately 80% of the field required different nitrogen rate compared to the UNIFORM rate.

The experiment was repeated in June, where all tramlines were used, however the headlands were excluded again. Nitrogen reference rate for N sensor was estimated as 11 kgN.ha^{-1} following the same methodology as for April. The maximum rate, set up for the SENSOR strips, was 15 kgN.ha-1 and minimum 5 kg N .ha^{-1}, the UNIFORM rate was determined as 11 kg N.ha^{-1} and for ZONAL application nitrogen rates of 7, 11, and 15 kg N.ha^{-1} were used. The average applied rate for SENSOR was 10 kg N. ha^{-1} and for ZONAL application 14 kg N. ha^{-1}. The experiment in June was analysed from the dose distribution point of view as well. The saving in fertiliser in June was at 56% of area using the SENSOR and 14 % using ZONAL application as given in Table 5.

Table 3 Nitrogen residual analyses

Treatment	N in soil, kg/ha	Other applications, kg/ha	Experiment application, kg/ha	Sum of applied nitrogen, kg/ha	Average yield, t/ha	Take off, kg/ha	N residuals, kg/ha	N residuals, %
Uniform	6	100	115	221	7.39	184.85	36.15	100
CC	6	100	99	205	7.5	187.5	17.5	48.4
FS	6	100	99	205	7.27	181.75	23.25	64.31

Table 4 Summary of application of nitrogen in April

Total area per treatment, ha	Treatment	Nitrogen rate					
		Less		UNIFORM (42 kg N. ha^{-1})		More	
		Area		Area		Area	
		%	ha	%	ha	%	ha
11.96	Sensor	19	2.23	18	2.12	63	7.61
11.97	Uniform	-	-	100	11.97	-	-
9.97	Zonal	30	2.98	23	2.31	47	4.68

Table 5 Summary of application of nitrogen in June

Total area per treatment, ha	Treatment	Nitrogen rate					
		Less		UNIFORM (11 kg N. ha^{-1})		More	
		Area		Area		Area	
		%	ha	%	ha	%	ha
13.17	Sensor	56	7.37	14	1.83	30	3.97
11.69	Uniform	-	-	100	11.69	-	-
11.74	Zonal	14	1.68	23	2.65	63	7.40

Lower nitrogen rate was applied at 56% of the area using the N sensor and at 14% of area using ZONAL approach. The same dose as the UNIFORM dose was applied only at 14% and 23 % of the field for SENSOR and ZONAL approach. So almost 80% of the field required different nitrogen levels compared with the Uniform dose. The saving of total Nitrogen applied at that field was 1.5 kg/ha, however, this was trivial. Also, it has to be stressed that the calibration of the NDVI data for the ZONAL application as well as the determination of reference rate of Nitrogen for the SENSOR data is very important, and it may influence the total nitrogen applied.

Discussion

Using the two sensors brought benefits, the lower nitrogen rate was applied over almost half of the field and the savings on Nitrogen were up to 15 kg/ha. The use of the sensors allows the nitrogen amounts to be decreased without any negative influence on yield; this increased the nitrogen efficiency of the application. Because the absolute yield values were probably influenced by soil conditions and the fertility of the soil, the absolute values of nitrogen were not the most influencing factor in terms of the yield achieved. According to the coefficient of variability, the yield was less variable along the strips where nitrogen was applied variably, compared to the uniform strips. Similar results were obtained by Feiffer et al. (2003). The nitrogen residuals in the area where Nitrogen was applied uniformly were 36.15 kg/ha, whereas in areas treated variable were the values of N in soil estimated to 17.5 and 23.5 kg/h. The variable application of nitrogen, which is based on the crop status, enables a reduction of nitrogen residuals comparing to the uniform treatment of 36 – 52%, which is a significant environmental benefit. The economical values of the benefit in the spatial redistribution of the nitrogen dose together with the benefit from reduction of nitrogen residuals in soil are however, difficult to calculate at current time. However, future work should consider the impacts of Nitrogen leaching through the de-nitrification of surface and ground water with the impact of nitrogen on soil fauna and flora as well as Nitrous oxide in the atmosphere. These would vary depending upon the soil and climatic conditions.

The most significant benefit was introduced by the spatial redistribution of nitrogen using the remote sensing approach. Because of the very poor stage of the crop after long winter in the 2006, the increase and decrease in application rates for different zones in the field were almost in balance; hence the amount of nitrogen saved was trivial.

Conclusion

Application of Nitrogen using ground based remote sensing systems is beneficial. However, the correct calibration of the sensors values is critical. In the UK conditions both ground based systems brought benefits in terms of nitrogen saving of 15kg N/ha, whilst the amount of nitrogen saved in Slovakia was small (1.5 kg/ha) in the 2006 season.

Variable application of Nitrogen brings potential environmental benefits. The variable application in the UK reduced the residual Nitrogen in the soil by between 36 and 52%.

The nitrogen use efficiency can be increased using the sensors. Despite the fact that the yield may be influenced by soil conditions, the sensors enabled the reduction in nitrogen without a negative influence on yield.

The use of sensors enabled the spatially redistribution of nitrogen to 80 % of the field area in Slovakia. This required a different application rate compared to that of the uniform farmer's best practice. The above mentioned small savings were due to the fact, that the increase and decrease in application rates were almost equal.

Future work should consider the economical values of the potential environmental benefits form variable application of Nitrogen.

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A SIMPLE MODEL OF THE BREAKING PART IN CPEM TESTS

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The CPEM (cooked potato effective mass) method is a variation of the common CPM method for potato sloughing assessment. It involves cooking the potato flakes on the sieve in a stirred water bath and determining their effective mass periodically during cooking. The resulting cooking curve consists from the cooking and breaking parts in a test with parameters: CT as cooking time required to disintegration starting and SBP as the rate of that disintegration. The breaking part is modelled in this paper on the basis of the cooking part and of the kinetic theory. Two years of CPEM tests performed on three potato varieties were used to analyse disintegration rate in dependence on tuber density. The modelled SBP values consisted of two components. The first one resulted directly from the kinetic model of the cooking part and expresses the main source of the disintegration rate dependence on tuber density. The additional mass factor is modelled tentatively by a power function, it is weakly correlated with tuber density and probably is also influenced by the CPEM experiment conditions. The sources of these causes are shortly discussed. The proposed model contributes to a deeper understanding of potato cooking.

Keywords: Potato, Cooking, Texture, Sloughing, Disintegration, Density, Kinetics

Introduction

The phenomenon of cooked potato disintegration or ”sloughing” is considered to be one of the principal characteristics of potato texture (Warren and Woodman, 1974). Sloughing is commonly assessed in sensory tests. Instrumental methods are mostly based on *CPM (cooked potato mass) - tests* (this group of tests used to be also referred to as CPW (cooked potato weight) - tests). During the CPM test (Anonymous, 1977), flakes of potato tissue are cooked in a stirred water bath then decanted and sluiced down on a sieve with 2 mm mesh. The mass of the remaining cooked potato tissue on the sieve is recorded and the characteristic time CT_{100} (the maximum cooking time up to which the initial 100 g potato mass remains on the sieve) is determined by interpolation as a measure for the resistance to sloughing.

The CPM test was modified into the *CPEM (cooked potato effective mass) sloughing method* in our previous papers (Hejlova, Blahovec and Vacek, 2006). The *CPEM method* involves cooking the potato flakes on the sieve in a stirred water bath and determining their effective mass periodically during cooking. Sloughing is characterised by two parameters, which are derived from the cooking and breaking parts in the resulting cooking curve (Fig. 1): *CT* as cooking time required to disintegration starting and *SBP* as the rate of that disintegration. Both parameters can be analysed in dependence on tuber density ρ, i.e. in linear models of cooking and disintegration stages, eventually related to a certain density ρ_0 (Blahovec and Hejlova, 2006)

$$CT = a_{CT0} - b(\rho - \rho_0) \tag{1a}$$

$$SBP = a_{SBP} - b_{SBP}(\rho - \rho_0) \tag{1b}$$

Potato softening due to cooking can be interpreted as molecular bond destruction in the whole volume of the cooked potato tissue (Daniels and Alberty, 1955). This process was described by the simplest kinetic equation of the first order with the standard solution

$$\frac{dc}{dt} = -kc \tag{2a}$$

$$c = c_0 e^{-kt} \quad , \tag{2b}$$

where k (min^{-1}) means kinetic coefficient dependent on the cooking temperature, t (min) is time of cooking and c denotes molecular bond concentration. The latter units are not specified, and mostly relative values related to the initial bond concentration c_0 corresponding to the raw stage are used. The kinetic coefficient k could be derived experimentally from an analogous model of texture changes expressed as a decrease of Young modulus of elasticity (Blahovec and Esmir, 2001).

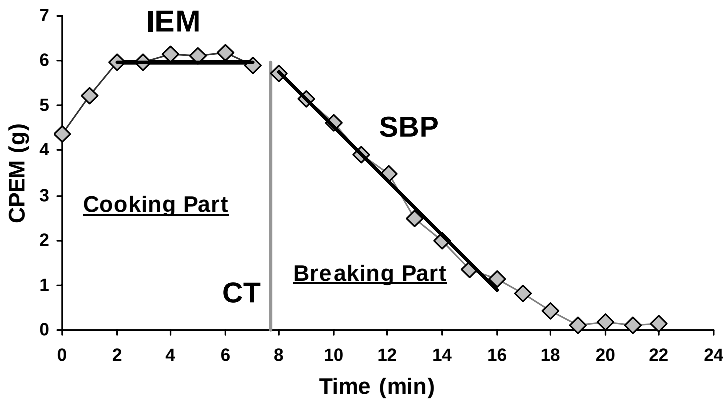

Fig. 1: Scheme of the CPEM cooking curve: *CT* (cooking time) defined as intersection of the *IEM* (initial effective mass) and the linear approximation of the breaking part by excluding its last part, the *SBP* (slope of the breaking part) derived as the slope of the approximation with opposite sign.

The CPEM tests were connected with that simple kinetic model (Blahovec and Hejlova, 2007). In this connection the cooking time *CT* derived from the cooking part of a CPEM test coincides with the time required to reaching the critical bond concentration c_{CT} at which the cooked potato tissue begins to disintegrate. The relative critical bond concentration c_{cr} represents the portion of the initial bond concentration c_0 that was not destroyed in the cooking part and follows from (Eq. 2b)

$$c_{cr} = \frac{c_{CT}}{c_0} = e^{-kCT} \qquad (3)$$

Two years of CPEM tests performed on three different potato varieties, in one case grown in six different cultivation modes, showed relatively close relationships between CPEM parameters and tuber density (Hejlova and Blahovec, 2007a,b). The linear model of cooking stage (Eq.1a) was replaced into the Eq. 3 creating a kinetic model of the cooking part. Hence the relationship between critical bond concentration and tuber density was studied (Blahovec and Hejlova, 2007).

The cooking curve resulting from a CPEM test $m=m(t)$ (Fig. 1) can be understood as a composite function of bond concentration c and time t. Then the parameter *SBP* can be expressed as the rate of depression of the effective potato mass at the time $t = CT$ in the following manner:

$$SBP = \left[-\frac{dm}{dt}\right]_{t=CT} = -\left[\frac{dm}{dc}\right]_{c=c_{CT}}\left[\frac{dc}{dt}\right]_{t=CT} . \qquad (4)$$

In this paper the breaking part of a CPEM test was modelled on the basis of the cooking part and of the kinetic theory. An estimation of *SBP* values was searched tentatively with the aim to analyse dependence of disintegration rate on tuber density using data from previous CPEM tests.

Kinetic model of the breaking part

The second term in the relation for *SBP* (Eq. 4) follows from Eq. (2b):

$$\left[\frac{dc}{dt}\right]_{t=CT} = -kc_{CT} = -kc_0 e^{-kCT} \qquad (5)$$

The first term in Eq. (7) expresses change of the effective potato mass during a CPEM test inside the sieve basket due to change of the cell wall bond concentration close to its critical value c_{CT}. It is determined by getting the potato fragments through the sieve meshes. The following estimation of this term is based on our conception of its asymptotic values. We assume

$$\lim_{c_{CT}\to 0}\left[\frac{dm}{dc}\right]_{c=c_{CT}} = \infty \, , \qquad (6a)$$

this value represents a firm fictive tissue which would not disintegrate for non zero bond concentrations. Further we denote and assume that

$$\lim_{c_{CT}\to c_0}\left[\frac{dm}{dc}\right]_{c=c_{CT}} = K \, , \; K < \infty \; . \qquad (6b)$$

One of the suitable functions with the required asymptotic values is the generalized power function:

$$\left[\frac{dm}{dc}\right]_{c=c_{CT}} \approx K\left(\frac{c_0}{c}\right)^n\Bigg|_{c=c_{CT}} = K\left(\frac{1}{c_{cr}}\right)^n , \; c_{cr} \in (0,1\rangle \qquad (7)$$

with the parameter $n>0$ (see Fig. 2).

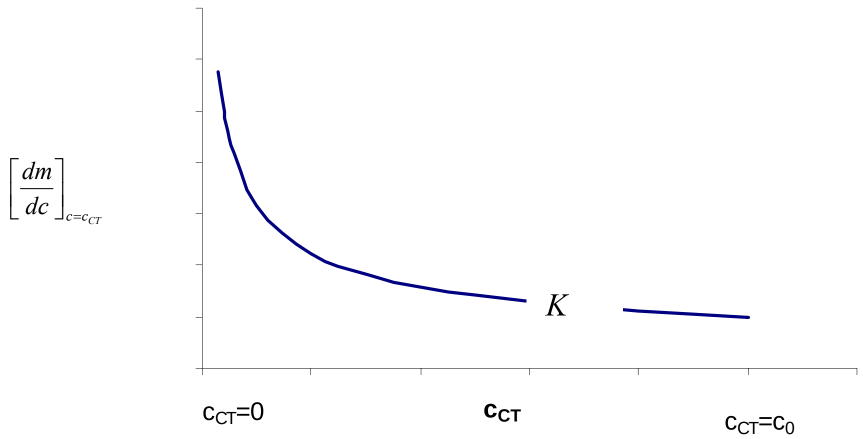

Fig. 2: Schematic conception of $\left[\frac{dm}{dc}\right]_{c=c_{CT}}$ in dependence on critical bond concentration, see Eq. 6a, 6b.

Then the estimation of *SBP* (Eq. 4) can be written as a product of two components

$$SBP \approx -\left[\frac{dm}{dc}\right]_{c=c_{CT}} \left[\frac{dc}{dt}\right]_{t=CT} = K\left(\frac{c_0}{c_{CT}}\right)^n kc_0 e^{-kCT} = Kc_0 k\left(e^{-kCT}\right)^{1-n} = m_0 SBP_{\text{mod}} \quad (8)$$

The model component SBP_{mod} results directly from the kinetic model of the cooking part as

$$SBP_{\text{mod}} = k\left(e^{-kCT}\right)^{1-n} . \quad (9)$$

The other term m_0 represents a mass factor [g] and can be computed from the experimental *SBP* data and its model component as

$$m_0 = Kc_0 \approx \frac{SBP}{SBP_{\text{mod}}} . \quad (10)$$

Our further analysis targeted the relationship between *SBP* estimation (Eq. 8) and tuber density. The parameter n was studied tentatively with the aim to find an expression for SBP_{mod} dependence on density which would be common for all tested potato groups. *SBP* values are positively correlated with density (Blahovec and Hejlova, 2006, Hejlova and Blahovec, 2007a,b) and SBP_{mod} (Eq. 9) dependence on density can be derived from linear models of cooking stage (Eq. 1a). Hence the parameter n should fit into the interval (0,1).

Applications to Previous Data

SBP_{mod} values (Eq. 9), m_0 values (Eq. 10) and corresponding linear models in regard of density (compare with Eq. 1a,b) for various n values, $0<n<1$

$$SBP_{\text{mod}} \approx a_{\text{mod}} + b_{\text{mod}}\rho \quad (11a)$$

$$m_0 \approx a_{m0} + b_{m0}\rho \quad (11b)$$

were computed in individual potato groups (Table 1). The parameter optimum value n_{opt} was related to the maximum regression coefficient b_{mod} in (Eq. 11a). The R^2 values regarding these models coincided with those from linear models of cooking stage (Eq.1a, Table 1). In all groups the n_{opt} corresponded to relatively low coefficients of determination in the relations between m_0 and density (Eq. 11b), in some cases even to its minimum (Fig. 3 a,b). Similarly low variances of m_0 were associated with n_{opt} in individual groups.

Table 1.: Statistical analysis of experimental and model parameters

		Number				SBP_{mod}		m_0		
Potato group		of	R^2 (CT)	R^2 (SBP)	n_{opt}	b_{mod}	R^2 (SBP_{mod})	MV	SD	R^2 (m_0)
		tests	(-)	(-)		($m^3.min^{-1}.kg^{-1}$)	(-)	(g)	(g)	(-)
A1	2004	9	0.39	0.33	0.35	0.00134	0.38	11.56	1.10	0.027
A1	2005	10	0.92	0.44	0.2	0.00179	0.95	10.17	2.79	0.003
A2	2004	10	0.66	0.74	0.3	0.00159	0.64	9.91	0.96	0.030
A2	2005	11	0.91	0.81	0.35	0.00185	0.90	8.90	1.82	0.320
A3	2004	10	0.62	0.82	0.4	0.00135	0.60	7.87	0.97	0.088
A3	2005	10	0.90	0.95	0.2	0.00178	0.91	11.32	1.57	0.023

Potato group		Number of tests	R^2 (CT)	R^2 (SBP)	n_{opt}	SBP_{mod}		m_0		
			(-)	(-)		b_{mod} ($m^3.min^{-1}.kg^{-1}$)	R^2 (SBP_{mod}) (-)	MV (g)	SD (g)	R^2 (m_0) (-)
A4	2005	10	0.87	0.87	0.4	0.00156	0.90	7.42	0.86	0.001
A5	2005	10	0.80	0.52	0.3	0.00166	0.82	7.53	1.46	0.168
A6	2004	10	0.67	0.52	0.2	0.00213	0.66	11.27	1.49	0.009
A6	2005	10	0.73	0.88	0.2	0.00150	0.74	11.29	0.95	0.241
Agria	2004+05	100	0.67	0.62	0.2	0.00148	0.67	10.91	2.34	0.001
Nicola	2004	9	0.49	0.31	0.35	0.00018	0.49	9.95	0.79	0.079
Nicola	2005	13	0.68	0.43	0.2	0.00021	0.70	11.21	1.49	0.108

Notes: CPEM data of Agria cultivated in six different regimes and Nicola see in (Blahovec and Hejlova, 2006, Hejlova and Blahovec, 2007a,b)
R^2 coefficient of determination in relations between given quantity and tuber density ρ (Eq. 1a,b, 11a,b respectively, only data with R^2(CT)>0.35 are involved into the analysis), MV mean value, SD standard deviation,
SBP_{mod} and m_0 computed according Eq. 9 and Eq. 10, respectively, with kinetic coefficient k = 0.178 (min^{-1}) for Agria, k = 0.081 (min^{-1}) for Nicola (Blahovec and Esmir, 2001, Blahovec and Hejlova, 2007)

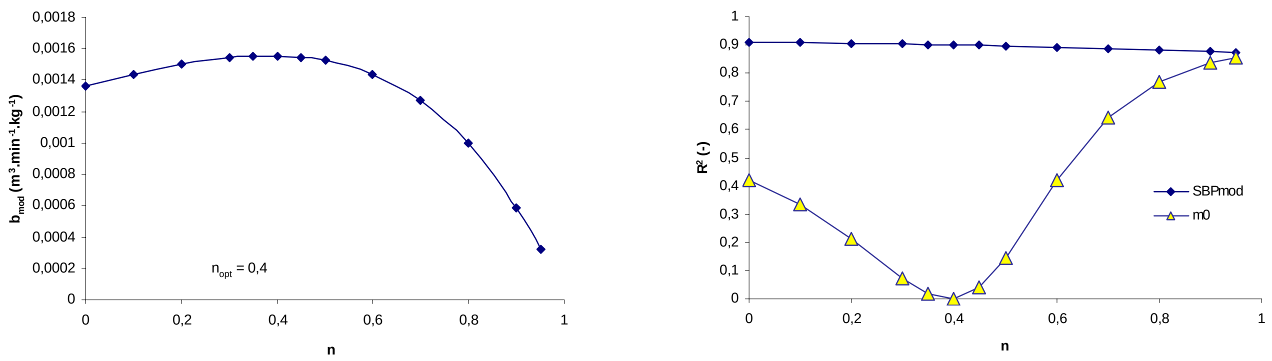

Fig. 3) Analysis of model parameters in dependence on parameter n (an example, data Agria 4 2005)
a) b_{mod} regression coefficient in Eq. 11a
b) R^2 in the relations between given quantity and density (Eq. 11a,b)

The main source of SBP estimation (Eq. 8) dependence on density laid probably in the dependence of its model part SBP_{mod} on density in individual groups. The latter was given by linear models of cooking stage, i.e. by the CT dependence on density (Eq. 1a). The choice of the optimum parameter value n_{opt} resulted into a week correlation between the additional mass factor m_0 and density in individual groups. This factor represented probably the CPEM experiment conditions (sieve and stirring parameters).

For Agria and Nicola tubers the parameter values n_{opt} between 0.2 and 0.4 were indicated (Tab. 1). The m_0 mean values corresponding to these n_{opt} values were included in the relatively narrow interval (7.87, 11.56) for both tested varieties (however some significant differences between the tested groups could be proven). This fact supports our guess that the parameter n_{opt} could express some inner disintegration relation associated with experiment conditions and relatively independent on the tested variety.

Conclusions

The disintegration part of the cooking curve in CPEM method follows the cooking part, especially in terms of kinetics of the controlling processes. Disintegration rate expressed as $\left[\frac{dm}{dc}\right]_{c=c_{CT}}$ is successfully described by the special power function with exponent n as a free parameter. The statistical analysis of previous CPEM data shows that $n \in (0.2, 0.4)$ is an optimum value for data plotted versus the tuber density.

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SEEDS AND GRAINS CHARACTERISTIC DETERMINATION USING ELECTRICAL PROPERTIES IN LOW FREQUENCY RANGE

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Electrical properties measurements are except of moisture content estimation applied for determination of various characteristics of agricultural materials and food, for example for determination of the frost sensitiveness, of chilling and freezing tolerance, of seeds germination, of mechanical stress and also at the pasteurization. These measurements are utilized at determination of other properties of grains, seeds, meat, sugar, milk, wood, soil, fruit and vegetable, infected food … We investigated changes in chemical components and in electrical properties of wheat grains and oleaginous seeds during storage. Relative permittivity decreases with storage time according to quadratic function. Similarly for the crude protein, wet gluten content and starch content and that is why a correlation exists between changes in relative permittivity and also in these components during storage.

Keywords: electrical properties, utilization, seeds, grains

1 Introduction

Electrical properties of the biological tissues have been of interest for many years. When studying the physical properties of tissue, it is necessary to consider its non-homogeneity from the macroscopic and microscopic points of view. When testing the electrical properties from the microscopic point of view, it is apparent that inside the cell is conductive because there is conductivity of ion type in the content of the organic and inorganic matter solutions. The cell membranes are not conductors. From the macroscopic point of view, it is possible to regard the biological materials as non-homogeneous semi-conductors or dielectrics. The density and structural arrangement of the cells in them and the properties of each type of tissue influence the electrical properties of these materials. The characteristics of loose and porous materials are also influenced by the properties of air, which is trapped between the parts or in the pores, most especially its relative humidity and temperature. The deployment of the parts in the pack, the size of parts, gappiness, contact surface and bulk density also influence the electrical properties of loose materials. Among the influential factors for porous materials the following can be involved: size and distribution of pores, porosity and bulk density. Further factors are temperature of the material, but the most significant is influence of the water presence, its uneven deployment in the material, different binding energy in each water bond in the material and sorption properties (Hlaváčová, 2003).

2 Electrical conductivity utilization

Biological material properties are determined from their leachates, too. There were for example seeds or grains deterioration described in the paper of Verma et al. (2001). The conductivity values of the seed leachates were recorded after different soaking periods. It was observed that as the ageing period increased, conductivity values also increased. However, a significant increase in leaching was observed after 24 h of soaking period. Results also showed that the increase in conductivity values of the seed leachates at different soaking periods was related to initial degree of deterioration of the seed lots. The conductivity values of the seed leachates in 3-year-old seeds were high compared with those of one- and two-year-old seeds in all soaking periods in all lots.

Couto et al. (1998) utilized this method for quantitative mechanical damage evaluation in soybeans. Two modifications on the electrical conductivity test methodology were made: the utilization of a new number of grains per volume of water; and the introduction of a stirring process. Samples of soybeans were damaged by cutting the grain at the cotyledon junction and by impact of a mass falling from different heights. The samples of varying levels of damage were soaked in distilled water and their electrical conductivities were measured over 160 min at intervals of 20 min. The results showed that at soaking times other than zero, the response of electrical conductivity due to variations in percentage of damage was linear or quadratic.

Panayotov and Aladzadhzian (1999) utilized the resistivity and absorption spectra of leachates from soaked pepper seeds. The resistivity decreased with development of seeds. Authors recommended to use these results in seed production and to obtain data on the condition and the sowing quality of seeds. Differences of the electrical conductivity, organic and inorganic constituents in leakage from aged and non-aged vegetable seeds were observed by Min (1995). The exudates from aged seeds contained higher concentrations of K, total sugars and total amino acids than those from control seeds. Dias and Marcos-Filho (1997) utilized the electrical conductivity tests for vigour of soybean seeds and Kim (1998) for vigour of rice seeds determination.

Panobianco et al. (1999) utilized the same method for determination of correlation between the electrical conductivity of soybean seed and seed coat lignin content. Seeds were tested for electrical conductivity using four replicates of 50 seeds per cultivar soaked in 75 ml of deionized water at 25°C for 24 hours. It was concluded that seed soaking electrical conductivity is influenced by the seed coat lignin content. The electrical conductance test can be used as a valuable tool in the screening process for lignin content during soybean breeding, as the lignin plays an important role in resistance to mechanical damage and thus is a component of seed quality.

In many works the seed and grains properties determination are described. Aladhzadhzian and Panayotov (1999) established a correlation between seeds germination and electrical resistivity. They observed that the resistivity was the lowest and optical density was the highest in younger seeds. The standardization of the electrical conductivity test for tree seed vigor was given by Sorensen et al. (1997).

Our measurements were made with variously treated seeds (filed, coated and encrusted) of 9 sugar beet cultivars (Hlaváčová, 2003). It was found that the electrical conductivity of seeds is affected by their surface treatment. The current passing through the pack of seed was measured. The current increases linearly with the voltage (in the measured voltage range to 200 V). The highest current flowed through the sample of filed seeds and the lowest through encrusted seeds (fig.1).

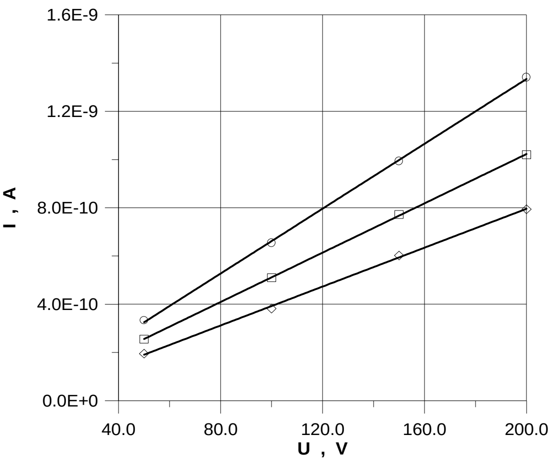

Figure1 – the relationship between the current passing through the sample and the voltage, for sugar beet seeds, of cultivars Intera (filed seeds, ○**)**, Polina (coated seeds, □) and Remona (encrusted seeds, ◇) at average moisture content of 9.39 %

Average conductivity at the moisture content of 9.39 % for cultivar *Remona* (encrusted seeds) was $1.741.10^{-10}$ $S.m^{-1}$, for cultivar *Polina* (coated seeds) $2.285.10^{-10}$ $S.m^{-1}$ and for *Intera* (filed seeds) $3.006.10^{-10}$ $S.m^{-1}$. It follows that coating and encrusting of seeds decrease their conductivity. The mode of sugar beet seeds surface treatment could be dedicated by the measurements of their electric properties.

Yu et al. (1995) utilized the electrical properties for selection of seeds with high viability, which is related to their amylase activity, proteinase activity and electrical conductance. They investigated the influence of high voltage electrostatic field separating effect on the biotic factors of rice, rape and sesame seeds during their sprouting period. When passed through a high-voltage electrostatic field, the rice, rape and sesame seeds were displaced towards the field. The separation between seeds of similar quality from the same height varied considerably and was related to the germination percentage of the seeds.

Many authors deal with the exploitation of electrical properties at mechanical stress determination in materials. De Andrade et al. (1999) evaluated the mechanical damage to the bean seeds using electrical conductivity. Seeds of Phaseolus vulgaris were mechanically damaged at velocities of 10.0 $m.s^{-1}$, 13.0 $m.s^{-1}$ or 16.5 $m.s^{-1}$. Measurements of the electrical conductivity showed good correlation with the degree of mechanical damage.

3 Dielectric properties utilization

Permittivity of granular materials has been a subject of extensive study due to its inherent relationship with moisture content. Quality of agricultural products during harvesting, storage, processing and trading is controlled by its moisture content. Various techniques have been developed to study the permittivity of granular materials. While measuring the permittivity of granular materials one ends up measuring the permittivity of the mixture of material with air, since in the bulk of granular materials there always exist air voids. The measurement techniques appropriate for any particular application depend on the frequency of interest, on the nature of the dielectric material to be measured and on the degree of accuracy required (Nelson, 1999). Berbert et al. (2001) described the electronic devices that measure an electrical property of the material that is dependent on its moisture content. It is believed that a sensing device based on the capacitance principle of moisture estimation is more likely to meet the needs of ease of use, speed of measurements, and overall lower cost as compared to that of an equivalent microwave system. Sensors for grain moisture content determination normally consist of two electrodes and the most appropriate arrangement is either as parallel or juxtaposed plates or concentric cylinders. The parallel plates arrangement has the advantage of providing a uniform electric field but, if the cell is not shielded, influence of external objects on the cell capacitance may introduce appreciable errors in the measurement. Three parallel plates (outer plates are connecting to ground) can be used as a measure to reduce the effect of stray capacitances between the cell and the surroundings. The main disadvantage of the concentric cylinders arrangement is associated with the non-uniformity of the electric field between the plates.

Estimation of water content from electromagnetic field measurements make use of the large relative permittivity of water compared to other material components. Teng et al. (1999) studied for example the characteristics and relationships between impedance and frequency, impedance and moisture respectively for the vegetable seeds. Snell et al. (2005) determined the relationships between the moisture content of chopped maize (chopped by a self-propelled forage harvester) and fundamental electromagnetic parameters, to aid in measurement of moisture content. Using an experimental SAIREM RF application unit at a frequency of 27.12 kHz, different parameters depending on the dielectric properties of the material were recorded, applying an electromagnetic field to chopped maize with different contents of dry matter. Li et al. (1996) described a capacitance sensor for the on-line measurement of flowing and static grain moisture. Han et al. (1996) used a needle-type capacitance method for measuring moisture content in grains. Ananyev (2001) described the determination of grain moisture and bulk density using values of dielectric permittivity components measured on the fixed frequency. There is established that the function

$$S = \frac{\varepsilon''}{\left(\sqrt{\varepsilon'} - 1\right)^2} \qquad (1)$$

at f = cons. depends only on moisture content and does not depend on density. These results can be utilized for grain moisture meters.

Thakur and Holmes (2001) used a three dimensional vector finite element method to model the permittivity of rice grain using the scattered far field radiation. Scattering of incident plane wave radiation is analyzed to extract the permittivity of granular material. Some reduced parameters obtained from the scattered electric field show a very good correlation with the permittivity of materials (both dielectric constant and loss factor). They noted the generalized mixture equation to be applicable to the rice and air mixture

$$e^{\alpha\varepsilon_{eff}} = v_1 e^{\alpha\varepsilon_1} + \left(1 - v_1\right) e^{\alpha\varepsilon_2} \qquad (2)$$

where ε_1, ε_2 and ε_{eff} are the permittivity of rice, air and their mixture, respectively, v_1 is the volume fraction of the rice, α is a constant which is – 0.3363 for rice and air mixture.

We investigated changes in chemical components and in electrical properties of wheat grains and oleaginous seeds during storage. Results showed that specific changes occurred in quality of all grains and seeds components – proteinic profile and saccharide complex during storage.

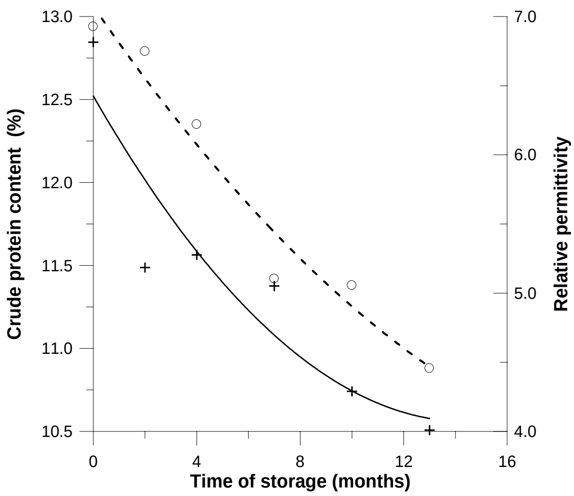

Figure 2 – changes in crude protein content (o) and in relative permittivity (+) during the storage for wheat grains at the frequency 3 kHz

Relative permittivity decreases with storage time according to quadratic function. Similarly for the crude protein, wet gluten content and starch content and that is why a correlation exists between changes in relative permittivity and also in these components during storage (Fig. 2). The stability of fat component is important in stored oil-seeds and it is longer at higher content of the oleic acid (Hlaváčová, Muchová, 2005).

Zhao (2000) discussed the electric field and magnetic field effects on plant seeds, affirms the positive effects of the electromagnetic field treatment on the physiology and biochemistry indexes, which can raise the vitality and germination rate of seeds, and increase the germinating energy of seeds. The present condition and developing process of seed dielectric separation apparatus and equipment are introduced and analyzed.

Dielectric properties of materials are measured in high frequencies range, too. Nelson (2005) presented perspective on dielectric properties of agricultural products, including their use for rapid measurement of moisture content in grain and in considering potential dielectric heating (radio-frequency or microwave) applications. Dielectric properties data for grain, insects, and fruit are presented and related to applications for selective heating of insects in grain and potential maturity and quality sensing in fresh fruits and vegetables. Principles are also discussed for the use of microwave dielectric properties for sensing moisture content in grains.

Time domain reflectometry has become a standard method for water content measurement in soils but also in other materials. The results presented by Pavlík et al. (2007) have proved the capability of TDR method for measurement of moisture content in granular agricultural materials. The applied measuring technique is applicable for the all studied materials except soybean Evans that has shown only slight dependence of relative permittivity on moisture content. The obtained data can be considered as calibration curves of TDR method for particular materials and can be utilized in agriculture and food industry.

4 Conclusions

Electrical properties measurements are except of moisture content estimation applied for determination of various characteristics of agricultural materials and food, for example for determination of the frost sensitiveness, of chilling and freezing tolerance, of seeds germination, of mechanical stress and also at the pasteurization. The mode of sugar beet seeds surface treatment could be dedicated by our measurements of their electrical properties. We also investigated changes in chemical components and in electrical properties of wheat grains and oleaginous seeds during storage. A correlation between changes in relative permittivity and also in some chemical components was found. However, plant grains and seeds are so complex in their composition and in their electric behavior, that it is usually necessary to measure the electrical properties under the particular conditions of interest to obtain reliable data.

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TEMPERATURE DEPENDENCIES OF DARK BEER RHEOLOGIC PROPERTIES DURING STORAGE

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At quality valuation of food material is important to know their physical properties particularly mechanical, rheologic and thermophysical. Automatically controlled processes at manufacturing, at handling and holding require exact knowledge about physical quantities of materials. Rheologic properties were measured by many authors. Results from measuring of rheologic properties of dark beer are shown in this paper. Measuring was performed by digital viscosimeter Anton Paar (DV-3P) and principle of measuring by this viscosimeter is based on dependency of sample resistance against the probe rotation. Sample of dark beer was stored in special cool box in temperature 3 °C and was measured in different days during two weeks. Measurements were done after the temperature stabilization from 7 °C to laboratory temperature. Dependencies of dynamic viscosity, kinematic viscosity and fluidity on temperature and on time of storing are described.

Keywords: dark beer, rheologic properties, dynamic viscosity, kinematic viscosity, fluidity

1 Introduction

In this paper are shown results from measuring of rheologic properties of dark beer. We can include into rheologic properties these parameters: dynamic viscosity, kinematic viscosity, fluidity and tangential tension. Materials, where internal friction is generated, can be characterized by viscosity. Dynamic viscosity $\boldsymbol{\eta}$ is defined as a constant between tangential tension $\boldsymbol{\tau}$ and gradient of layer velocity **grad** $\boldsymbol{v}$.

$$\tau = \eta \text{ grad } v$$

Physical unit of dynamic viscosity is Pa.s and unit of tangential tension is Pa. Kinematical viscosity $\boldsymbol{\nu}$ is defined as a ratio between dynamic viscosity $\boldsymbol{\eta}$ and density of used material $\boldsymbol{\rho}$.

$$\nu = \frac{\eta}{\rho} \quad (1)$$

Physical unit of kinematic viscosity is $m^2.s^{-1}$. Reciprocal value of dynamic viscosity $\boldsymbol{\eta}$ is called fluidity $\boldsymbol{\varphi}$ and physical unit of fluidity is $Pa^{-1}.s^{-1}$.

$$\varphi = \frac{1}{\eta} \quad (2)$$

Rheologic properties were measured by many authors. Buchar et al. (2005, 2003), investigated these properties of eggs yolk, milk products and ketchups. Severa et al. (2007) examined influences of storing on viscosity of egg fluids. Marudova and Zsivánovits (2005) described rheologic properties of pectin films. Biczó et al. (2005) examined methods for determination of rheologic properties of chocolate mass. At quality valuation of food material is important to know their physical properties particularly mechanical, rheologic and thermophysical (Božiková, 2005). Automatically controlled processes at manufacturing, at handling and holding require exact knowledge about physical quantities of materials. Still are detected new methods that are utilizing new modern apparatuses and microscopic components. Very fast development is possible to observe at utilization of microwave at measuring properties of soil and food (Hlaváčová, 2002). Tóth and Opáth (2006) were concerned with physical and chemical properties of beer and they also described ways and equipments for beer filtration.

2 Material and methods

Used sample of dark beer was obtained from Department of animal husbandry and food production of Slovak University of Agriculture in Nitra.
Measuring was performed by digital viscosimeter Anton Paar (DV-3P). Principle of measuring by this viscosimeter is based on dependency of sample resistance against the probe rotation. Probe with signification R2 was used in our measurements. We were able to choose frequency of probe rotation from 0.3 min^{-1} to 200 min^{-1}. We had used these frequencies: 1 min^{-1}, 10 min^{-1}, 50 min^{-1}, 100 min^{-1}, 150 min^{-1} and 200 min^{-1}.

Sample of dark beer was stored in special cool box in temperature 3 °C and was measured in different days during two weeks. Measurements were done after the temperature stabilization from 7 °C to laboratory temperature. Dependencies of dynamic viscosity on temperature are constructed. Values of kinematic viscosity and fluidity were calculated from measured values of dynamic viscosity according to equations (1) and (2). Dependencies of kinematic viscosity on temperature and temperature dependencies of fluidity are drawn. Dependency of these parameters on time of storing is described.

3 Results

For illustration on Fig. 1 – 3 are shown dependencies of dark beer dynamic viscosity on temperature and on Fig. 4 are dependencies of dark beer dynamic viscosity on temperature after different time of storing. Progress of graphic dependencies can be described by decreasing linear function

$$\eta = -A\left(\frac{t}{t_0}\right) + B \qquad (3)$$

where t is temperature, t_0 = 1 °C; A, B are constants dependent on kind of material, and on ways of processing and storing .

Table 1 – Coefficients A, B of regression equation (3), and coefficients of determination

Measurement Coefficients	First measurement	Second measurement	Third measurement
A	0.262 424	0.263 636	0.267 576
B	23.998 8	24.118 2	24.331 2
R^2	0.980 412	0.989 489	0.988 368

In Tab. 1 can be seen coefficients A, B of regression equation (3), and also that coefficient of determination had high values for all measurements.

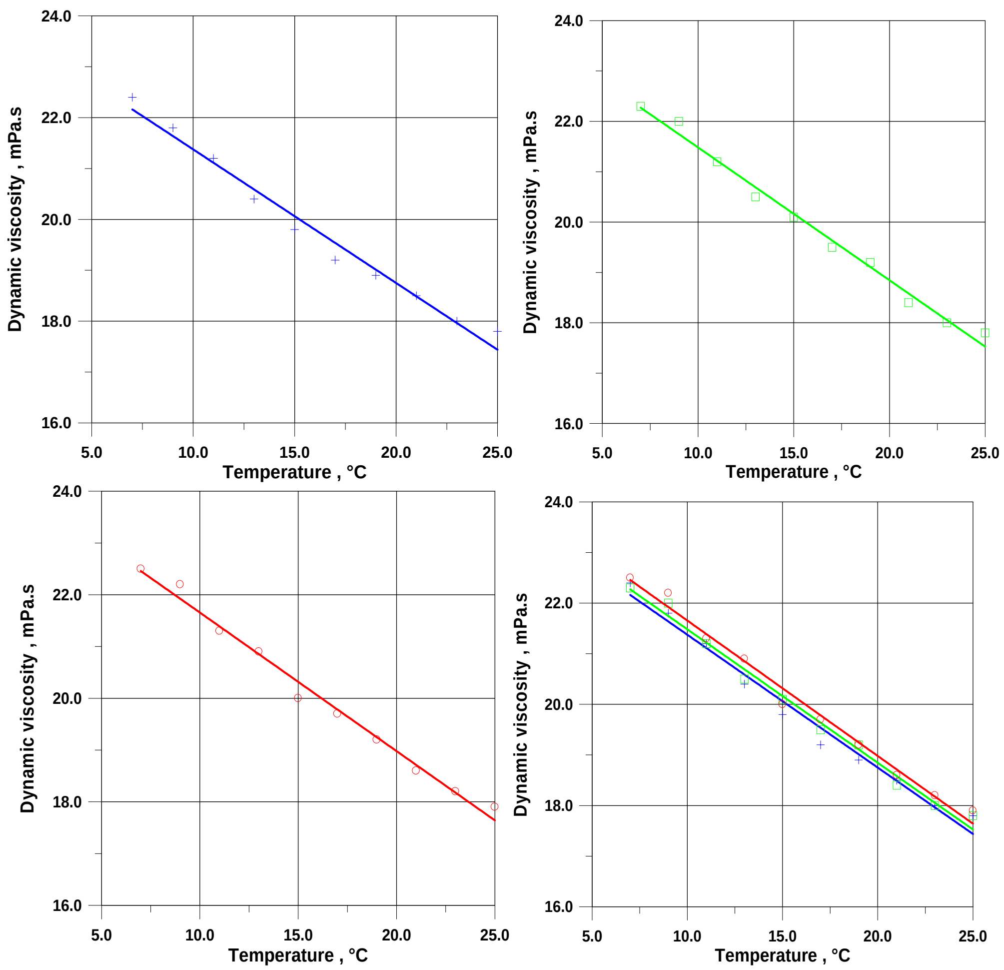

Figure 1-4 – Dependencies of dark beer dynamic viscosity on temperature after different time of storing : first measurement (+), second measurement after one week of storing (□), third measurement after two weeks of storing (○)

Temperature dependencies of dark beer dynamic viscosity had decreasing linear shape for all measurements (Fig. 1 – 3) and it is also evident that dynamic viscosity had increased a bit with time of storing (Fig. 4).

The dependencies of dark beer kinematic viscosity on temperature are on Fig. 5 – 7 and on Fig. 8 are dependencies of dark beer kinematic viscosity on temperature after different time of storing. Progress of graphic dependencies can be described by decreasing linear function

$$\nu = -C\left(\frac{t}{t_0}\right) + D \qquad (4)$$

where t is temperature, t_0 = 1 °C; C, D are constants dependent on kind of material, and on ways of processing and storing .

In Tab. 2 can be seen coefficients C, D of regression equation (4), and also that coefficient of determination had high values for all measurements.

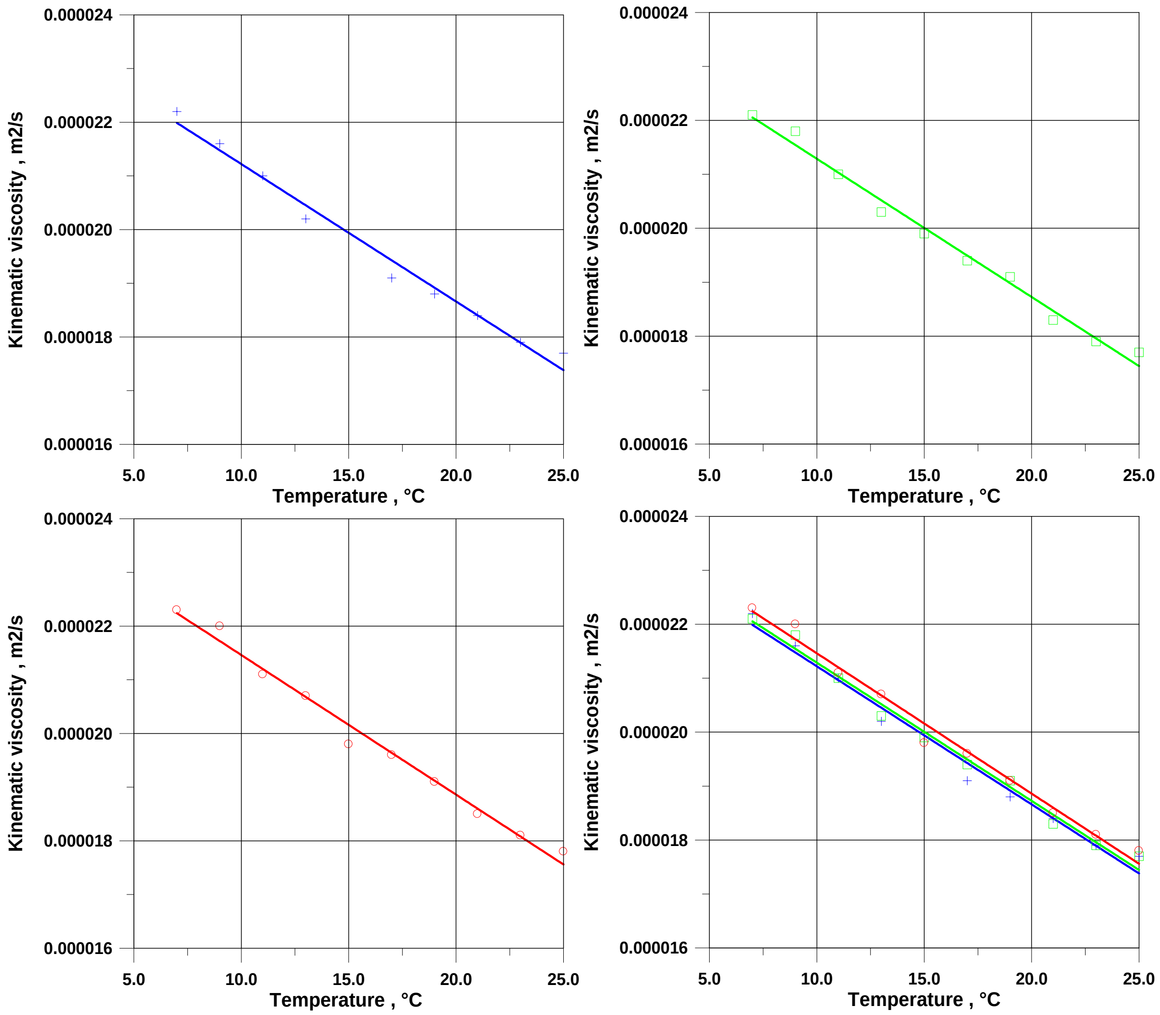

Figure 5-8 – Dependencies of dark beer kinematic viscosity on temperature after different time of storing: first measurement (+), second measurement after one week of storing (□), third measurement after two weeks of storing (○)

Table 2 – Coefficients C, D of regression equation (4), and coefficients of determination

Measurement / Coefficients	First measurement	Second measurement	Third measurement
C	2.558 78*10^{-7}	2.560 61*10^{-7}	2.6*10^{-7}
D	2.377 8*10^{-5}	2.384 7*10^{-5}	2.406*10^{-5}
R^2	0.984 068	0.988 674	0.987 080

The dependencies of dark beer kinematic viscosity on temperature had decreasing linear shape for all measurements (Fig. 5 – 7) and it is evident that kinematic viscosity had increased with storing time (Fig. 8).

Temperature dependencies of dark beer fluidity are on Fig. 9 – 11 and on Fig. 12 are dependencies of dark beer fluidity on temperature after different time of storing. Progress of graphic dependencies can be described by increasing linear function

$$\varphi = E\left(\frac{t}{t_0}\right) + F \qquad (5)$$

where t is temperature, t_0 = 1 °C; E, F are constants dependent on kind of material, and on ways of processing and storing .

Table 3 – Coefficients E, F of regression equation (5), and coefficients of determination

Measurement / Coefficients	First measurement	Second measurement	Third measurement
E	0.664 636	0.667 152	0.658 923
F	40.164 8	39.869 6	39.694 1
R^2	0.992 104	0.992 957	0.994 731

In Tab. 3 can be seen coefficients E, F of regression equation (5), and also that coefficient of determination had high values for all measurements.

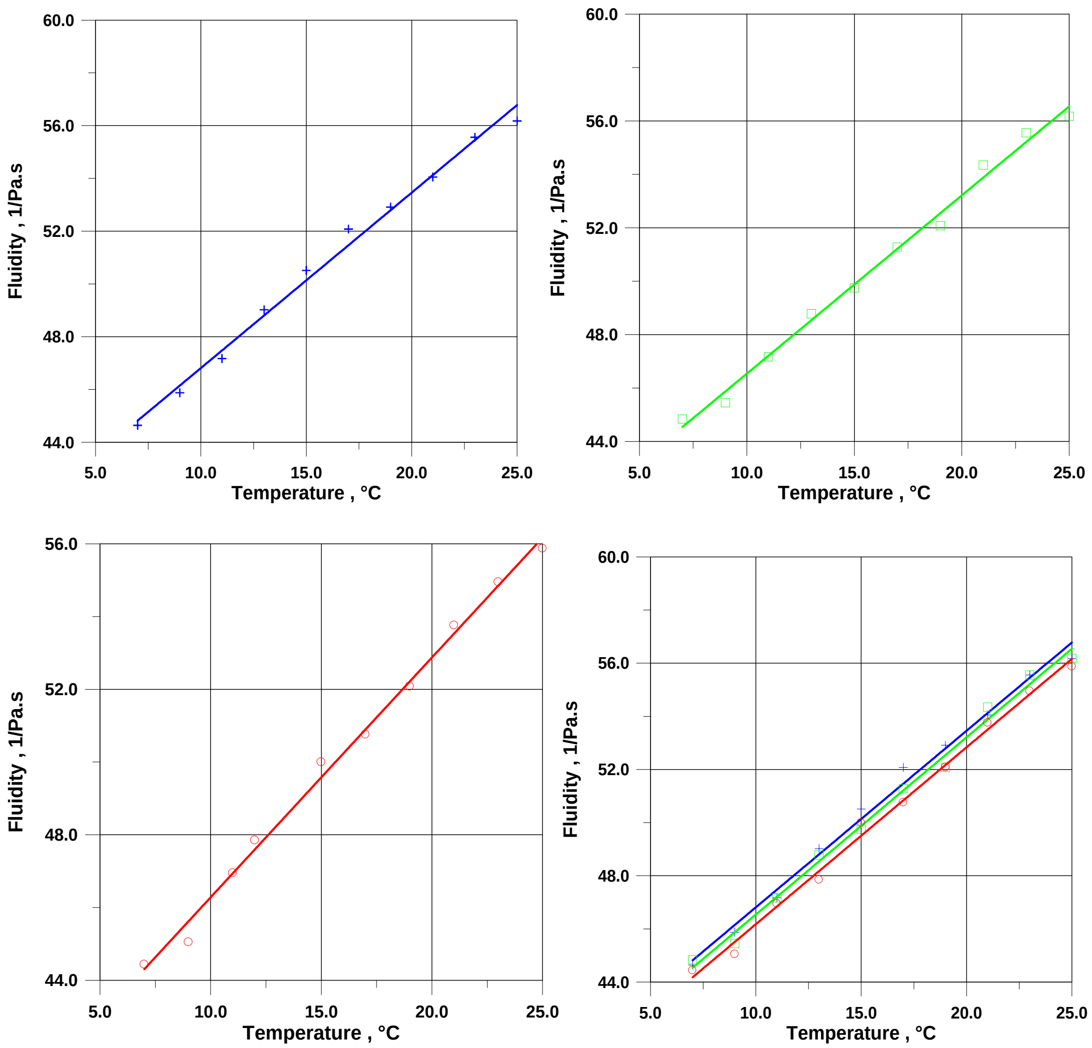

Figure 9-12 – Dependencies of dark beer fluidity on temperature after different time of storing : first measurement (+), second measurement after one week of storing (□), third measurement after two weeks of storing (○)

The dependencies of dark beer fluidity on temperature had increasing linear shape for all measurements (Fig. 9 – 11) and it is also evident that fluidity of dark beer had decreased a bit with time of storing (Fig. 12).

4 Conclusions

At quality valuation of food material is important to know their physical properties particularly mechanical, rheologic and thermophysical. Automatically controlled processes at manufacturing, at handling and holding require exact knowledge about physical quantities of materials. Rheologic properties were measured by many authors.

Temperature dependencies of dark beer dynamic viscosity had decreasing linear shape for all measurements and it is also evident that dynamic viscosity had increased a bit with time of storing.

The dependencies of dark beer kinematic viscosity on temperature had decreasing linear shape for all measurements and it can be seen that kinematic viscosity of dark beer had increased a bit with storing time. The dependencies of dark beer fluidity on temperature had increasing linear shape for all measurements and it is evident that fluidity of dark beer had decreased a bit with storing time. Measured values of dynamic viscosity and calculated values of kinematic viscosity and fluidity were obtained with good precision and all drawn dependencies had very high coefficients of determination.

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OVERLAY MATERIALS AND THEIR TRIBOLOGICAL BEHAVIOUR

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At present a great number of machines and mechanisms of various types are used in the industrial production. Often the whole operation depends on the trouble-free service of single parts and many times a minor defect may conduce to the shutdown of the whole production line or of the other operation. From this reason the uncaused losses of many thousands often occur. One of the very effective measures of the wear resistance increase is surfacing of functional surfaces using the suitable overlay material. Used overlay materials have various properties. In the paper the chosen overlay materials are compared by means of the abrasive wear determination. The wear resistance was tested using the laboratory apparatus with bonded abrasive particles (according to CSN 01 5084).

Keywords: overlay materials, functional surfaces, abrasive cloth, abrasive wear, abrasive particles

1 Introduction

The optimal user utility of various products, machines, machine parts, tools and instruments affects remarkably the economy in all fields of productive and nonproductive activity. Among others it is important from the point of view of most of the materials consumption, namely of metals and metal alloys.

Losses caused by wear are not only losses of material, but they are also significant in losses in production, namely in the case of important functional parts outage. Owing to wear of the important machine functional parts often a destruction of a greater complex occurs. Then the losses are very perceptible.

In practice several ways are possible how this aim can be reached. One of them is the surfacing of functional surfaces by the use of overlay materials of special properties. Surfacing is used not only for renovation but for new machine parts production, too. Wear resistance is an important indicator, which characterizes the overlay material suitability for the given purpose. The knowledge of all factors is necessary for the design and for the process of manufacture and renovation.

Surfacing is used not only for renovation but for new machine parts production, too. It may bring a significant effect in saving of material, costs and time. The great advantage of surfacing is the relative rapid wear resistance increase.

The main saving is in the possibility to use the common carbon or low-alloy steel and the material of higher wear resistance is applied only on edges and surfaces which get worn.

2 Experimental determination of abrasive wear resistance

Laboratory tests

According to the conditions in the contact area the laboratory tests are classified in

- Testing machines with bonded particles
- Testing machines with free particles
- Testing machines with a layer of free particles between two contact surfaces.

Bonded abrasive particles can be in form of an abrasive cloth or of an abrasive wheel. Machines with abrasive cloth are used for testing of metal materials most often. Simplicity and reliability are their advantage. The scattering of results is relatively small. The variable quality of used abrasive cloth is their disadvantage. It must be running compensated by the use of etalons.

Following machines pertain to this class:

- Machines with rotary motion – CSN 01 5084 "Determination of metal material resistance against wear by abrasive cloth",
- Machines with linear reciprocating motion, eventually machines with abrasive belt.

The advantage of machines with rotating disk is the possibility of abrasive wear testing under high temperatures. The disadvantage of all machines with bonded particles is the decreasing abrasiveness of the abrasive wheel or of the abrasive cloth in the course of tests. The abrasive particles become blunt and they crumble out by the interaction with tested surfaces. More-over the surfaces are befouled by the worn out particles.

Testing machines with free particles is possible to classify in;

- Machines with abrasive vessel
- Machines with elastic disk

- Machines with abrasive drums.

The principle of machines with abrasive vessel is the vessel containing abrasive particles, which the test specimens are dipped in. The interaction of specimens and abrasive particles motion causes that the specimen surfaces wear out.

The advantages of machines with abrasive vessel are the better approximation to service features, the possibility to use various abrasive particles and to test under high temperatures, too. The disadvantage is the decreasing abrasiveness owing to their interaction with tested specimen surfaces (crushing, blunting, contamination by worn out particles etc.). In practice it is solved by the periodical exchange of abrasive particles.

At machines with elastic disk the abrasive effect is provoked by particles showered between the specimen and the rotating disk. In this way the conditions near to the operation of parts working in soil are simulated. The reduced repeatability of test results at the use of nonstandard abrasive of various particles size is the disadvantage.

Machines with abrasive drum are very simple and reliable. They make possible measurement of several specimens in one stage. The possibility of various abrasive types use (e.g. soil, sand, scappling, grit) is the advantage.

Except the above mentioned machines a row of pilot character machines exists (laboratory jaw crushers, hammer mills etc.).

It is usually possible to simulate only some of basic parameters. Therefore the laboratory test results are applicable only after the total analysis of real service conditions. On the other hand in laboratory conditions we can study the single factors influence on the wear character and intensity.

Field tests

Field tests make possible to watch and evaluate the wear directly on the given machine part or assembly group. The test results are often influenced by a variability of operation factors. Therefore they are significant only for the concrete production equipment working in similar conditions.

3 Tested materials and testing method

For determination of abrasive wear resistance three overlay materials were chosen, namely coated electrodes of ESAB. Overlays of seven layers were welded on. The nominal chemical composition of the overlay metal is presented in Tab. 1 (according to the catalogue of the manufacturer).

Tab. 1 Nominal chemical composition (%)

Overlay material	C	Si	Mn	Cr	Ti	V
A	0,25	0,5	0,3	13	-	-
B	4,5	0,8	1	33	-	-
C	3	2	0,3	6,3	4,8	5,7

The manufacturer characterizes the overlay materials as follows:

- A – electrode for the corrosionproof martensitic-ferritic deposit, suitable for cladding on shafts, table rollers, pinions, seatings etc.
- B – high-productive electrode for cladding on parts of earth moving and stone treatment machines subjected to high abrasion by sand, gravel, ore, coal and other mineral matters; the overlay is corrosionproof at temperatures up to 1000° C.
- C – basic electrode giving the deposit with high fraction of fine carbides in martensitic matrix; it is abrasive wear resistant, suitable for machines for rock drilling, hammers, scrapers, excavators etc.

The overlay was made according to conditions recommended in the catalogue of ESAB. The steel CSN 11 373 (according to CSC 41 1373) was the basic material of dimensions 80 x 80 x 20 mm. After surfacing from the plate the specimens of dimensions 25 x 25 x 20 mm were made.

4 Wearing test

The tests of the abrasive wear resistance were carried out using the pin-on-disk machine with abrasive cloth according to CSN 01 5048 (Fig. 1). The machine consists of the uniform rotating disk whereon the abrasive cloth is fixed. The test specimen is fixed in the holder and pressed against the abrasive cloth by the weight. Further it consists of the screw which makes possible the radial feed and of the limit switch. During the test the specimen moves from the outer edge to the centre of the abrasive cloth and a part of the specimen surface comes in contact with the unused abrasive cloth.

The testing apparatus according to CSN 01 5084 was accommodated with regard to the necessity of bigger specimens (25 x 25 x 17.5 mm) jigging. The test conditions as load, speed and length of the pad were equal for all specimens. The Vickers diamond hardness HV 30 of all specimens was determined using the hardness testing machine HPO 250.

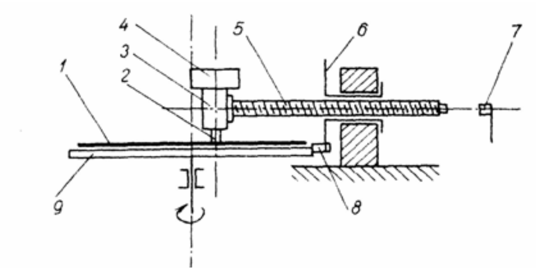

Figure 1 Diagrammatic arrangement of the pin-on-disk machine for the abrasive wear resistance determination using the bonded particles (1 - abrasive cloth, 2 - specimen, 3 - holder, 4 - weight, 5 - screw, 6 - nut with cog, 7 - limit switch, 8 - pin, 9 - horizontal plate)

5 Test results

The wear resistance of overlay materials was tested from the overlay surface to the basic material by steps of 1.5 mm. The hardness was measured on the front surface of dimensions 25 x 25 mm. The same surface was worn out. Afterwards the surface was grinded off to the depth of 1.5 mm and the whole process was repeated (hardness, wear resistance). The test results are presented in Figs. 5, 6 and 7. The wearing test was finished when the overlay thickness of about 2.5 mm was reached, because the specimen of smaller thickness could not be fixed in the holder. The microstructure of the overlay surfaces was evaluated, too (Figs. 8, 9 and 10).

The tests were finished when the distance from the overlay surface of 16.5 mm was reached, approximately in the boundary between the overlay and the basic material.

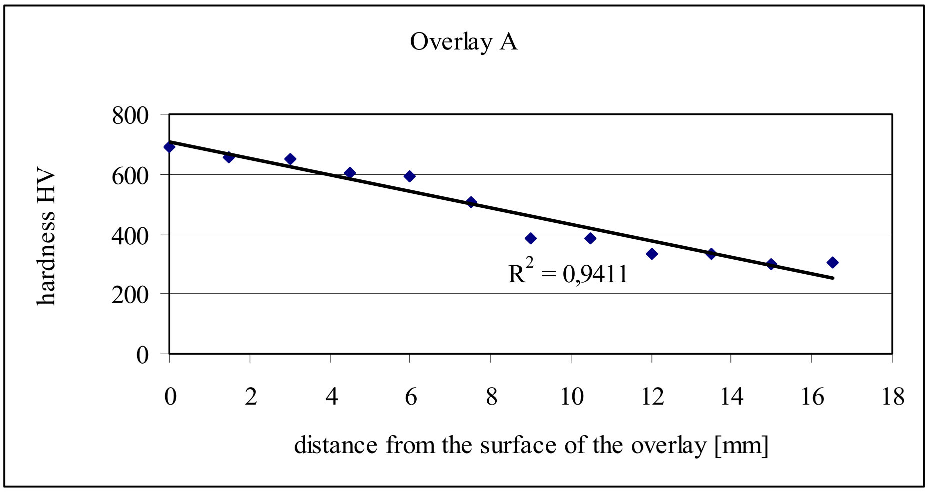

Figure 2 Relation between hardness and distance from the surface of the overlay A

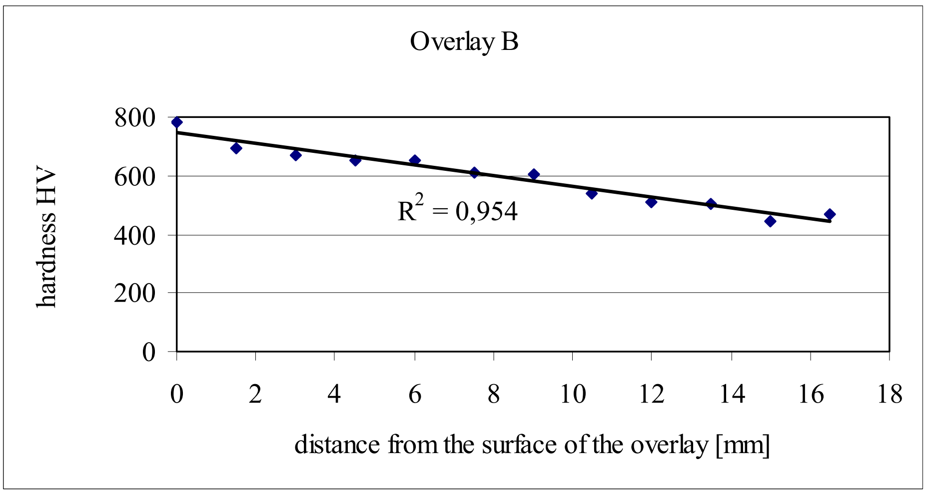

Figure 3 Relation between hardness and distance from the surface of the overlay B

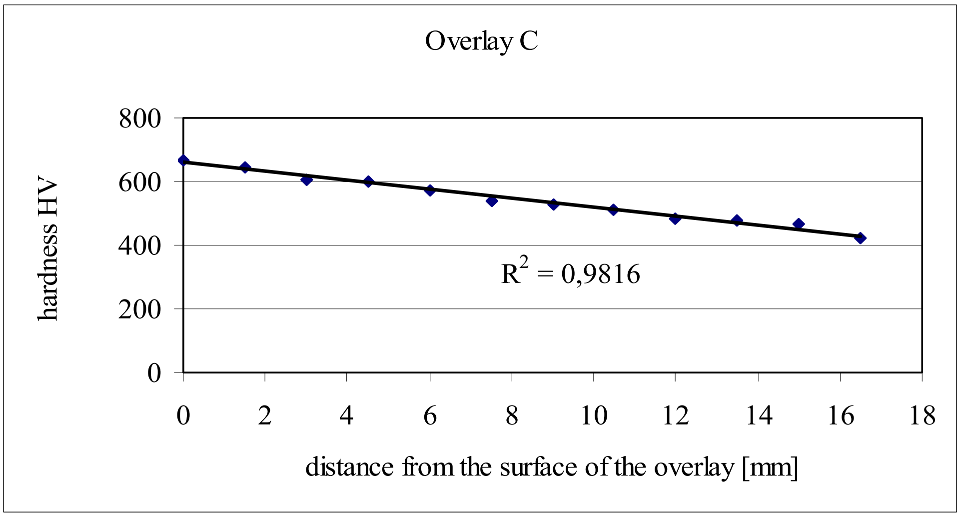

Figure 4 Relation between hardness and distance from the surface of the overlay C

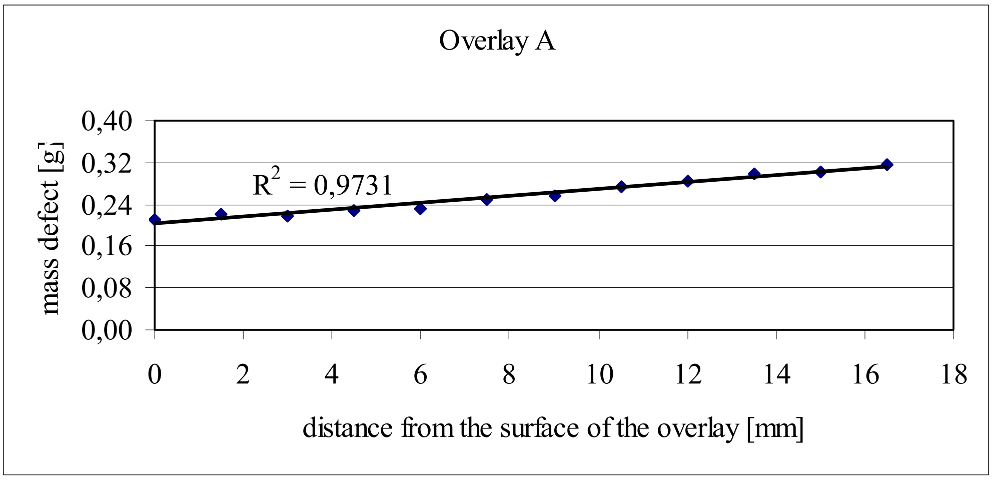

Figure 5 Relation between mass defect and distance from the surface of the overlay A

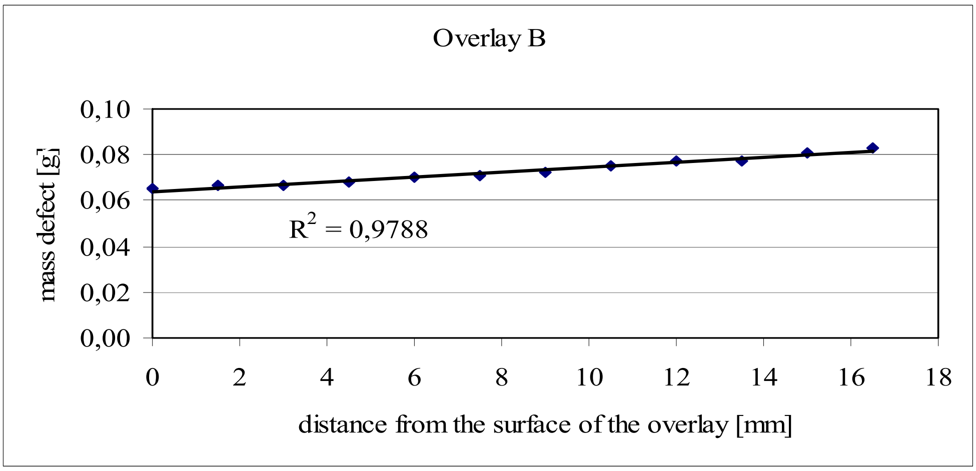

Figure 6 Relation between mass defect and distance from the surface of the overlay B

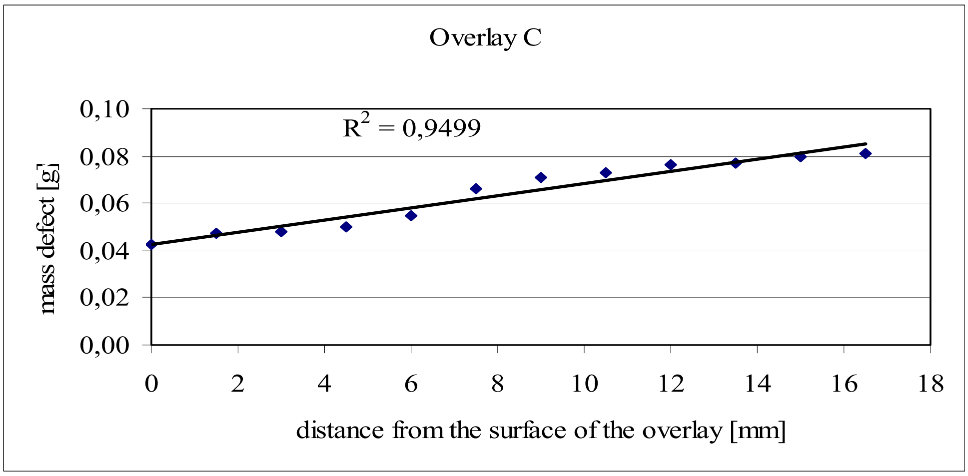

Figure 7 Relation between mass defect and distance from the surface of the overlay C

Table 2 Metallography of the overlay materials

A	martensite with needlelike orientation
B	carbidic formations with fine martensite
C	fine needlelike martensite with Cr, V and Ti carbides

6 Conclusions

At renovation by surfacing or at preventive surfacing such processes are looked for in order to reach the best wear resistance. The wear resistance depends on the overlay hardness and on the microstructure.

According to the presumption the experiments confirmed that the hardness of all three tested overlays decreases in the direction to the basic material. The decreasing trend is possible to express by a linear equation (by a line) (see Figs. 2, 3 and 4). At the wearing tests the mass defect of single layers was determined. The mass defect increased (again according to the presumption) in the direction to the basic material (see Figs. 5, 6 and 7).

The decreasing character of the overlay hardness can be explained by the different cooling rate and by the different chemical composition of tested overlays. At all layers of multilayer overlays the mixing with previous layers occurs. This tendency is most expressive at the first layer when the overlay metal intermixes with the basic metal. In this way the "dilution" of the overlay metal by the previous layer metal occurs. In practice the alloying elements content of the previous layers is always smaller. Besides at cooling the reciprocal diffusion of elements in the liquid mass and in the solid solution occurs in the direction of the concentration gradient.

With regard to these presumptions it is possible to say that the course of the chemical composition will correlate with the resultant overlay hardness and the content of the most important elements of the overlay material will decrease in the direction to the basic material.

Acknowledgement:

The paper has been done during the solution of the grant TF CZU 31140/1312/313105 of the title "Study of martensitic overlay layers and of the structural phases influence on their properties".

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EXAMS OF OVERLAY MATERIALS WITH REGARD TO ABRASIVE WEAR CAUSED BY BONDED ABRASIVE ELEMENTS

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In the paper there were published test results of the abrasive wear resistance of BOHLER THYSEN Co. overlay materials. Using the abrasion tester with abrasive cloth there was compared the abrasive wear resistance of single-, two- and three-layer overlays according to the ČSN 01 5084.

Keywords: abrasive wear, abrasive particles, welding, overlay material

1 Introduction

A great part of machine malfunctions has its origin in the wear of single parts. The seizing of functional surfaces, affected by impeded working conditions, causes machine defects, too. At some events these defects can be prevented by various design adaptations. From constructions reasons we cannot sometimes change the machine design. Then it is necessary to choose the suitable material or to accommodate the surfaces of functional planes and edges.

Above all the material suitability depends on the wear type. The machine part wears more quickly if it works at heightened or even at high temperature and in chemical active environment. Wear is a very complicated physical-chemical effect. Simply schematic we can imagine the wear as the scraping or the abrasion of the functional surface. Owing to wear the part stops to have the specified size and form, the set becomes minor effective and reliable and within the further operation the critical condition can be reached and the failure occurs.

One of the effective provisions in order to the wear resistance increase is the surfacing of functional surfaces using the suitable overlay material. The used overlay materials have different properties. At their choice we must respect the stress mode and the composition of the basic metal. Other overlay materials are suitable for work with sand and gravel, other ones for tools for soil cultivation.

At high stressed parts, where we wish the most long service life, we must choose the better material than the basic metal is. To this purpose we have at disposal the various alloy steels, alloys containing high percentage of carbide generating elements, hard nonferrous alloys on the cobalt or nickel basis, overlays with wolfram carbides etc.

The surfacing is used not only for renovation but for new machine parts production, too. It may bring a significant effect in saving of material, costs and time. The advantage of the surfacing is the quick wear resistance increase. As a rule it is applied where we cannot reach the required surface quality using the usual methods of heat or chemic-heat treatment, e.g. face hardening, case hardening, nitriding, carbonitriding or hard chroming, by reason of difficult working conditions. The signification of the surfacing becomes evident at big machine parts which are very hard worn out. Otherwise the whole part has to be made from a costly material. In many cases the surfacing is the sole solution how to keep the mentioned mechanism working without expensive reconstructions or without the performance decrease. The machine parts with overlays have often so long service life that the choice of this more expensive metallurgical surface treatment is multiple rewarding.

For surfacing of minor stressed surfaces it is possible to use the cheaper electrodes. On the functional surfaces, which must be more resistant, it is necessary to use the more resistive material.

2 Tested overlay materials

In the repair practice many overlay alloys of different properties are used. It is possible to classify them into these classes:

1) Martensitic overlays: this class includes all overlays which can acquire the martensitic structure by hardening. The maximum hardness of the heat treated martensitic overlay depends above all on the carbon content. The hardening or the other heat treatment is exceptional, therefore for the classification the hardness reached by cooling by heat removal into the basic material, so called natural hardness, is decisive.

2) Austenitic overlays: they are very wear resistant after the strain hardening. These steels are very ductile, but they have relatively low hardness – about 200 HV. By hard strokes the surface formation hardens and the hardness increases till to 500 HV and is more wear resistant.

3) Ledeburitic overlays: in contrast to martensitic and austenitic overlays the overlay from the alloyed cast iron has the characteristic ledeburitic structure of very high abrasive wear resistance. Above all the hypereutectic cast irons, containing the long needles of free carbides in the basic more ductile eutectic, are very suitable for hard wear conditions caused by mineral abrasive. Partly the cheaper white cast irons are used, which differ only by the higher chromium content (2 to 5 %), partly the high alloyed cast irons, which contain 20 to 30 % of chromium.

4) Nonferrous materials on the cobalt and nickel basis: nonferrous materials on the cobalt basis are used with regard to their excellent properties to special purposes. Their merits are:

- high hardness till to about 700 º C,
- maximum hardness can be reached without the heat treatment,
- high stability to chemical attack,
- high wear resistance.

5) Carbides: the tungsten carbides have the high hardness and the abrasive wear resistance by minerals. The overlay demands the ductile basement of the basic material to acquire besides the abrasive wear resistance the impact resistance, too.

Four overlay materials of BOHLER TYSSEN Co. were chosen. The abrasive wear resistance of single layer, twin layer and three-ply layer were compared. The directive chemical composition of tested materials is presented in Tab. 1.

Use field:

UTP LDURIT 60 is the universal overlay material determined for the hardening of parts, which are exposed tu the intense emery wear at low effort, e.g. conveyer screws, dipper teeth, sand pump mixers and for cover layers on the ductile weld metal or on the hard Mn steel.

UTP LEDURIT 65 is determined for the hardening of parts, which are exposed to the intense mineral wear at increased temperatures to 500º C. The high wear resistance is reached thanks to Mo, V, W, Nb carbides. It is suitable for the use to tool hardening for the soil cultivation parts, parts in the building and stone industry as spiders and sintering grates.

UTP DUR 600 is determined for the universal hardening of parts from steels, alloy steels and Mn hard steels which are exposed to abrasion, pressure and impact. Preferred use field is the surfacing of parts for soil working, e.g. elevation dredger teeth, and parts for working of rock, e.g. breaker jaw, breaker cone, impact strip and hammer of the grinding mill bruiser, cutting edge and working surface of the cool work tool. Machining of the weld metal is possible only by grinding.

UTP DUR 650 Kb is determined for the hardeming of the parts which wear out at uniform impacts. The main use field is the surfacing of tools soil working machines and for rock breakers. Machining of the weld metal is possible only by grinding.

Tab. 1 Nominal chemical composition (%)

electrode	C	Si	Cr	Mn	Mo	Nb	W	V	Fe
60	3,2	1,0	29	x	x	x	x	x	rest
65	4,4	x	23,5	x	6,5	5,5	2,2	1,5	rest
600	0,5	2,3	9	0,4	x	x	x	x	x
650 k	0,5	0,8	7	1,3	1,3	0,5	x	x	x

3 Test process and evaluation

Four overlay materials were tested (Tab. 1) using the abrasive cloth according to ČSN 01 5084. Numbers 60, 65, 600, 650 marks the overlay material type, numbers 1, 2 and 3 marks the number of layers.

Figure 1 Overlay using the electrode 60 – 3


Figure 2 Overlay using the electrode 65 – 3


Figure 3 Overlay using the electrode 600 – 3


Figure 4 Overlay using the electrode 650 – 3

The test specimens of 25 x 25 x 17.5 mm size were made using the grinding apparatus for the metallographic samples preparation. The supply of a great quantity of the cooling liquid is its advantage. Then during the grinding any excessive heating does not occur. Using the above mentioned process 3 specimens were cut from each plate.

The etalons were made from the bar steel 12 014 of the square section of 25 x 25 mm. The hardness HV 30 of all specimens was measured using the hardness tester HPO 250. The measured results are presented in Fig. 6.

The relative wear value ψ_h [%] is calculated as a ratio of the mass lost of the test specimen to the mass lost of the reference specimen (etalon). The test results are presented in Fig. 6. As we do not know the density [ρ], the relation presented in the standard ČSN 01 5084 was adapted and the relative wear value is calculated using the relation (1).

$$\psi_h = \frac{W_{hZ}}{W_{hPZ}}.100 \quad [\%] \qquad (1)$$

Where W_{hZ} - mean mass of lost of the tested specimen [g]

W_{hPZ} – mean mass of lost of reference specimen (etalon) [g]

The tests of the abrasive wear were carried out using the pin-on-disk machine with abrasive cloth according to ČSN 01 5084 (Fig. 5). The pin-on-disk machines with abrasive cloth are used most often. Their advantages are the simplicity and the reliability. The results variance is relative small. The disadvantage is the variable quality of the abrasive cloth, which must be continuous compensated by use of etalons. The machine consists of the uniform rotating disk whereon the abrasive cloth is fixed. The test specimen is fixed in the holder and pressed against the abrasive cloth by the weight of 2.35 kg. The screw makes possible the radial feed of the specimen. The limit switch stops the test. During the test the specimen moves from the outer edge to the centre of the abrasive cloth and a part of the specimen surface comes in contact with the unused abrasive cloth.

The test machine according to the ČSN 01 5084 was accommodated. The holder is adapted for the specimens of 25 x 25 x 17.5 mm size.

The wear resistance tests were carried out as the comparison tests. The wear was determined by weighing. The test conditions, as load, speed, length of the path were equal. The specimens and etalons were tested alternately.

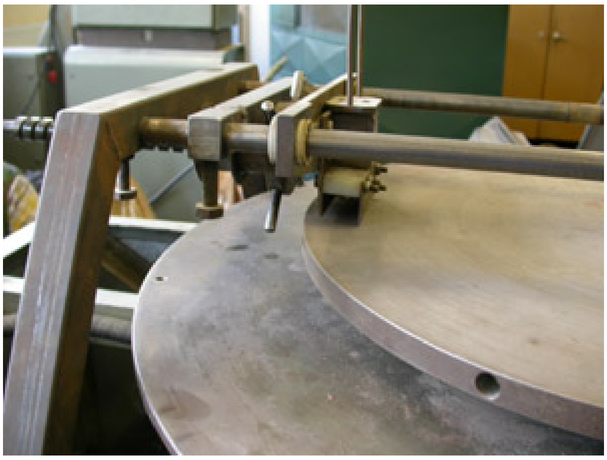

Figure 5 The pin-on-disk machine for the wear resistance tests

4 Tests results

From the results it follows that the best overlay material was the material Nr. 65 which presented the wear of less than 6 % at the single layer and of 4.3 % at the three-ply layer. From the Fig. 6 it follows that the hardness decrease decreases the wear resistance, too (etalon) and conversely (overlay material Nr. 65). The overlay materials Nr. 600 – 1, 2, 3 have got the same wear resistance. Evident it is influenced by the similar chemical composition. The measured results show that the number of the layers influences the amount of the wear, too. At the overlay material 600 the wear difference between the single layer and the three-ply-layer is almost 20 %.

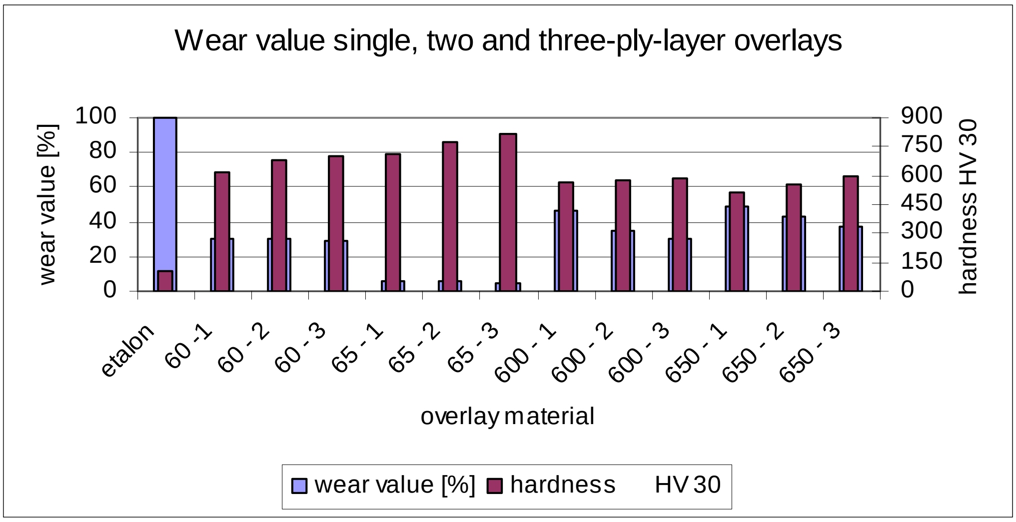

Figure 6 The relative wear and hardness values of tested overlay materials according to ČSN 01 5084

5 Conclusions

In the paper there are published the abrasive wear results of overlay materials of BOHLER THYSEN Co. The wear resistance, using the pin-on-disk machine with abrasive sloth according to ČSN 01 5084, was tested at single, two and three-ply-layer overlays.

It is evident from the table of the chemical composition that the overlays marked 60 and 65 are high alloyed with chromium. The overlay material 65 does not contain Si, but it contains next alloying elements (Mo, Nb, W, V). All these elements create with C carbides. The overlay material 600 and 650 pertain to the class of lower chromium content.

For every use the overlay material must be chosen according to the load mode. Commonly the hardest overlay material of high wear resistance (vide Fig. 6 – overlay material 65) is impossible to use when the impact, tensile and bend occur, because they are less failure resistant. The producer recommends this overlay material for the constructional parts hardening, when the intense emery wear at low load occurs and for the cover layer on the ductile weld material or Mn hard steel. Conversely the overlay material 650 has got the lower wear resistance, but it can be used when impact occurs. Its matrix is more ductile and therefore the splitting does not occur. The producer recommends this overlay material for the constructional parts hardening where the wear and even impact occurs. Always we must look for the optimum choice with regard to wear resistance x toughness.

When solving a definite problem it is necessary to take into consideration the technical and economical problems. It means that the problem must be realizable with low costs of the whole surfacing process.

Acknowledgement:

The paper has been done during the solution of the grant TF CZU 31140/1312/313105 of the title "Study of martensitic overlay layers and of the structural phases influence on their properties".

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STAFF TRAINING AND INFORMATION FLOW HANDLING AS A TOOL FOR QUALITY IMPROVEMENT AND CLAIM COST REDUCTION

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Nowadays many firms are so focused on improving quality of their services and manufacture that they often forgot to imprint their visions on employees. Usual procedure is to implement new standards and briefly inform staff about changes and what they are supposed to do to fulfill management's needs. But the key element is usually forgotten – the employee has to know why he has to do so and must be attuned with firm's visions and goals. The information flow is usually so complicated that in crucial situations is crowded with unusable or incomplete data so final decisions may be incomplete or may miss some critical elements. Good management has to set up a communication tree for better, faster and more important the lowest error tolerance factor. But there may be problems in rivalry and competition between divisions and thus this problem should be solved by special interpersonal training that is slowly coming into management's standards.

Keywords: Staff training, interpersonal relations, improvements in claim process

1. Introduction

The quality improvement of technological process may be achieved by many different ways according to management of particular firm. Human factor is the most important part in this section more than any other element included in technical industry. Robots and automatic assembly lines do their perfect flawless job as long as human factor do his job done. Although automats help eliminate human flaws in assembly or construction, these machines are dependant on humans as far as maintenance goes. So after all workers may endanger whole process by quality of their work. If standards are set up for common procedures, it's imperative for employees to accustom with these new rules in order to improve quality of their work. Staff training and education is one of the criteria that are crucial in selecting particular job for future employee. And it is not just enlargement of current knowledge base but really good training program should help people to set up new education areas that may be useful in case analysis. Proper training may result in shorter reaction times, shorter decision making process and of course reduces economic influence on customers and firm.

2. Competence of worker

Determined by many factors like:

- Motivation and Shared firm vision
- Qualification
- Salary
- Technical and technological equipment
- Information and training
- Interpersonal relations

Motivation and Shared firm vision

For proper efficiency of worker is crucial to be attuned to firm policy and vision. The most workers actually don't know firm's goals or visions. Such worker is not interested in goodwill of firm so his acts are in self profit way. Motivating process is long run and many firms are starting focusing on well behaving employee in order to increase his efficiency and interpersonal connections. Cultural aspects are also important in implementing motivation programs for staff. By implementing certain visions you may encounter impenetrable wall of misunderstanding just because of multicultural details.

Qualification

In order to increase production capability or quality outputs in crucial to maintain certain level of qualification for all workers in firm. Most of employees wont self educate so it's up to management to increase theirs capability and bring more flexibility to process. Many secondary actions do not require high amount of qualification so it's possible to spread knowledge base of key workers beyond they primary tasks and make them more flexible for other supplement tasks. In after sales departments where most of claims are being solved is high and professional qualification required for decisions that may result in economical impacts or benefits on firm.

Salary

Salary is also key factor in determining employee's efficiency. It has the highest motivating factor of all but may have impact on worker's results. Flexible bonuses or penalties should be implemented in certain crucial departments so results of their work would have immediate effects on staff salary.

Technical and technological equipment

Proper equipment and technical data are one of the base requirements for accurate and efficient decision making. If we focus on equipment and tools that are involved in process we have to decide and analyze if those tools are used effectively with maximum usage potential. Usually with new parts or machinery comes staff training in order to maintain highest performance and fulfill claim policy involved in process.

Information and training

In order to maintain organized and fully competent department like after sales department that takes care of claim events is important to define efficient information flow. The most used ways are reliable and sufficient for ideal claim event. Internet and e-mail (internal or external) faxes and telephones. But in order to improve customer satisfaction and reduce used time it's better to cooperate with some other ways.
Modern systems allow customers to create their own RMA document with brief description of their problems. Those information are easily process able because the whole system is integrated in one. So the claim department is aware of situation before the customer himself shows up. This may improve reaction times by being able to get proper parts and in result the whole process is faster than the customer expects. Of course there is imperative to supervise the whole documentation in order to exclude mistakes or events that are not included in claim warranty.

Interpersonal relations

This aspect of interpersonal behavior is often overlooked or it is known as not so important. But society within the firm is creating working atmosphere so in stressful conditions performance will eventually decrease. Also there is a risk of missing or incomplete data just because of human behavior. Or rivalry between departments should be kept in reasonable lines. Small amount of rivalry helps to increase efficiency and working potential but in larger scales it will result in communication problems and lack of cooperation. Nowadays trend is to focus on interpersonal relations and team building actions help to improve cooperation between people and help to melt ice and trust more each other.

3. Training procedure

The first step on staff training is to decide what type of training is better for employees. Two main types of training are available for all firms like **External** and **Internal** training programs. External training programs have some positives and negatives and it is better to choose which one is better under circumstances of usage.

External training

Positives

- Training is professional
- Used methods and procedures are handled with care
- Implementation on firm with focus on problems
- No interpersonal burdens

Negatives

- Expensive
- Not always ready in order to repeat or redefine
- May take longer for trainee to accommodate with problems

Internal training

Positives

- Cheaper
- Well-known problematic areas of training focus
- No Ice barrier
- Easily repeatable and redefine structure

Negatives

- Not so professional learning techniques
- May create interpersonal barriers
- Usually is not taken so seriously

Training plans

In order to implement training procedures into life the one of the first steps is to define if training should be **Periodical** or **One time.** Periodical training helps to improve communication skill and qualification with every new trained procedure and implementation. Onetime training is optimal for Special occasion or sudden changes in working procedures.

- Staff have to be notified of any priorities for training which have been identified within the department as a whole or within specific sections
- Staff should also be encouraged to take the initiative to consider their own training and development needs

Training records

A record of all training undertaken should be maintained by all members of staff. Later on is possible to change specific problematic area of training and substitute it with something else. Record should involve time, numbers of attendants, summary of topics and results. In compare to feedback of training is possible to eliminate mistakes done by training and improve the whole process

Evaluation

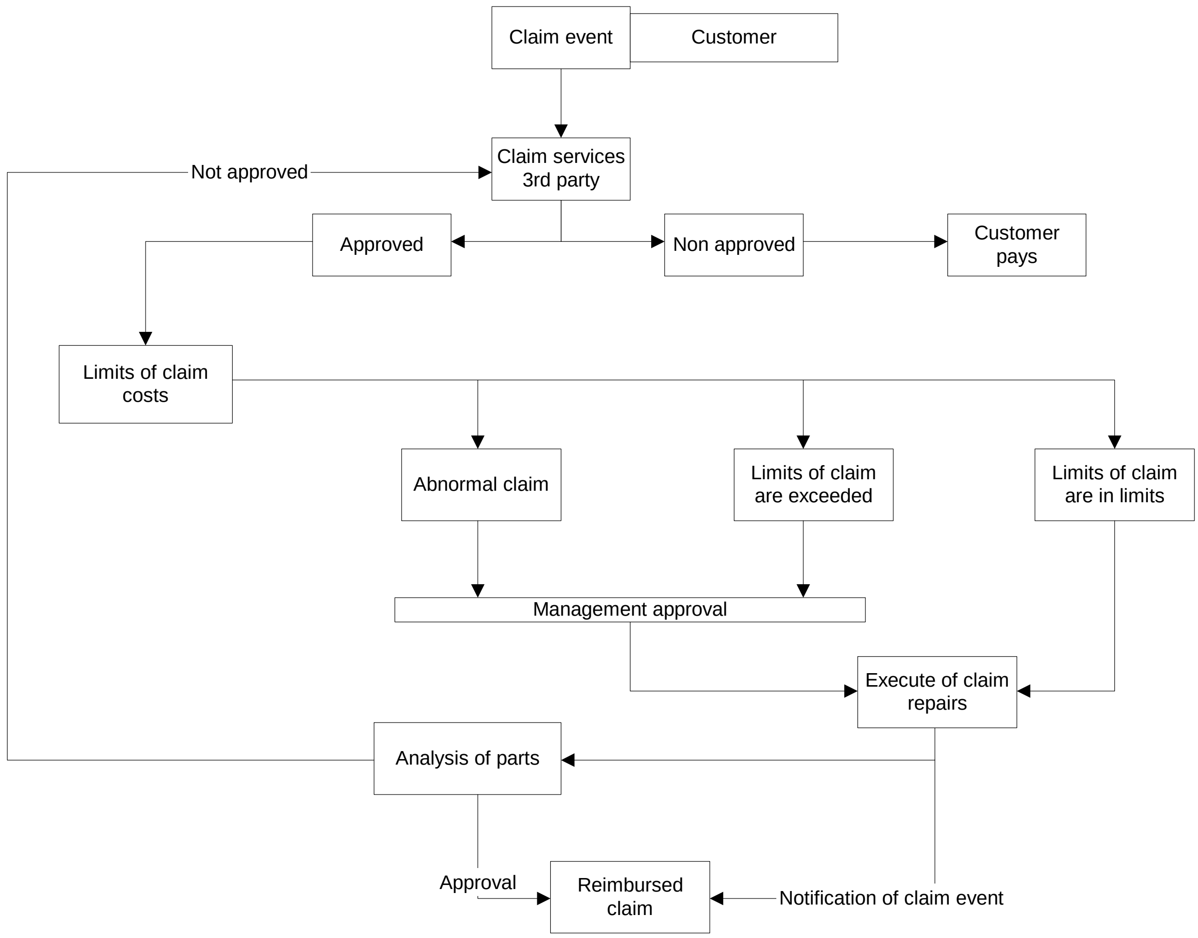
Managers also have an important role in monitoring the impact of training and development in relation to their own staff team. This will involve ensuring that staff complete a Training Record Form, which encourages personal reflection and also ensures that the activity is recorded on the database. It is also appropriate to arrange some form of debriefing with the member of staff concerned, to discuss what has been learned and whether any operational or other changes should be made as a result (e.g. the debriefing offers the opportunity for two-way feedback). In broader terms, the overall operation of the staff training policy is monitored annually by the departmental training coordinator, in conjunction with heads of sections/services. [1]

Information flow

In order to make clear and visible process is crucial to arrange such information flows that would save as much time and money as possible. Key decision steps should remain on departments but some low important decision should be forwarded to subsection to ease whole process. Charts will show the whole staff how to proceed in specific situation. Some type of basic Information scheme is visible on pic.1

Responsibility

While the departmental training coordinator can take an overview, it is ultimately the responsibility of each section/service head to ensure that appropriate and effective training and development activities are in place within their own section. In practice it is recognized that this operational responsibility may be delegated to other staff with supervisory responsibilities (e.g. "team leaders" or senior clerical staff, etc). [2]



Pic.1: Basic type of Information Flow [claims via 3rd party company]

Tips:

- Discussion with the relevant member of staff, in order to clarify the identified development need and to agree a way forward. This might involve identifying an appropriate training course within the Staff Development program or approaching an external training provider.
- Clarification of what is likely to be covered within the proposed activity and what it is hoped will be gained (ie learning outcomes). This might involve some form of informal pre course/conference 'briefing' when, for example, a member of staff might be asked to investigate a particular relevant issue, with a view to reporting back to other members of staff.

4. Conclusion

Staff training is very long time and complex process that will result in improvement of work results also in eventual positive economic impacts in claims department. In order to implement large scale training program is important to decide and mark crucial segments and parts of process that are supposed to be improved. Next step is planning – where, when, who, what. Increase of capability and reliability of employees will bring satisfaction to customers even if they encounter such unpleasant event as claim.

Source :

[1, 2]
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GALILEO – NEW VISION FOR TRAFFIC CONTROL?

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This article covers the problematics of satellite navigation system Galileo, which is present coming up under the European Union patronage. Outline main technologic piers of the system and describe several items which are basics of this system. There are also shortly described reasons of origin – from politic and economic view. In passage, which describes potency of use of Galileo system for vehicle systems, is outlined several particular possibilities, how could be this system used in future in real vehicle service. The goal of article is to show possible future use of Galileo as primary navigation system for transportation and to prove by comparation its advantages compared to GPS system which is spread worldwide today.

Key words: Galileo, GPS NAVSTAR, EU

Introduction

At the beginning of the new millennium satellite navigation became a genuine tool of everyday life, with unprecedentedly wide possibilities for application. It navigates our passenger vehicles, helps co-ordinate systems of the emergency services, provides navigation support to aircraft and ships, with ever greater scope and precision. It can be used for monitoring stolen cars or fishing boats on the open sea, can manage inventory of transited goods, forms the basis for toll collection or speed control systems. In brief, satellite navigation has become a part of the normal life of a modern person, and it is expected that in the near future personal use of satellite navigation shall become just as common as ownership of a mobile telephone.

Maximum utilisation of a vehicle fleet, short downtime of vehicles and constant provision of information to the control centre concerning the location of vehicles are today the foundation blocks for the success of every logistics company. Transport controllers need to know when goods will be delivered and received, and where they are located at any given moment. Also ordinary, non-commercial road traffic is increasing on the existing European road network, and even despite increasing safety measures, the accident rate is also rising. All of the above problems must be resolved effectively. A new satellite navigation system, with the name of Galileo, can be of assistance here. The Galileo system is not as new as may initially seem, but its implementation has been somewhat delayed. Nevertheless, great hopes have been placed on its completion.

The political background

In the spirit of a sentence from an article by the former Prime Minister of Sweden Carl Built, published in the Financial Times: "If Europe truly wishes to be taken seriously as a partner by the US, while ensuring that it has access to capabilities critical for its economic development, it must demonstrate that it has both the will and the means to develop a presence in space" (Carl Bildt, 31 December 2001), France initiated the establishment of a European satellite system entitled Galileo as a response to certain pressure from the USA and as a necessary "defence" against the USA in this direction.

At this point it is necessary to remind ourselves that the American satellite system GPS Navstar, which today is used by so many people, companies and institutions, is primarily a military system, one component of which is made available to the public. From this it ensues that in the case of an unspecified military-political crisis, the representatives of the USA could decide to temporarily or permanently deactivate the system. It is difficult to estimate the catastrophe that would result from such a step. Despite this there is little that would prevent the USA from implementing this measure in extreme circumstances.

The Galileo navigation system shall be technologically fundamentally more sophisticated with regard to the fact that its development was commenced several years after the American GPS. Because use of GPS systems is primarily military and the European system is civil, Europe and the USA in the past have mutually considered their systems to be competing, and entirely dismissed the notion of any compatibility or closer co-operation (technological development etc.). In 2002 – 2003, however, discussions opened between the two parties, and a declaration published in March 2004 literally fundamentally changed the situation – both parties agreed on the compatibility of both systems. Simply speaking it is possible to say that both parties exchanged the technological parameters and any new instrument shall thus be possible to use either system or both simultaneously. The Galileo system, according to the original plans, was planned for launch into operation in 2008, although due to the influence of poorly chosen forms of financing a considerable delay has taken place. This year there was finally a change in the system of financing, in which the European Commission announced that the entire system shall be financed from EU resources. On the basis of this new information, realistic launch is now considered for 2011 – 2012.

Technological parameters

The entire system shall contain four basic segments. **Global, regional, local** and **user**. In this, the global segment shall be further divided into the **cosmic** and **terrestrial** system.

Parameters of Galileo satellite signal

Galileo shall transmit 10 signals in three frequency bands:

- 4 signals shall be within the frequency range of 1164 - 1215 MHz (E5a, E5b)
- 3 signals shall be within the frequency range of 1260 - 1300 MHz (E6)
- 3 signals shall be within the frequency range of 1559 - 1591 MHz (L1)

All ten signals shall serve in various combinations for an extensive range of services according to the table 1.

The carrier waves are modulated by a number of signals (codes), through the help of which a time reading of the satellite, information about courses of satellites and further information is transmitted. Each of the satellites broadcasts simultaneously on all channels, but the receiver according to its designation shall use only the relevant frequencies and codes for that receiver. The code transmitted by the signal is composed of two states – 0 or 1, and is inbuilt into the carrier wave in such a manner that upon a change of status the phase of the broadcast signal is altered by 180°, so-called double-phase modulation. Codes are produced depending on the satellite oscillator – the sequence of states 0/1 is produced by hardware equipment. The value in the given bit is (is not) changed on all frequencies stated in the previous outline, and a sequence of states is thus generated, which is subsequently a modulated carrier wave.

Segments of system

Global segment – cosmic section

The fundamental element of the Galileo system shall be a network of thirty satellites in a central orbit in three orbit levels at an angle of 56° to the line of the equator. Each level shall contain nine active satellites, which shall be spaced equally within the orbit at 40°, and one inactive substitute satellite, which in the case of failure shall replace any active satellite.

The height of the orbit at 23 222 km has the property that the same location of satellites around the Earth always repeats after ten days. During these ten days each satellite orbits the Earth seventeen times. The height of the orbit of the satellite was chosen in such a manner as to eliminate as much as possible the impacts of the disturbance gravitation field. It is expected that after initial optimisation of the orbit, no directing manoeuvres shall be necessary throughout the entire life span of the satellites. The chosen height of the orbit also ensures a high degree of visibility of the satellites. The tolerance of deviation of individual satellites from the “ideal” orbits is conditioned by the requirement to maintain a constant constellation. The permitted deviations are such that each satellite should move within a distance of +/- 2° with regard to the neighbouring satellites in the same orbit, and also no more than +/- 2° from the level of the path.

Global segment – terrestrial section

The core of the terrestrial segment shall be two control centres. Each control centre shall manage monitoring and control functions supported by a specialised terrestrial control system (**Ground Control Center, GCC**) and “mission” functions, supported by the terrestrial “mission” segment (**Ground Mission Segment, GMS**). GCC shall be responsible for maintenance of the position of satellites, whilst GMS shall be responsible for monitoring of the navigation function of the entire navigation system. GCC shall make use of a global network of five TT&C (Tracking, Telemetry and Command) stations for communication with each satellite, according to a schema combining regular and planned contacts, together with long-duration tests and random contacts.

Table no. 1: Overview of navigation signals according to Galileo services

Service	Basic service – single frequency	Basic service – dual frequency	SoL service	Ordinary paid service	Extended paid service	Public reglated service
Signal no.						
1 (E5a)		X	X		X	
2 (E5a)		X	X		X	
3 (E5b0			X		X	
4 (E5b)			X		X	
5 (E6)						X
6 (E6)				X	X	
7 (E7)				X	X	
8 (L1)						X
9 (L1)	X	X	X	X	X	
10 (L1)	X	X	X	X	X	

Regional and local segments – terrestrial

The regional component of the Galileo system should be composed of several External Region Integrity Systems (ERIS), created and operated by private specialists, states or groups of states outside of the territory of the EU. These systems shall ensure reporting about the integrity of the system independently of the reporting of the Galileo system, in order for example to satisfy the requirements for guarantee of the system of the given states or institutions.

The local components should serve for improvement of the local reception of the Galileo signal, for example as ensuring the navigation system in areas where signals from the satellites cannot be received. These local components shall be created and operated by private companies.

User segment

The wide range of capabilities of user receivers understandably depends primarily on the type of instrument and the degree of sophistication of processing the signals. In general it is possible to say that launch of the Galileo system at least in trial operation shall mean a further significant acceleration in the development of user segments.

Use of Galileo for vehicle systems

Galileo can enable changes to the role of the navigation satellite system from a passive information device to an active facility, supporting the driver not only in the field of navigation, but also in the area of active safety elements.

Directional control of vehicle headlamps

The precise and reliable navigation system shall in future, depending on the distance of the vehicle from the bend, vehicle speed and character of the bend, enable tilting of the headlamps in advance. In the case of crossroads this shall follow the route selected by the driver before the journey. It shall be possible to regulate advance tilting and the maximum angle of rolling of the headlamps according to the driver's requirements. **AFS (Advanced Front Lighting System)** – front headlamps are automatically set according to driving speed and the angle of turning of the steering wheel.

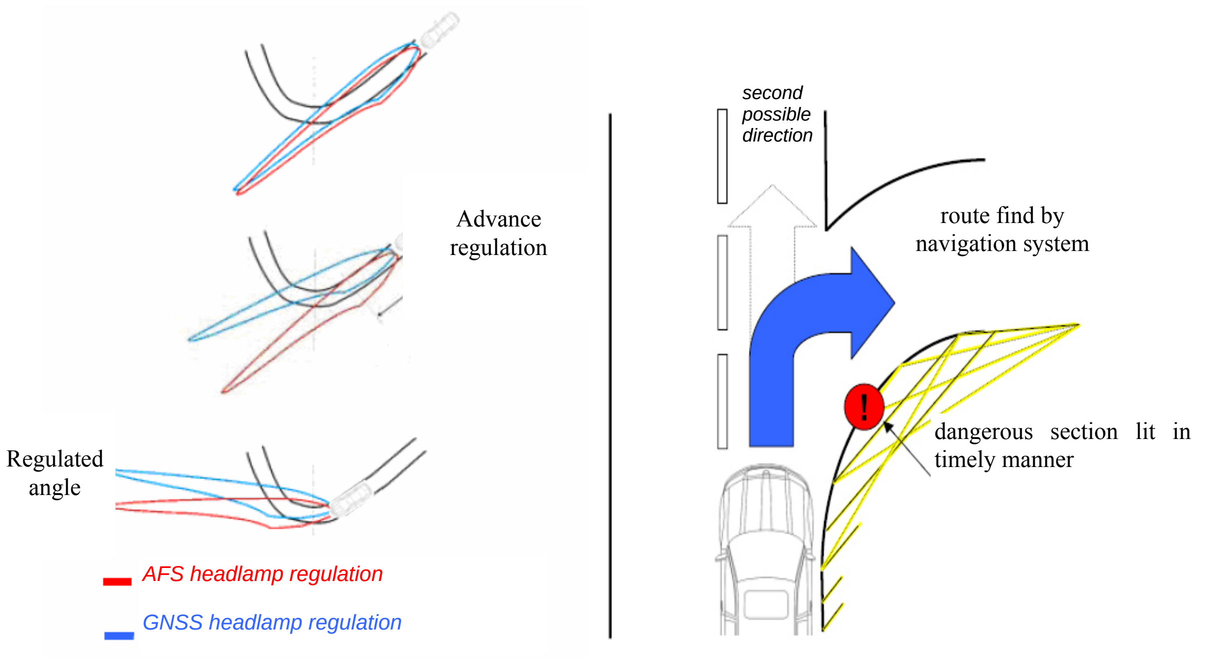

Fig no. 1: Comparison of AFS and navigation direction regulation of headlamps

Fig no. 21: Various styles of lighting road according to type of communication route

Change of headlamp mode

The on-board system designates the type of communication route (city, motorway, country road) according to the position of the vehicle, and adapts lighting of the road accordingly in order to ensure maximum comfort for the driver and for oncoming vehicles. [5]

Automatic gears – "NAVI Shift System"

Using knowledge of precise position and knowledge of the following section of road, including height profile obtained from a detailed map in the navigation equipment, the NAVI Shift system pre-selects the gear level of the vehicles automatic gearbox for the subsequent section, reducing the number of gear changes.

Fig no. 2: Schema of lighting dangerous section before turning

ADVANTAGES

- no losses of performance as a result of gear changes
- reduction of fuel consumption
- increased driver comfort
- longer time interval for wear of gearbox

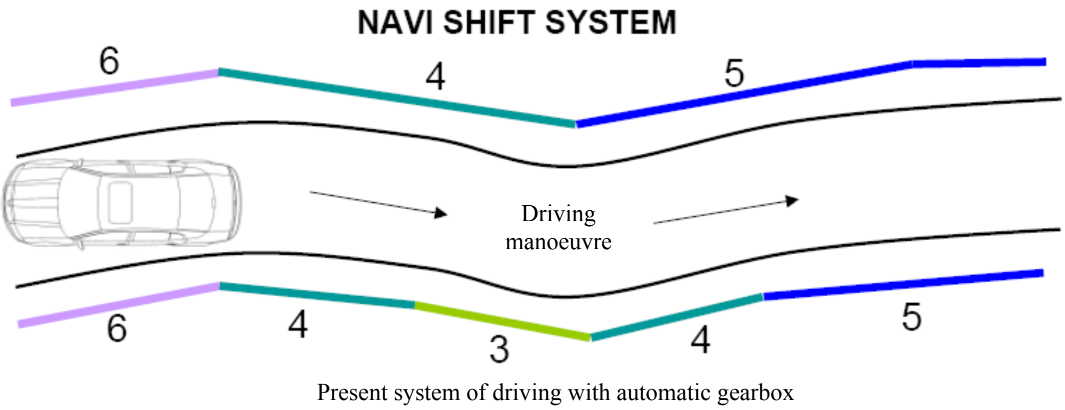

Fig no. 3: Comparison of style of classic automatic gearbox and Navi Shift system

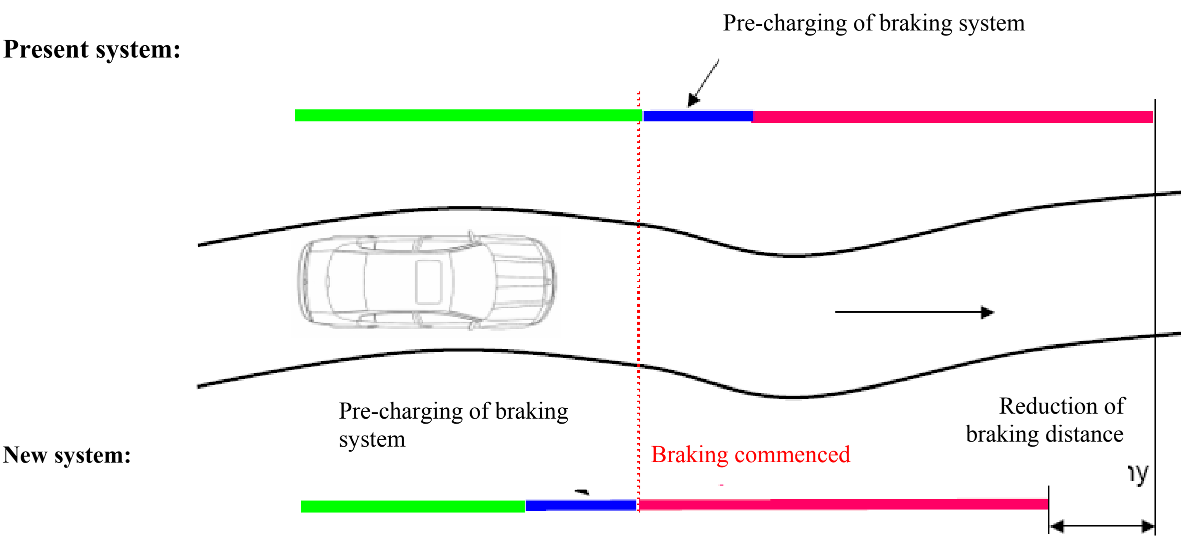

Fig no. 23: Comparison of classic braking system and system of brake activation

Support for activation of brake system

Using knowledge of precise position and knowledge of the following section of road, including height profile obtained from a detailed map in the navigation equipment, the system of support for the brake system can prepare the vehicle brakes into working position before the commencement of actual braking. This reduces the response time between pressing the pedal and obtaining the braking effect. The working position means an increase of pressure of the braking fluid in the braking system of the vehicle to the value for commencement of actual braking. The result is to reduce the braking distance.

Conclusion

GIOVE A, the first trial satellite of the Galileo system, was placed in orbit on 12 January 2006, and successfully commenced transmission of a navigation signal. Despite the delay to the project and the at present increasingly frequently appearing contrary opinions, this is irrevocable evidence of the capability of the Galileo system. Precise satellite navigation with the possibilities Galileo brings must necessarily culminate in an enormous boom, just as was the case ten years ago, when mobile communication technology enjoyed a similar expansion. The launch of Galileo into fully operational capability shall stimulate a wave of new investments in the development of subsequent applications, open new markets throughout the entire world and become a genuine worldwide, global navigation system.

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EFFECTS OF IMPACT LOADING ON MECHANICAL PROPERTIES OF CORN KERNEL

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At different stages of designing also and producing agricultural machines, in order to optimizing the energy consumption and in order to producing optimal agricultural equipments, understanding of the products and food mechanical properties is one of a great importance. In general these mechanical properties are including: stiffness , compressive resistance , impact resistance , shear resistance and etc. Since at different stages of agricultural production, impact forces have a great influential power, thus the study of impact resistance would be necessary. Concerning with determination of physical and mechanical properties, three common corn kernel varieties namely TWC647,KSC604 and KSC704 at three level of moisture content – (11-13%),(14-16%), (17-19%) on the basis of wetness have been tested under impact loading, In the impact loading test (dynamic), initially the percent of corn rupture at 190mj and 310mj of fix impact energy was calculated and then the effects of corn moisture and variety on kernels rupture under the influence of impact loading was assessed. Our findings show that the moisture and the variety of kernels have meaningful influence on the percent of kernels rupture. In the impact loading test, the most resistant variety was TWC647 and the least resistant variety was KSC704. On the other hand with the increase of moisture content the percent of kernels rupture decreased.

Introduction

Considering with the increasing world need to the corn kernel, increasing of under cultivation area in addition to increasing the product efficiency should be regarded as an important issue. On the other hand, in all stages of corn production such as cultivation, harvesting, storing and handling, reduction in product losses should be considered as an important way in product optimization. These loses may have originated from the influence of different forces on the corn body in that stages. So in the process of making devices for actions such as pulverization, crushing and pressing of the corns, the determination of the maximum and minimum forces could be necessary. The main objective of this study is to determine the role of corn variety and moisture content, in kernel rupture under impact loading as an assessment index.

Once two objects clashing, their kinetic energy interacting by immediate forces and will cause deformity. Once a solid elastic object is compresses, it initially expanded and then returns to main state. If an object with the mass of (m) moves with the velocity of (V), then it has the (MV) movement scale. Changes in movement scale are equal to force time sub curve. A solid elastic object with the mass of (m) which moves with the (V_1) before impact and (V_2) after impact, and the F(t) is the force on the body between times of t_1 and t_2, in this situation;

$$M_1v_1 - m_2v_2 = \int_1^2 F(t)\,dt$$

A combination of above equation with hertz relations could be used in the impact time and maximal impact impact force calculation . If two spherical objects with the radius of R1 and R_2 and mass of (m_1) and (m_2) clashing with the relative velocity of (V), then interacted maximal force at the contact point equals to:

$$F_{max} = \left[\frac{4}{3(k_1+k_2)}\sqrt{\frac{R_1R_2}{R_1+R_2}}\right]^{\frac{2}{5}} \qquad \left[\frac{5}{4}\frac{m_1m_2}{m_1+m_2}v^2\right]^{\frac{3}{5}}$$

$$T_{CON} = 2.9432V^{-1}\left[\frac{15}{16}\frac{(k_1+k_2)m_1m_2V^2}{m_1+m_2}\right]^{\frac{2}{5}} \left[\sqrt{\frac{R_1R_2}{R_1+R_2}}\right]^{\frac{1}{5}}$$

In these relations (K) rates are fixed and E_1 is, the sample elasticity coefficient, E_2, is the loaded object elasticity coefficient.

$$K_1 = \frac{1-\mu_1^2}{E_1} \quad , \quad K_2 = \frac{1-\mu_2^2}{E_2}$$

In order to determination of impact breakage effect, Deniral et a1, designed a loin hammer for corn milling. Their findings show that:

1. The corn seed special breakage decreased with temperature increment. This factor has an exponential relation with temperature.

2. The breakage of corn seed with small in vitro hammer toward the time at semi logarithmic coordinates, as a first grade linear relationship which its gradient is called the special breakage rate and it defines the compressed impact sensitivity.
3. The least corn seed breakage is at 25% of moisture content. Changes in moisture content would cause increase in corn seed breakage rate.
Bilanske et a1, calculated the return coefficients of corn seeds by throwing them on the steel surface and found that, with the increase of surface thickness, the return coefficient increased. Increase in throwing height would cause the reduction in return coefficient which shows that, corn seeds absorb more energy at higher speeds.

Materials and Methods

For the purpose this study, three corn varieties namely TWC647, KSC604 and KSC704 have been selected. In this test, of each corn variety 100g samples were randomized and selected. To determine the in vitro moisture content of each corn variety, three 100g corn samples were put in the drying oven for 3 hours in 103^0c. The moisture degree was assessed in the basis of standard weight technique. To obtain the required kernel moisture, in the time of each test, one 100g sample of each variety was selected and to gain the balance moisture, after 72 h, calculated water rates were added to each sample. In order to prevention of corns germination, all samples were stores at less than 4^0c. Levels of moisture contents selected in this study were (11%-13%), (14%-13%), (17%-19%). In this study all the corn varieties with different moisture levels on the basis of wetness were put under loading impact test in (H) direction. In this study the effects of variety and moisture content on the kernels rupture calculated. At the end of the test, data collected were separated in different files with EXCEL software and then conclusions and statistic analysis were conducted with MSTATC software. The analysis conducted was including variance analysis and average rates comparison by Duncan's test.

Conclusion and Discussion

According to our findings, with the increase of moisture content, the required rupure energy would be increased. Results show that; kernels with (17-19%) of moisture content have the most impact resistance and accordingly, the least impact resistance belongs to kernels with (11-13%) of moisture content. Results of impact loading test show that; with the increase of moisture content, the percentage of corn breakage would be decreased. The percentage of ruptured corns in three varieties of TWC647, KSC604 and KSC704 in three levels of moisture content (11-13),(14-16),17-19) on the basis of wetness under 190mj and 310 mj of impact energy was determined. According to above tables, it understood that; the varieties of TWC647 and KSC604 are the most and least varieties, respectively. Our findings show that the moisture and the variety of kernels have meaningful influence on the percentage of kernels rupture. In the impact loading test, the resistant variety was KSC704 and the least resistant variety was TWC647 KSC704. On the other hand with the increase of moisture content the percent of kernels rupture decreased.

According to above tables, it reveals that, the corn variety and moisture content at both levels of impact energy have a meaningful relationship with corns breakage, thus KSC604 with the moisture of (17-19%) is the most resistant variety against the impact loading. it also observed that with the increase of moisture content, the percentage of kernels breakage decreased and the reason of this reduction could be related with corn viscoelasticity properties.

Table1 – average percentage of ruptured corn seeds at 190mj

KSC704	KSC604	TWC647	Variety / Moisture
87	95	84	(11-13)
90	93	88	(14-16)
100	140	90	(17-19)

Table2- average percentage of ruptured kernel under 310 mj

KSC704	KSC604	TWC647	Variety / Moisture
59	61	49	(11-13)
54	65	50	(14-16)
62	70	60	(17-19)

Table3 – conclusions of variance analysis related to kernels rupture under 190 mj

F	MS	SS	df	Source of variable
	0.4677	4.21	9	Repeat
34.82**	10.1	20.2	2	Variety
40.344**	11.7	23.4	2	Moisture
1.896**	0.55	2.2	4	Variety * moisture
	0.290	20.9	72	Error

Table4 – conclusions of variance analysis related kernels rupture under 310 mj

F	MS	SS	df	Source of variable
	0.09	0.81	9	Repeat
65.11**	2.8	5.6	2	Variety
84.88**	3.65	7.3	2	Moisture
	0.085	0.54	4	Variety * moisture
	0.043	3.1	72	Error

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THE POSSIBILITY OF THE USE OF RNA FROM BREWERY SPENT YEAST FOR ENRICHMENT OF CATTLE FEED

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The waste from brewery are following: spent grain (leached barley malt), spent yeast from primary and secondary fermentation (lagering or maturation), kieselguhr, sludge from whirlpool and used water. The spent grain is almost regularly used as cattle feed, but spent brewer´s yeast is nearly in every brewery led in drainage system, despite of the fact it conteins a lot of vitamins, trace minerals and ribonucleic acid (RNA). The above described disposal of the waste treatment is however not acceptable from the point of enviromental protection and producer of this pollution if caught in the act should pay enormous penalty. To solve this problem was accepted a consideration how to reuse brewer´s spent yeast both as a source of vitamins, trace minerals or for an isolation of the ribonucleic acid (RNA). The isolated RNA could be used for both an enrichment of cattle feed and for human nutrition with aim to increase imunity systém of living organism. In laboratory scale has been done the research of different methods of RNA recovery.

Keywords: ribonucleic acid, brewery yeast, spent grain

1.Inroduction:

The word "*yeast*" comes from the old english language "*gist*" or "*gyst*", meaning *boil*, *foam*, or *bubble*. Yeast microbes are probably one of the earliest domesticated organisms. People have used yeast for beer production throughout long history. Archaeologists digging in Egyptian ruins found early grinding stones and baking chambers for yeasted bread, as well as drawings of 4,000-year-old bakeries and breweries. In 1680 the dutch naturalist Anton van Leeuwenhook first microscopically observed yeast, but at the time did not consider them to be living organisms but rather globular structures. In 1857 french microbiologist Luis Pasteur proved in the paper "*Mémoire sur la fermentation alcoolique*" that alcoholic fermentation was conducted by living yeasts and not by a chemical catalyst as had been considered by all scientists. Pasteur showed that by bubbling oxygen into the yeast broth, cell growth could be increased, but the fermentation inhibited - an observation later called the *Pasteur effecct* brewer's yeast was derived from the unicellular fungus *Saccharomyces cerevisiae*, which causes the fermentation process basic to the brewing of beer. Different strains of this yeast are used in the production of the various types of beer, *Saccharomyces carlsbergensis* for bottom fermentation and *Saccharomyces cerevisiae* for top fermentation.

Yeasts are a growth form of eukaryotic microorganismus classified in the kingdom Fungi. Approximately 1,500 species of yeasts have been described, most of which reproduce asexually by budding, although in a few cases by binary fission. Yeasts are unicellular, although some species with yeast forms may become multicellular through the formation of a string of connected budding cells known as *pseudohyphae*, or *true hyphae* as seen in most molds. Yeasts size can vary greatly depending on the species, typically measuring 3 to 7 micrometres in diameter, although some yeasts can reach over 40 µm. The brewer´s yeast contains following major vitamins :

-Vitamin B1 (thiamin) – releases energy from carbohydrate in the diet, and is important for the heart and nervous system.

- Vitamin B2 (riboflavin) – releases energy from carbohydrate in the diet, and maintains healthy skin, eyes and digestive tract.

- Niacin (Vitamin B3) – releases energy from carbohydrate, and helps to maintain healthy skin, digestive tract and nervous system. Further contains pyridoxine, pantothenic acid, folate, vitamin B12 and biotin, and such trace minerals as chromium and selenium. It also contains beta-glucans, ribonucleic acid (RNA), para-aminobenzoic acid and myo-inositol. A substance isolated from brewer's yeast called skin respiratory factor or SRF has found application in some cosmetic and wound-healing products, as well as in some hemorrhoidal preparations. The chemical identity of SRF is untill now unknown.

High-chromium brewer's yeast has putative antidiabetic activity and anticarcinogenic activity. It also contains beta-glucans, ribonucleic acid (RNA), para-aminobenzoic acid and myo-inositol. A substance isolated from brewer's yeast called skin respiratory factor (SRF) has found application in some cosmetic and wound-healing products, as well as in some hemorrhoidal preparations. The chemical identity of SRF is still however unknown. Brewer's yeast has been a popular nutritional supplement for many years. Much of the brewer's yeast marketed for nutritional supplement use is grown specifically for that marketplace. The supplements are prepared from dry, crushed cells of *Saccharomyces cerevisiae*. There are other yeast preparations, such as *Saccharomyces boulardii*, in which the cells are alive; are used as probiotics. Yeasts are a growth form of eukaryotic microorganismus classified in the kingdom Fungi. Approximately 1,500 species of yeasts have been described, most of which reproduce asexually by budding, although in a few cases by binary fission. Yeasts are unicellular, although some species with yeast forms may become multicellular through the formation of a string of connected budding cells known as *pseudohyphae*, or *true hyphae* as seen in most molds. Yeasts size can vary greatly depending on the species, typically measuring 3 to 7 micrometres in diameter, although some yeasts can reach over 40 µm. The yeast species *Saccharomyces cerevisiae* has been used in baking and fermenting alcoholic beverages for thousands of years. It is also extremely important as a model organism in modern cell biology research, and is the most thoroughly researched eukaryotic microorganism. Researchers can use it to gather information into the biology of the eukaryotic cell and ultimately human biology. Other species of yeast, such as *Candida albicans*, are opportunistic pathogens and can cause infection in humans. Yeasts have recently been used to generate electricity in microbial fuel cells, and produce ethanol for the biofuel industry. Yeasts do not form a specific taxonomic or phylogenetic grouping. At present it is estimated that only 1% of all yeast species have been described.

The Benefits of Brewer´s yeast are following:

- Sleep **-** it has been shown to help people having difficulty sleeping. This is due to the Niacin and Vitamin B6 present in the yeast, which work together to produce the brain chemical seratonin, which is essential for restful sleep.
- Fatigue – It has been shown to help people who feel fatigued, since many of the B group vitamins present are essential in the release of energy from the carbohydrates in the food we consume.
- Diarrhoea – It has been used to treat diarrhoea caused by Clostridium difficile.PropertiesBrewers yeast contains many different vitamins, minerals and amino acids.

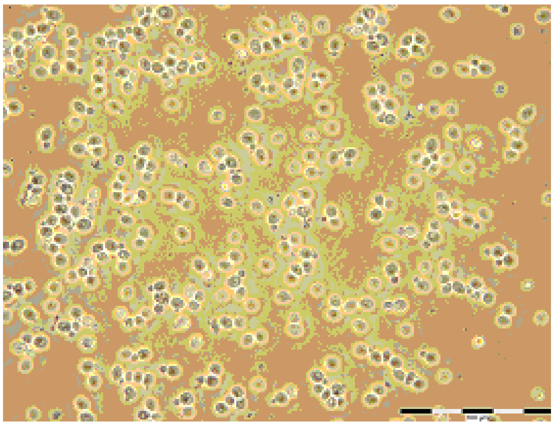

Figure 1 – Cell sof the brewer´s yeast (magnified 600x, courtesy Budweiser Brewery, Šavel and Košina]

Nucleic acids were discovered in 1868 (some sources indicate 1869) by Johann Friedrich Miescher (1844-1895), who called the material ‘nuclein’ since it was found in the nucleus. It was later discovered that prokaryotic cells, which do not have a nucleus, also contain nucleic acids. The role of RNA in protein synthesis had been suspected since 1939, based on experiments carried out by Torbjörn Caspersson, Jean Brachet and Jack Schultz. Hubert Chantrenne. From brewer´s □rast □rast□y□ ribonucleic acid (RNA) helps to improve an immunic system of of living organisms. The ribonucleic acid or RNA is a nucleic acid polymer consisting of nucleotide monomers that plays several important roles in the processes that translate genetic information from deoxyribonucleic acid (DNA) into protein products; RNA acts as a messenger between DNA and the protein synthesis complexes known as ribosomes, forms vital portions of ribosomes, and acts as an essential carrier molecule for amino acids to be used in protein synthesis. RNA is very similar to DNA, but differs in a few important structural details: RNA nucleotides contain ribose sugars while DNA contains deoxyribose and RNA uses predominantly uracil instead of thymine present in DNA. RNA is transcribe (synthesized) from DNA by enzymes called RNA polymerases and further processed by other enzymes. RNA serves as the template for translation of genes into proteins, transferring amino acids to the ribosome to form proteins, and also translating the transcript into proteins. In the literature are described different □ras of nucleic acid isolation from different yeast´s strains. In this paper is shown under laboratory scale developed the new □rast with a flow sheet of RNA production (figure 4).

3. Used raw material and description of the RNA production line

For laboratory research has been used a rast brewer´s yeast, gained from The Tutorial and Research Brewery of the University of life science in Prague, rast y of Engineering, Department of technologic supplies of buildings. For the fermentation of aerated and down cooled pitched wort are installed two insulated tanks there with capacity 20 hl each (fig. 2, 3). The used strain of bottom brewer´s trast was *Saccharomyces carlsbergensis* obtained from different breweries and from Research institute for Brewing and Malting in Prague. The flow sheet of laboratory scale production line for RNA recovery is shown on figure 4.

figure 2 – fermentation tanks
(Tutorial and Research Brewery of the University of Life Science Prague)

Figure 3 – harvested yeast from fermentation tank
(Tutorial and Research Brewery of the University of Life Science Prague)

The cooled down, pitched and aerated wort is pumped via pipeline **1** into fermentation tank **2**, equipped with a cooling jacket **3**. The fermenting beer is cooled down by cooling agens, incoming by pipeline **4**, warmed cooling medium is continuously taken away by pipeline **5.** After finishing proces of wort fermentation a young beer is pumped by pipeline **6** for maturation into lager tank **10,** harvested yeast at 7 % dry mass passes by pipeline **7** to be collected for washing and storage in balance tank **8**. The sludge from fermentation tank **2** is led into drainage system **9.** The washed yeast is pumped from balance tank **8** via pipeline **11** for thickening in special equipment **12**. After thickening process the value of dry mass of the yeast increases from original 7 % dry mass to final value 15% dry mass. At this value of dry mass is yeast led for lysis of cell wall to boiler **15** where will be put on impact of hot caustic soda (inlet of NaOH is via pipeline **14)** with a NaOH concentration lying in the range 10- 20 % and temperature varying from 50% to the 80 degrees of Celsius. The boiler **15** is equipped with an agitator, for heating is installed steam jacket (the steam inlet **16**. condensed water outlet **17**). The temperature of the process will be controlled by means of temperature probe fixed on the wall. After finishing of the lysis of yeast cells – the duration of the process depends on the temperature and the caustic concentration and will be a matter of next research activities of the authors – the destroyed yeast cells consisting of solid and liquid phases are transported to the centrifuge **19**. The separated solid phase is taken from centrifuge by pipeline **20** a will be used as a cattle feed, the liquid one will transported via pipeline **21** for further treatment – drying in special equipment **22**. The result of drying process a powdered RNA will be transported by pipeline **24** for packány, the evaropated water flows by line **24** to drainage system.

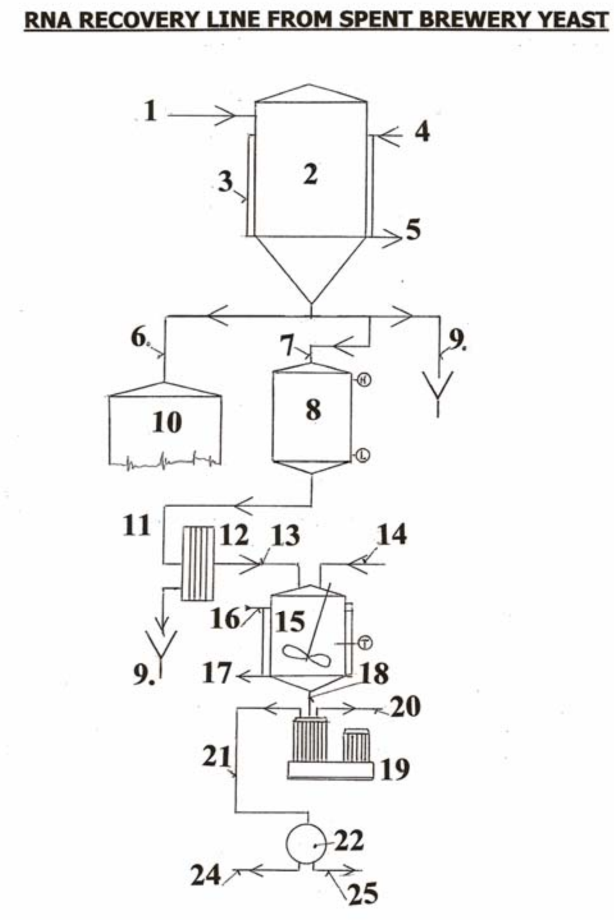

Figure 4 - Flow sheet of the laboratory RNA production line from the spent brewer´s yeast

4. Discussion of gained results

The composition ot this RNA production line may vary within the progress of research activities and on the base of the evaluated results. In cooperation with selected agricultural farms will be checked the efficiency of producted RNA applied as a single medicament or used as an enrichment of common cattle feed.

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MARTENSITE OVERLAY LAYER AND ITS INFLUENCE ON SUBSTRATUM

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Abstract: The adhesive bonding technology is influenced by a number of factors which affect the adhesive bond strength. Correcting coefficients have to be considered in construction calculations too. The correcting coefficients correct the strength deviations caused by the particular factors. As I have already said, there are many factors influencing the adhesive bond strength, but I am going to devote to three basic factors – The adhesive layer thickness, surface preparation and the environment temperature which will straight affect the adhesive bond. The aim of this experiment is to determine the correcting coefficients for three above mentioned basic factors.

Keywords: Weld deposit, Hardness, Structure, overlay material

1 Introduction

For repairing using surfacing or for preventive surfacing such procedures are sought so that the best wear resistance would be gained. The wear resistance depends on the overlay hardness and on the structure. The overlay hardness is affected by many factors. The chemical composition of the weld deposit belongs to these factors and it affects the temperatures of the austenite transformation starts. The alloyed elements content influences the hardenability and the trough-hardenability. Using the martensitic overlays we have to secure the martensite start conditions in the whole overlay volume.

The conditions of the martensite start can be modified by the quenching rate of the weld deposit, too. The next factor which affects the resultant weld deposit hardness is the mixing of the basic molted down material and the overlay material. The rate of the melting down and then the rate of the overlay material thinning can be affected by the surfacing conditions (the voltage and current rate). In the top of it the surfacing conditions affect the by heat influenced zone, which properties are different from the properties of the basic material and of the weld deposit. Using multilayer deposits the next factor accedes, namely the tempering resistance of the surfaced overlay material. At low tempering resistance the expressive variation in hardness and in wear resistance of single overlay zones occurs. The limitless tempering resistance of the overlay material is the ideal state.

The properties of martensitic overlays depend on the tempering temperature. The tempering processes affect expressive the hardness. It is caused by the martensite tempering and by the transformation of the retained austenite in the deposit. At the same time carbides can arise, which owing to their size will take part in the abrasive wear mechanism.

The by heat affected depth of the first layer is determined by its thermal conductivity. For the basic material the first layer acts as the heat barrier and it is possible to presuppose that the next heat effect will be minor.

2 Material and methods

2.1 Materials

The substrate material was steel CSN EN S325J0 with dimensions of 80 x 80 x 25 mm. The commercial hardfacing and buffer consumables, in the form of solid wire coated electrodes, were used as per the direction of the electrode manufacturer.

2.2. Welding conditions for hardfacing deposits

Hardfacing electrodes were deposited on the plate without preheat in the flat position using manual metal arc welding method. Before welding, the electrodes were dried at 100 °C for 2 h. On completion of weld deposits, each test piece was allowed to cool in air. The welding parameters of the electrodes are given in Table 1.

2.3. Chemical composition, metallography and hardness test

The chemical composition (Table 2) was determined on the overlay surface of the specimen using GDOES [10]. The Hardfacing deposited plates were sectioned using the high speed SiC cutter with cooling for deposit chemistry, metallography sample (20 x 20 x 25 mm) and also for wear test sample (25 x 25 x 25 mm).
Metallography test samples were then ground successively using belt grinder and emery papers and finally polished with Al_2O_3 powder, cleaned with acetone and dried. The polished samples were etched with Nital (electrode A) and Vilella-Bain´s (electrode B) reagent and the microstructures were observed using both an optical microscope.

Bulk hardness values of different Hardfacing deposits were taken in a Vicker´s micro hardness testing machine using a 0.1 kg load and 136° diamond pyramid indenter. Using these specimens the micro hardness was measured from the surface to the basic material (Fig. 1).

3 Results

In the case of the one-layer overlay the mixing of the tested overlay material with the basic material occurs. It is presented in Tab. 2 and 4. The chemical composition was determined on the overlay surface of the specimen using. The structures of tested overlay materials are shown in Figs. 2 to 5.

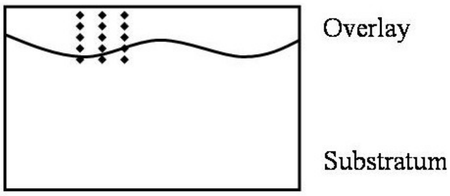

Figure 1. Scheme of hardness measurement cross overlay

Electrode	Curent (A)	Voltage (V)
1 and 2	120	16

Table 2. Chemical composition of electrodes and of base metal (weight percentage), Fe - Rest

	C	Si	Mn	Cr	Mo	V
Substratum	0,047	-	0,24	0,076	-	-
Electrode 1	0,5	2,3	0,4	9	-	-
Electrode 2	0,4	1,0	1,0	9,5	0,6	1,5

Table 3. Chemical composition first layer of two-layer overlay (weight percentage), Fe - Rest

	C	Si	Mn	Cr	Mo	V
Electrode 1	0,49	1,62	0,32	6,78	-	-
Electrode 2	0,29	0,55	0,34	6,25	0,31	0,66

Table 4. Chemical composition second layer of two-layer overlay (weight percentage), Fe - Rest

	C	Si	Mn	Cr	Mo	V
Electrode 1	0,60	1,89	0,39	7,86		
Electrode 2	0,38	0,70	0,66	8,41	0,47	0,99

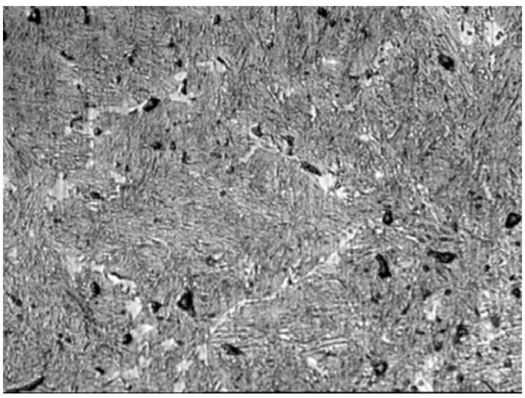

Fig. 2 Electrode 1 – martensite and fine austenite grains, nital 500×, first layer

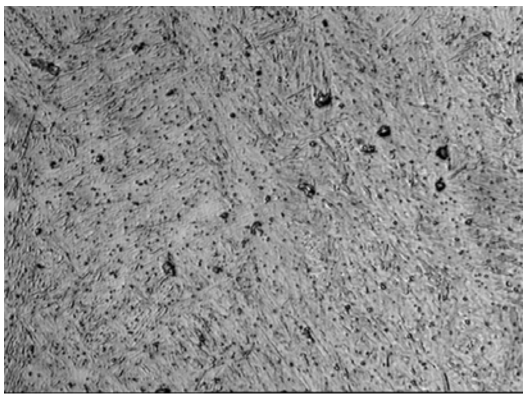

Fig. 3 Electrode 1 – martensite without fine austenite, nital 500×, second layer

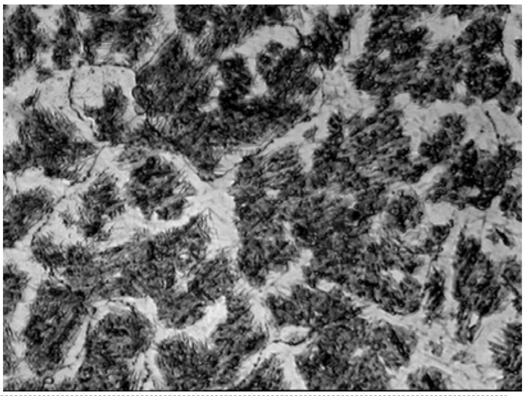

Fig. 4 Electrode 2 – martensite and retained austenite on the boundaries of grains, Villela-Bain 500×, first layer

Fig. 5 Electrode 2 – martensite without retained austenite, Villela-Bain 500×, second layer

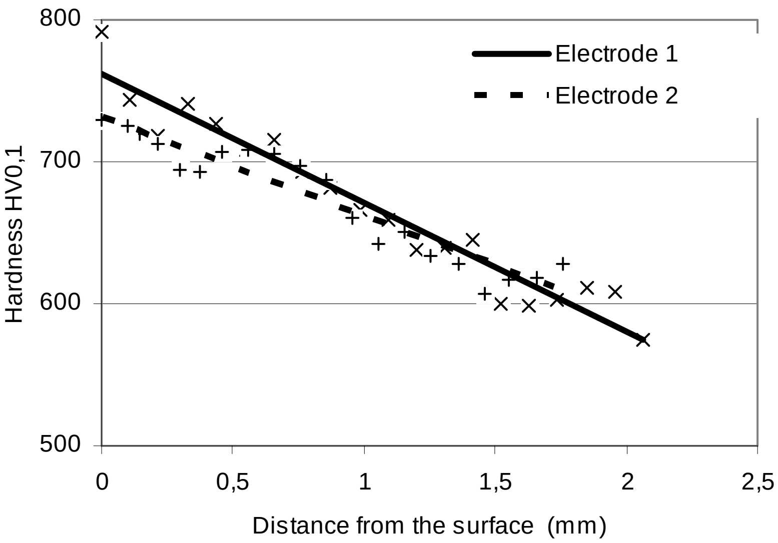

Figure 6. Overlay hardness related to the distance from the overlay surface (one layer deposit)

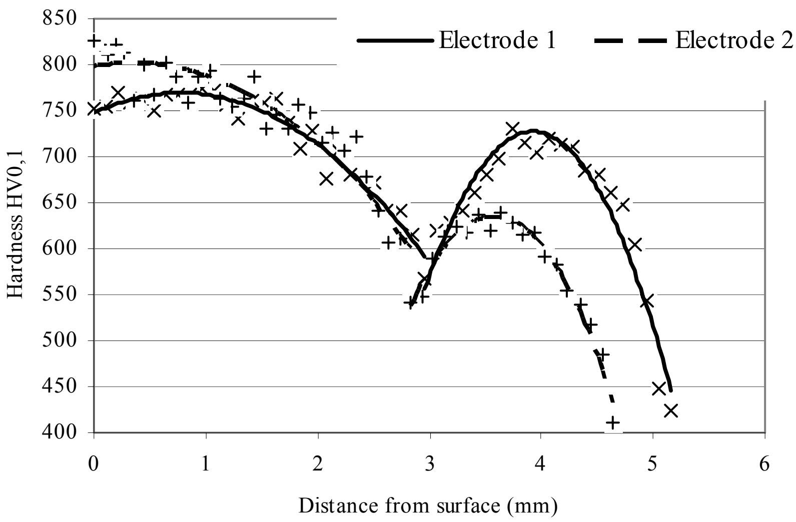

Figure 7. Overlay hardness related to the distance from the overlay surface (two layer deposit)

Conclusion

[1] The resultant hardness of tested overlays single layers was variable. Its character cannot be described by one equation.

[2] In single overlay zones the martensite and austenite content was determined. On the basis of this study the decreasing content of retained austenite in the direction to the first layer was determined. In the first layer no retained austenite occurred.

[3] The decreasing character of the overlay hardness can be explained by the different rate of cooling in single zones and by the different chemical composition, too. The strengthening occurs, what corresponds to the given chemical composition and structure.

[4] Owing to the mixing of the overlay first and second layer and to the by heat affected zone the decrease in hardness occurs. In the minor affected zones of the first layer the hardness increase occurs up to the points where the first layer and the basic material interact.

[5] The measured values of the overlay layer wear rate can by described by the conic. But this description neglects the single zones of the overlay layer.

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INFLUENCE OF HEAT EXPOSITION ON TRANSITION BEHAVIOUR OF STEEL

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The strain aging of iron is a phenomenon which runs trough at the temperatures under 350º C, and when in the course of time (e.g. in time dependence) the physical and mechanical properties of the alloy change. At the room temperature it runs trough relatively slow. With the increasing temperature the phenomenon rate increases.

Keywords: Steel, Impact energy, Transition curve

1 Introduction

Every point lattice imperfection and also the atom in the additive solid solution, too, creates the stress field in the surrounding lattice. If such a imperfection, called dilatation centre, diffuses to the dislocation or the dislocation moves to the dilatation centre, the distortion energy of the system decreases. For the separation of the imperfection from the dislocation it is necessary to expend the energy, that is to say, when these imperfections are present, the material strengthens itself.
The interaction energy between the carbon and nitrogen atoms depends on their location with regard to the dislocation. When the equilibrious conditions stabilize, the atom diffuses in the location of the maximum relaxation in the neighbourhood of the dislocation. Then for the movement of the dislocation it is necessary to apply the stress to master the interaction between the atom and the dislocation that is the stress must act on the dislocation and the dislocation releases. The intensity of the stress depends on the atoms number and distribution around the dislocation and on the method of release.

For the given concentration of the carbon and nitrogen atoms in the matrix the equilibrium distribution is positioned around the dislocation. At the critical concentration, when in the dislocation centre the maximum dilatation is reached, the carbon and nitrogen atoms arrange along the dislocation or the precipitates can arise.

As soon as the dislocation releases from the atmosphere by the external stress, its move is not affected by the clamping. The new clamping of released dislocations occurs when the atoms from the additive solid solution can diffuse towards the dislocation.

2 Experimental methods

The ageing influences very the mechanical and physical quantities e.g. conductivity, physical properties (especially the yield point), toughness etc. Our study was directed to the determination of the transite curves using the Charpy impact test. The specimens were of 10x10 mm size, cold formed, when the amount of deformation of the primary bar semi-product was 10 %. We monitored the change of the curves course and the transite temperature $t_{tr\ 27J}$ in the state without the ageing and with the ageing at the different times and at the temperatures of 100º C. For each transite curve the set of 50 to 100 standard specimens from the steel 21MnTiB was used for the Charpy impact test (ČSN EN 10 045-1). The chemical composition is presented in Tab. 1, the structure state in Fig. 1. For the successive temperatures (graduation 20º C) five specimens were used. In the transite domain the graduation was decreased to 5º C.

For the measuring the specimens were cooled in the bath of the ethanol cooled using the liquid nitrogen and at the lower temperatures than the ethanol melting point is in the bath of the penthanol again using the liquid nitrogen. The specimens were in the bath minimal 20 minutes and then broken using the Charpy impact machine.

Table 1 Chemical composition of the steel 21MnTiB (weight percentage)

C	Mn	Si	B	Cu	Ti	Al	P
0,2	0,89	0,09	0,005	0,057	0,015	0,03	0,015

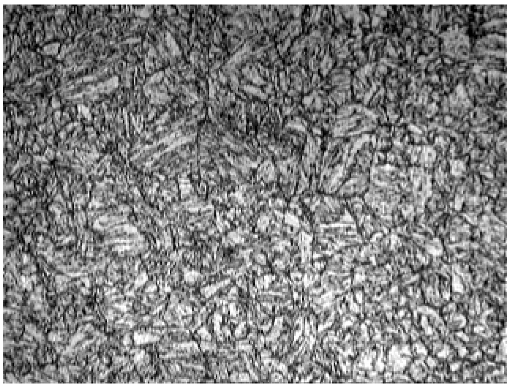

Figure 1 Sorbitic structure of steel 21MnTiB

3 Results and measured values

The typical property of the transite curves is the great variance of the experimental determined values; above all in the transite area the representation of measured data files by means of a continuous curve demands a suitable smoothing method. .Besides the non-parametric smoothing methods, which are almost all numerical e.g. spleins, the possibility of the regression exists using the suitable regression functions which contain the regression parameters. Their values together with the regression function type describe unambiguous the transite curve.
Most often the transite curve is described as the function of hyperbolic tangent in the form:

$$KV = \frac{H+L}{2} + \frac{H-L}{2} \cdot tgh \frac{2.(t - t_{tr})}{\Delta t} \qquad (1)$$

where
KV - impact energy
L - lower impact energy level
H - upper impact energy level
t_{tr} - transite temperature
t - temperature test
Δt - transite domain width

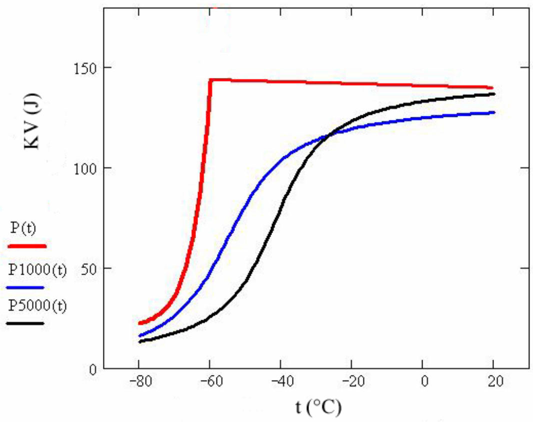

Figure 2 Transite curves of the steel 21MnTiB in the heat treatment state at the ageing temperature 100°C. P(t) – without ageing, P1000(t) – ageing 1000 hours, P5000(t) – ageing 5000 hours.

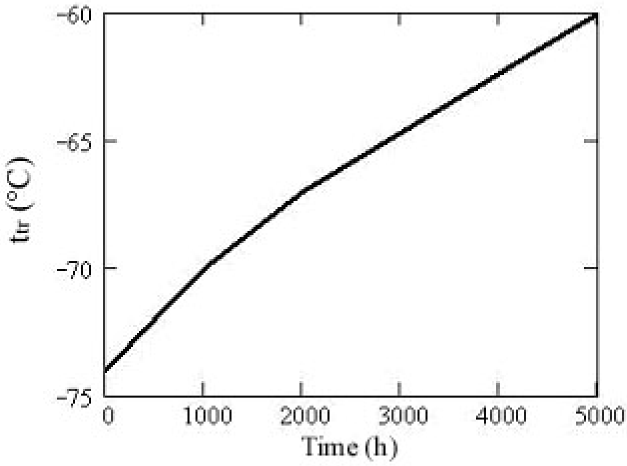

Figure 3 Graphic representation of the transite temperature (steel 21MnTiB) determined as the minimum impact energy 27 J, related to the ageing time, ageing temperature 100º C.

Figure 4 Brittle fracture of steel 21MnTiB at the temperature -75 °C

Figure 5 Ductile fracture of steel 21MnTiB at the temperature 20 °C

Figure 6 Fracture area of steel 21MnTiB at the temperature -40 °C. Semi-brittle fracture.

Conclusions

Steel 21MnTiB is the aluminium-titanium-killed steel. In the annealed state the transite temperature increased by 15º C owing to the ageing at 100º C. As the description of the transite curves is made using the least-squares method from the measured values of the definite dispersion variance, we can observe the ageing influence on the fracture pattern. This observation gives more precision to the results and eliminates the errors affected by different methods of the transite temperature determination. At this observation we directed at the temperatures, where the failure was fully tough, at the macrofractographical observation without the indication the indication of the cleavage fracture. We present the results, where we show how much increased the temperature for the fully tough fracture for the state without ageing and the state after 5000 hours ageing at the appuertant temperature:

- Steel 21MnTiB, at 100º C ageing temperature displacement of 40º C

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MONITORING OF WINTER RAPE VARIETY COMPOSITION QUALITY FOR RAW MATERIAL UTILIZATION

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There is evaluated 7 samples of rapeseed – variety Spacer (MSP 04), Caracas, Cando, MSP 06, Californium, Extra and Catonic with respect to technical parameters of pressing without seed heating, moisture content and oil content. For obtained rapeseed oils and from them produced fatty acids methyl esters are in laboratory determined phosphorus content and oxidation stability. The linolic acid content (18:2) and linolenic acid content (18:3) is decisive factor influencing oxidation stability. Sample Spacer (MSP 04) has shown lower content of linolenic acid with higher share of linolic acid and MSP 06 reduced content of linolenic acid with high share of oleic acid. The oxidation stability of sample MSP 06 is significantly highest and reaches value of 15.2 hours. Phosphorus content in all samples of rapeseed oils and fatty acids methyl esters is laying deep under the standard requirement.

Keywords: winter rape varieties, fatty acids composition, oxidation stability, phosphorus content, rapeseed oil, fatty acids methyl esters

1 Introduction

The vegetable oils are characterized by the fatty acid profiles, particularly degree of un-saturation (double bonds presence) and molecular length (carbon chain length).

The natural oils and fats are typically composed from triglycerides of fatty acids (FA) mixture. Part of FA represents about 90 % m/m and the glycerine part about 10 % m/m of fat and oils molecules. Individual FA are characterized by a number of the carbon atoms in the hydrocarbon chain in range from C8 to C22 and also by a number of the double bonds in the chain (Guo, A., Petrovic, Z. 2005). Typical FA compositions of monitored vegetable oils are presented in table 1.

The expertise is focused to the assessment of rape seeds samples of variety Spacer (MSP 04), Caracas, Cando, MSP 06, Californium, Extra and Catonic as a raw material for production of fatty acids methyl esters (FARME) in dependence on moisture, seeds fat content, phosphorus content, oxidation stability and composition of rape oil fatty acids acquired by the „cold" pressing and methyl esters produced from the fatty acids.

Table 1: Composition of vegetable oils fatty acids (Bockey 2006)

Fatty acids v %	Rape „00" type	Rape HO*	Sunflower	Sunflower HO*	Soya	Palm oil	Coconut
caprylic C8:0							6
caprynic C10:0							5
lauric C12:0							49
myristic C14:0						1	18
palmitic C16:0	4		6	3	5	42	9
stearic C18:0	2	7	5	4	4	5	3
oil C18:1	60	86	20	91	30	41	7
linoleic C18:2	21	4	63	3	50	11	2
linolenic 18:3	11	3	1		11		
eicosenic C20:1							
erucic C22:1	1						
Saturated fatty acids in total	7	7	11	7	9	48	91
Jodine number	111	83	135	84	130	54	9
Oxygen	10.8			11		11.3	14.4
Fat content	40 – 50	40 – 50	35 – 52	35 – 52	18 – 24		

* HO (high oleic) high content of oil acid

2 Methodological procedure and used methods

The proper pressing was conducted by the testing device of RIAEng, p.r.i. – oil auger press DD 85G Comet with perforated pressing cylinder. Through this cylinder and nozzle for oil cakes discharge flow the pressed impure oil. The pressing head, which creates transfer between the pressing cylinder and nozzle, can be heated electrically always at the start of the pressing. During the pressing process the heating is applied only according to the pressed oil crops type. The rape has not been heated before its input to the press and was processed under normal conditions. The obtained oil was gently re-filtered after the crude oil separation and stored in cooled boxes before proper analysis. At the pressing were fixed these values: pressing head temperature, pressed oil amount, oil cakes, pressing performance in $kg.h^{-1}$ of winter rape and gross yield, i.e. percentage share of obtained impure oil from the pressed sample. For the oil cakes the residual oil content was determined by the classical method.

The pure oil sample preparation was carried – out by:

- ČSN ISO 661 (58 8753) Animal and crop fats and oil
  Sample preparation for analysis:
- ČSN 58 8759 Methods of fats and oil testing. Water content determination - Karl Fischer method.
- Phosphorus content determination: ČSN EN 14102
- Elements content determination in fats and oils by the ICP spectrophotometer.
- ČSN ISO 660 (58 8756) Animal and crop fats and oils. Determination of number of acidity.
- ČSN ISO 5508 (58 8766) Animals and crop fats and oils. Analysis of fatty acids methyl-esters by the gaseous chromatography.
- AOCS Cd 1c- 85(93) method
- Iodine number – calculation from the gaseous chromatography
- Oxidation stability determination: ČSN EN 14112
  Determination of fat and oil oxidation stabilities with the device Rancimat 679.

The laboratory production of fatty acids methyl esters was realized by the following procedure:

- reesterification of the 1st stage: 2000 ml of rape oil at temperature 30 ^oC + 280 ml of methanol + potassium hydroxide (KOH = 1,6 % for rape oil), 15 min. blending by the mechanical agitator
- separation: min. 120 min. of gravitational separation in separator
- reesterification of the 2nd stage: separated FARME 1st of temperature 30 ^oC + 70 ml of methanol + potassium hydroxide (as the 1st stage), 15 min. blending by the mechanical agitator
- separation: min. 120 min. of gravitational separation in separator
- demetanolization: methyl esters heating on 50 ^oC + blending + aeration 20 min.
- soaps removal: FARME + 80 ml 0,3 g of citric acid + 80 ml water, 10 min. blending
- washing water separation: min. 60 min.
- FARME drying: heating on 50 ^oC + blending + aeration min. 30 min.

The methyl esters production procedure is, identical with those applied at the pilot production plant RPN Chrudim according to the know-how of RPN Chrudim and RIAEng, p.r.i. Prague.

3 Results

3.1 Assessment of rape seed samples

Water and oil content are evident from table 2.

The seed samples moisture is under required value in all cases and can be anticipated that all assessed seed varieties would be dried under value of 8,5 % of water under the operational conditions. The oil content of all samples (except sample Spacer MSP 04) is good and hopeful. The best assessed is sample Caracas.

Table 2: Water and oil content in investigated samples of rape seed

Variety	Water content (% m/m)	Fat content (% m/m)	
		in samples	conversion to 8 % m/m water content
Spacer (MSP 04)	5.3	39.8	38.7
Caracas	5.5	47.6	46.3
Cando	5.3	46.5	45.2
MSP 06	5.5	43.6	42.4
Californium	5.4	45.5	44.2
Extra	5.4	46.5	45.2
Catonic	5.4	45.0	43.8

Table 3: Balance data of rape seed pressing (regime set-up 3.5 – 40 rev.min^{-1})

Variety	Pressing head temperature	Time (min)	Weight (g)			Performance (kg.h^{-1})	Rough yield (%)
			oil with extrusion	oil cakes	total		
Spacer (MSP 04)	58 °C	138	8 139.9	20 945.5	29 085.4	12.64	27.98
Caracas	61 °C	156	11 552.5	17 983.3	29 535.8	11.36	39.11
Cando	85 °C	169	10 879.2	18 313.8	29 194.0	10.41	37.34
MSP 06	64 °C	153	10 130.2	19 572.5	29 702.7	11.65	34.11
Californium	64 °C	157	10 835.3	18 452.6	29 287.9	11.19	37.00
Extra	62 °C	200	13 959.8	22 664.5	36 624.3	10.99	38.12
Catonic	100° C	201	13 453.6	26 136.4	39 590.0	11.82	33.98

Table 4: Determination of fat content in oil cakes

Variety	Fat content		Dry matter (% m/m)	Fat average content in d.m. (% m/m)
	(% m/m)	(% m/m in d.m.)		
Spacer (MSP 04)	17.67	18.84	93.83	18.86
	17.71	18.87	93.83	
Caracas	17.34	18.95	91.51	18.82
	17.12	18.70	91.51	
Cando	18.09	19.15	94.45	19.25
	18.31	19.38	94.45	
MSP 06	16.09	17.09	94.15	17
	15.92	16.91	94.15	
Californium	15.83	16.79	94.28	16.72
	15.69	16.65	94.28	
Extra	16.27	17.30	94.06	17.17
	16.02	17.04	94.06	
Catonic	18.79	19.90	94.42	19.68
	18.38	19.47	94.42	

Table 5: Fatty acids composition, phosphorus content and oxidation stability in investigated samples of rape seed

Variety	Fatty acids composition (mg.kg^{-1})							Phosphorus content (% m/m)	Oxidat. stability (hours)
	myristic	palmi-tic	palmitic-oleic	stearic	oleic	linoleic	lino lenic		
	14:0	16:0	16:1	18:0	18:1	18:2	18:3		
Spacer (MSP04)	0.1	4.7	0.2	2.0	62.1	24.6	2.6	2.0	9.65
Caracas	below 0.1	4.4	below 0.1	1.7	63.1	17.1	10.5	1.5	9.20
Cando	below 0.1	4.5	below 0.1	1.7	61.1	18.6	10.8	1.1	6.00
MSP 06	below 0.1	3.5	0.2	2.0	76.3	11.9	2.8	3.7	15.20
Californium	below 0.1	4.1	0.2	1.7	62.5	19.5	9.3	1.7	6.48
Extra	below 0.1	3.8	0.2	1.4	63.2	19.2	9.3	7.8	6.72
Catonic	0,1	4.6	0.2	1.9	63.7	18.5	8.2	5.3	7.60

3.2 Pressing of rape seed samples

The balance data of pressing are evident from table 3. In table 4 are presented parameters of acquired oil cakes.

The samples Cando and Catonic were to be pressed under the increased temperature of the pressing head. Other temperatures are given by the process of own pressing. The variety Spacer (MSP 04) pressing has shown the lowest yield even from the balance data.

3.3 Assessment of oil samples

In tab. 5 are presented values – fatty acids composition, phosphorus content and oxidation stability of investigated samples.

For all samples the phosphorus presence is almost insignificant (low). The quality standard for FARME allows 10 mg.kg^{-1} and can be expected that at all technological processes of FARME production there will occur phosphorus content decreasing in comparison with the input raw material. The technology for oil acquisition from the seed does not affect the phosphorus content in the seed. Result of this is to expect probably other (higher) phosphorus contents in oils acquired mainly by the large-capacity processes. From this aspect all the assessed samples are satisfactory.

The parameter of the rape oils oxidation stability which will be used as a raw material for FARME production should considerably exceed the required value for final FARME. From this point of view the samples Californium and Extra are less satisfactory. In contrary, the best in stability of sample MSP 06. In contrary, the best is stability of the sample MSP 06. Stability of this oil sample is significantly high and is connected with a low content of linolenic acid.

Fatty acids composition of oil samples

From the chemistry of fats and oils result the facts which can be summarized by the following way with respect to the realized expertise:

- with increasing iodine number the ability of hydrocarbon chain of fatty acids to undergo to the chemical changes caused by oxygen increases,
- double bonds are more reactive in general,
- conjugated arrangement of double bonds is more reactive than the insulated bonds,
- double bond which is most distant from the functional group (carboxyl, ester bond) is most reactive,
- there exist pro-oxidant and anti-oxidants, the pro-oxidants accelerate the changes, the anti-oxidants slow-down the changes,
- in practice should be eliminated or suppressed the hear, light, metals (Fe, Cu) and particularly air oxygen effects,
- final products of FARME oxidation reactions can be:
  - Results of the carbon chain shortage are volatile compounds as aldehydes, short fatty acids, ketones etc.,
  - Results of polymeration processed are the high-molecular compounds created by connection of the double bonds of two or more fatty acids chains. They can be bonds through the oxygen or direct bonds of the carbon atoms.

About the fact, what type of reactions prevails decide the reaction conditions, particularly temperature.

The volatile compounds probably will not be a obstacle during FARME combustion and we can anticipate that they will be volatilized under higher temperature. The serious obstacle of the engine perfect operation could be polymers creating even solid sediments in the fuel.

For reasonable assessment of the oils chemical composition as basic raw material for FARME production is necessary always to consider two qualitative parameters, i.e. oxidation stability and cold resistance – CFPP (Dittmar 2003). It we improve the cold resistance by increasing of the linoleic and linolenic acid content, we deteriorate the oxidation stability. If we increase the oxidation stability by higher presence of the palmitic and stearic acid we deteriorate the cold resistance.

Conclusions of fatty acids spectrum of assessed samples

The fatty acids spectrum of the investigated samples of the rape enables to definite the following conclusions:

- The saturated fatty acids content, mainly palmitic and stearic does not exceed usual values for the rape oils and does not make anxiety that some oil will produce FARME with unsatisfactory cold resistance. The value of CFPP of non-aditive FARME -10 ^{o}C can be considered satisfactory.
- The linoleic acid content (18:2) and linolenic (18:3) is a decisive factor influencing the oxidation stability.
- From this aspect very interesting sample is MSP 04 (Spacer) and sample MSP 06. Both have shown reduced content of the linolenic acid (18:3). The first acid due to increased content of the linoleic acids (18:2), the second one due to increased content of the oleic acid (18:1).
- It can be expected that the oxidation stability of the sample MSP 06 will be significantly higher. This is also confirmed by the found value of 15.2 hours.

3.4 FARME samples evaluation

Phosphorus content and oxidation stability in FARME produced from the investigated samples of the rape seed are presented in table 6.

Table 6: Phosphorus content and oxidation stability of rape methyl esters samples produced from the investigated varieties of rape

Variety	FARME	
	Phosphorus content ($mg.kg^{-1}$)	Oxidation stability (hours) *
Spacer (MSP 04)	0.10	7.65
Caracas	0.29	7.20
Cando	0.10	6.30
MSP 06	0.10	12.06
Californium	0.93	6.20
Extra	0.10	6.20
Catonic	0.50	7.10
Comparative FARME sample from production plant RPN Chrudim	0.50	6.50

* RANCIMAT 110 ^{o}C

The phosphorus content in all FARME samples is considerably under the standard requirement. Nevertheless, it is necessary to remember that phosphorus content in oil considerably influences method of oil acquisition from the seed this parameter will not make the problems for any oil sample and appropriate FARME.

Oxidation stability of produced FARME is in line with those of initial rapeseed oils and all samples were higher than the minimum requirement of 6 hours. Significantly higher it was for the sample Spacer, MSP 06 and Catonic.

4 Conclusions

For final and complex assessment of rape seed samples must be taken into account the agronomical-economical properties. For example, when we have at disposal the rape seed with high yield per hectare and with only average spectrum of fatty acids, then we also probably have an economical space (oil price as raw material) for utilization of effective antioxidant for FARME.

For eventual further development of seed there will be probably sufficient to obtain the oil samples through the standard procedure and to determine for them the fatty acids spectrum as dominant evaluating parameter. The aim should be the minimization of the linolenic acid content in favor of the oleic acid content increasing. From this aspect the best sample is MSP 06. It is also desirable to minimize the stearic acid content.

It seems that FARME preparation from the investigated oil samples and its analytical assessment is desirable.

With development of the dietologists demands can be expected that the optimal composition of fatty acids for oils determined for human nourishment and technical purposes should not vary in principle.

We also have to remember the development of the farmers demands, e.g. total content of glukosinolates and their content in the extracted meals and oil cakes or cellulose content because high economical benefit of these by-products considerably in influences the FARME economy.

For assessment of the oil plants cultivars suitability from future market from a view of the fatty acids profile it can be stated as follows:

- Linolenic acid is relative unstable. Stability decreases with the un-saturation level in the sequence saturated acid > oil > linoleic > linolenic. At the same time also the food industry requires high stability of vegetable oils and fats (with regard to high temperature on utilization, multiple oil application, long-time service life).
- Standard rape oil is traditionally hydrogenated due to stability improving (Clarke 2005).
- Vegetable oils with <3 % m/m linolenic acid and >75 % m/m of oil acid do not need hydrogenation. The rape is close to these figures and gradually the sunflower cultivars with high content of oil acid are introduced.
- For the cultivars with high content of erucic acid is anticipated their application in biologically degradable plastics and lubricants and possibility of conversion to behenic acid.
- Very low content of unsaturated fatty acids (e.g. linolenic <2 % m/m) is associated with high stability, biological degradability and natural multi-purpose utilization due to handling with the fatty acids profiles (Clarke 2005).
- The bio-fuel market should not act directly as a driving force of oil quality, but profile with high content of oil acid is better for bio-fuels as compared with current commodity rape oil, therefore it can accelerate the cultivars choice.
- The above mentioned facts bring serious effects for agronomist. Political requirements for bio-fuels production could have impact on ecological inputs, nitrogen fertilization in particular.

The work comprises partial results of the research project of the Ministry of Agriculture of the Czech Republic 0002703101 – Part 6 “Research of new opportunities of effective utilization of agricultural products for non-food purposes” solution.

We express our thanks to firm Monsanto CR Brno – Mr. R. Lesák – for assurance of rapeseed varieties samples.

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OPTIMIZATION OF STANDARD PREVENTIVE MAINTENANCE INTERVALS

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In the paper, the methodology of optimization of planned preventive maintenance is proposed, which is based on the utilization of data obtained from a maintenance information system – adjusting the database structure, collection and processing of data. The data processing algorithm is based on the application of theory of replacement and its modification for the given problem. The core principle of the algorithm is the minimization of costs of maintenance and operation of production equipment. The algorithm can be either used as a separate tool or integrated into the computer maintenance management system as a complementary module. Therefore it enables to optimize the intervals of various levels of planned preventive maintenance of most of the production equipment in a company. A practical example of application of such algorithm is presented in the end of the paper.

Keywords: maintenance, optimisation, preventive maintenance interval

1. Introduction

In every firm a number of production equipment items can be found, for which a standard maintenance system based on a machines' operating time is applied. However, the used maintenance intervals (periods) are often determined just basing on a qualified estimate of the manufacturer or maintenance manager. This leads to an increase of machinery operating costs – too short maintenance period results in an increase of maintenance costs, too long maintenance intervals lead to increase of costs due to poor technical condition of the production equipment. The efforts to apply sophisticated methods of preventive maintenance optimization are hindered by a number of problems. Some maintenance management information systems use for instance Markov processes, though these can be applied only for large populations of very similar machines. Known stochastic models are based on the knowledge of failure probability in various stages of the object's life – however, this implies the use of statistical methods and monitoring of a set of other metrics of machine's performance (reliability characteristics). The needed stochastic model of object renewal (replacement) then could be described and developed afterwards when the analysis of machine's operation history is done. Furthermore, the known models of optimization of preventive maintenance mostly consider only two-state elements. Some of these models could be successfully applied, but only in specific cases (electronic components, pipeline systems etc.). Generalizations or utilization of these methods for other applications, in this case for a population of heterogeneous machines of a manufacturing plant, would be very difficult or impossible.

One of the other ways of determination of optimal standard maintenance period is the application of renewal (replacement) theory in the field of maintenance using maintenance data recorded in a maintenance information system. The practical output of such application for a maintenance manager is the possibility of justified correction of preventive maintenance periods, basing on the results of algorithmic testing of data recorded in the maintenance information system.

2. Fundamentals of algorithm for optimization of preventive maintenance period

General criterial function of replacement seeks the minimum of average unit costs of replacement and operation – the minimum of the function marks the optimum time for replacement (see Equation 1).

$$u(t) = \frac{N_O + N_P(t_S)}{t_S} \rightarrow \min \tag{1}$$

where: N_O Costs of replacement (Kč)
$N_P(t_s)$ Cost of operation (Kč)
t_s mean time of operation (w)
$u(t)$ average unit costs of replacement and operation (Kč.w^{-1})

For calculation of optimum period of standard maintenance, the function can be modified as follows:

$$u(t) = \frac{N_Ú + N_P(t)}{t} \rightarrow \min \tag{2}$$

where: $N_Ú$ costs of preventive maintenance (Kč)
$N_P(t)$ costs of operation (Kč)

t time of operation since the last standard preventive maintenance (w)

u(t) average unit costs of preventive maintenance and operation (Kč.w^{-1})

It is obvious, that the costs of maintenance itself act in the way of prolonging the standard preventive maintenance period. Conversely, the costs of operation, which rise due to worsening technical condition when extending the maintenance period, make the preventive maintenance period as short as possible. The sum curve *u(t)* must have a local minimum, which needs to be found in order to determine the optimum period of preventive maintenance.

The costs of preventive maintenance $N_{Ú}$ for specific types of maintenance are known. The cost items usually include costs of materials, wages including overheads and costs of downtimes, if caused by maintenance. These costs are recorded for each maintenance action in the maintenance information system.

The monitored items of costs need to include all the costs, caused by the deteriorated technical condition of the machine. In most cases these include the following cost items:

a) costs of repairs (after failure maintenance)
b) losses due to downtimes of production equipment
c) costs of nonconforming products (scraps) produced due to bad technical condition
d) costs of overconsumption of energies due to inefficiency caused by bad technical condition
e) losses due to worse performance of a machine caused by its bad technical condition

Though not every maintenance information system allows monitoring of all of the above described items of costs, those most important for the optimization of maintenance period (a, b, often also c) can be recorded in every maintenance information system and therefore can be utilized in the optimization algorithm.

3. Algorithm of optimization of preventive maintenance period

The recorded maintenance data of a selected object (production equipment) is processed by the algorithm in the following way:

1. The following information is entered: ID code of the selected maintained object, type of maintenance and the number of historical periods to be processed (statistically, basing on hundreds of processed types of maintenance, the sufficient number of periods is *k*=6 to 8)
2. For the chosen maintained object (production equipment) all the after-failure maintenance actions performed during the chosen history (ie. after-failure maintenance actions done between the standard preventive maintenance, for *k* periods)
3. In each period between preventive maintenance, the costs of operation and cumulative costs of operation are calculated. The costs of operation are calculated as follows:

$$N_P(t) = t_p.a_1 + t_{pú}.a_2 + N_m(+p_{nv}.a_3 + \Delta E) \quad (3)$$

where:

$N_P(t)$ costs of operation for gradually deteriorating technical condition of a machine (Kč)

t_p labor consumption of maintenance after failure (hrs)

a_1 hourly wage costs of maintenance personnel including overheads (Kč.hr^{-1})

$t_{pú}$ duration of downtime due to after-failure maintenance (hrs)

a_2 hourly downtime costs of the machine (Kč)

N_m costs of material used for after-failure maintenance (repair) (Kč)

p_{nv} number of nonconforming products (scrap) manufactured between maintenance actions in k-th period (pcs)

a_3 loss (costs) of producing a nonconforming product, scrap costs (Kč)

ΔE costs of overconsumption of energy in the k-th period (Kč)

The last two terms of the equation are intentionally left in parentheses, because these are only rarely recorded in a suitable form and therefore it is not feasible to use them in most of manufacturing plants (firms). Nevertheless, the dominant item of calculated costs is the costs of downtimes, which are typically by far higher than all the remaining items (for instance one hour of manufacturing line downtime in automotive industry equals to several millions Kč). Therefore the determination of optimal preventive maintenance period is not significantly affected by the two last terms in the equation and these can be ignored.

4. The average unit costs of maintenance and operations are calculated as the cumulative costs over the time of operation
5. Finally, both the partial components of the total average unit costs are summed and the resulting values are fitted with a 2nd degree polynomial function. The coefficient of determination R^2 is calculated. The sum curve is then analysed to find the minimum and appropriate optimal time of operation between preventive maintenance actions (optimal preventive maintenance period). In case the R^2 values for more than a half of samples do not

amount to at least 0.5, a warning message is shown indicating that the optimal period can not be determined with sufficient reliability and the algorithm is terminated.

6. the results of optimal periods of preventive maintenance for all the analysed historical periods between preventive maintenance actions are then processed as a weighted average of the obtained optimal maintenance periods and coefficients of determination, while only periods for which $R^2 \geq 0.5$ are considered:

$$I_{Úopt} = \frac{\sum_{i=1}^{k} t_{opti} . R^2{}_i}{\sum_{i=1}^{k} . R^2{}_i} \qquad (4)$$

7. The resulting optimal periods for selected types of preventive maintenance and production equipment are then visualized to the maintenance manager in a table. The table summarizes for each type of maintenance and production equipment the present maintenance period and the calculated optimal maintenance period. The three cases (Fig. 1) can then occur: the present maintenance period is too short and it is possible to make it longer (case a); the present period is close to the calculated optimum and therefore confirmed as correct (case b); the present period is too long and needs to be shortened (case c). For each type of maintenance and machine the codes of three most frequent failures are shown – maintenance manager then can adjust both the duration of preventive maintenance periods and also the scope of preventive maintenance.

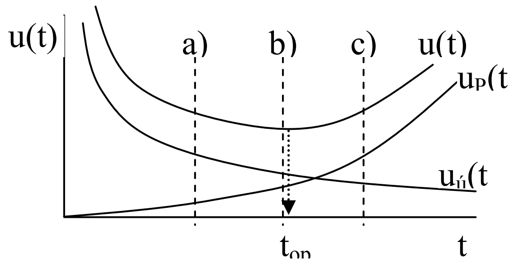

Fig.1 Example of graphical processing of data for optimal period of one type of preventive maintenance

4. Example of application of the algorithm for optimization of preventive maintenance period

The described algorithm was tested for real data from a maintenance information system in a manufacturer of small machinery. In the phase of testing, MS Excel spreadsheet was used for processing of the data. The data were imported from the database of performed maintenance actions and then processed according to the previously described procedure. As an example, the optimization of quarterly period of standard preventive maintenance of Suhner drilling machine was selected. The original period of maintenance was 90 days. The costs of this preventive maintenance amounted to 15 450 Kč, wage costs of maintenance technician including overheads were 330 Kč/hour, one hour of downtime was appreciated to 4 500 Kč. The maintenance data for the selected machine have been recorded since 2002, data from the 8 previous consecutive 90-day periods of preventive maintenance for the calculation of optimal maintenance period. For each analysed period the minimum of total costs was found and the optimal period of preventive maintenance with the coefficient of determination of the obtained sum function *u(t)* were determined. The example of graphical processing of one of the analysed periods is presented in Fig. 2.

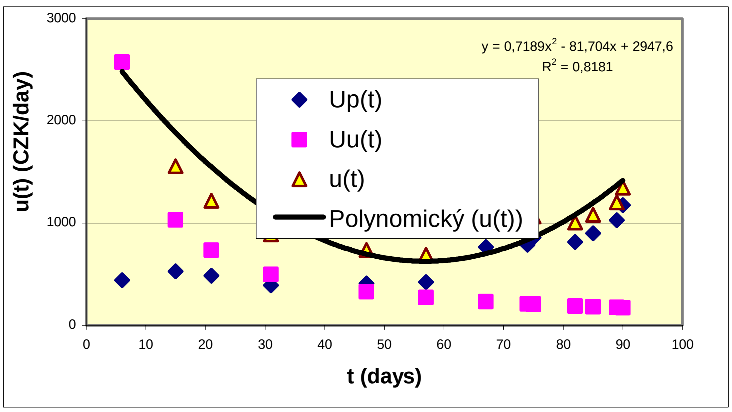

Fig. 2 Example of graphical processing of data from one of the analysed maintenance periods

After the data from all 8 analysed maintenance periods have been processed, the optimal period of the given type of preventive standard maintenance was calculated as weighted average of all the t_{opt}, for which the value of $R^2 \geq 0.5$ (see Tab. 1).

Tab.1 Final processing of the partial values

Period	t_{opt}	R^2	$t_{opt}.R^2$
1	57	0,82	46,74
2	53	0,89	47,17
3	62	0,85	52,7
4	46	0,5	23
5	45	0,83	37,35
6	54	0,68	36,72
7	46	0,77	35,42
8	56	0,71	39,76
	Sum:	6,05	
Optimal maintenance period:			**52,70 days**

This means that the original period of preventive standard maintenance 90 days was too long and should be shortened to just 53 days. The maintenance manager can also look at the table of failure codes for the selected maintained object, either complete, or only the three most frequent (see Tab. 2), and for the possible correction of the scope of preventive maintenance also at the notes of maintenance technicians regarding the performed repairs (example of these notes is shown at Fig. 3).

Tab. 2 The list of most frequent failures for the selected maintained object.

code of failure	number of failures
E00	47
E50	64
M00	56
M30	32

Replacement of position sensor M8 Mi PNP
Defective position sensor of loading
Failure of sensor NK2
Replacement of piston FESTO
Broken sensor cable.
Replacement of position sensors M8 Mi PNP
Leaking air hose
Defective sensor SICK
...

Fig. 3 Example of notes of maintenance technicians (translated).

For this real-data example, the following corrections were accepted:

- the period of preventive maintenance was shortened from 90 days down to 53 days
- the maintenance scope was extended with other operations according to the occurrence of most frequent failures and information from the notes of maintenance technicians (regular checks of sensor cables and preventive replacements of inexpensive sensors of position)

In the manufacturing plant this algorithm was applied for 98 types of preventive maintenance for various machines. For 34 of them the original maintenance period was significantly out of the calculated optimum and was therefore corrected. The monitoring (though still only short-term) of changes of costs for machines with corrected maintenance periods (and mostly also scope of preventive maintenance) shown that 3 months after the corrections were imposed the costs of operation (influenced especially by the reduction of downtimes) of these machines dropped in average by 14 %. A more profound analysis and evaluation will be carried out six months after the corrections of standard preventive maintenance.

5. Conclusion

In the paper the methodology for optimization of planned preventive maintenance is proposed. The methodology is based on the data from the maintenance information system – adjustment of the databases structure, data collection, selection/filtering of the data, testing and final processing. The algorithm of data processing is based on renewal (replacement) theory and its modification for the solution of the given problem. The core of the algorithm is the minimization of costs of maintenance and operation of production equipment. The algorithm can be used as a supporting tool for a maintenance information system or developed and integrated into the maintenance information system as a supporting module. Therefore the algorithm enables easy optimization of planned preventive maintenance periods for most of the production equipment in a production plant. The first results of its application for real data from a manufacturing plant show that the proposed method is suitable and improves efficiency of maintenance system.

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STATISTICAL SURVEY ON THE FIELD OF MOBILE AGRICULTURAL MACHINERY IN COMPANIES OF CZECH REPUBLIC

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Contemporary agricultural companies posses variety of mobile agricultural machinery. This machinery varies in type and also in age. Unfortunately nowadays there is no complex information regarding to current status of this machinery in Czech Republic. Therefore to gain complex view of the status of this machinery it was necessary to start survey at Czech University of Life Sciences.

Main target of this project is to gain information from selected companies. This information will be statistically evaluated and will provide basis for establishing technical, technological and organizational back up by mobile agricultural machinery for model companies. It will also outline status of machinery in selected companies. Information required for statistical analysis will be obtained by questionary survey. This survey will be carried out by distribution of printed questionnaires in combination with internet based application for data collection. Final proposal will serve to needs of all applicants who will be interested in this matter. This proposal may be treated as guidelines for companies who run their business under circumstances specified in the proposal.

For purposes of this survey will be used internet based application which will provide comfortable access to the database of the survey for all informants. Database filled by the data and supplied by the date gained through printed questioners will be evaluated by statistical methods. For this evaluation and analysis will be used MS-Excel eventually other database software.

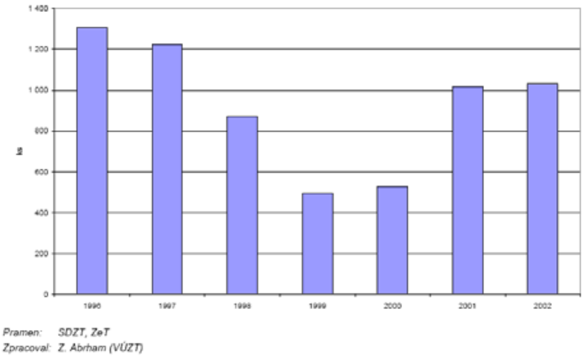
The survey was prepared in a way which is supposed to guarantee maximum rate of return. Even the most simplified questioner is expected to have only 50 to 60% rate of return. Therefore large scale of statistical analysis will take place in this project.

Keywords: Mobile machinery, Statistical survey

Introduction

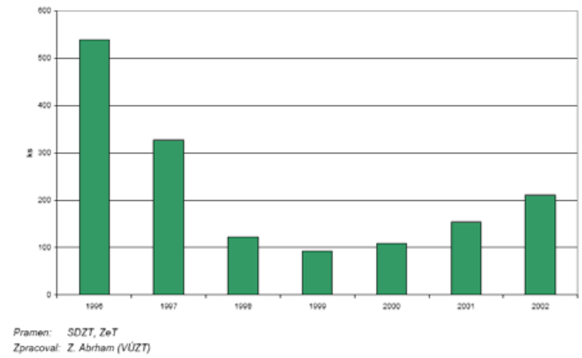
Nowadays there is a big number of private agricultural companies on a Czech agricultural market who own number of mobile agricultural machinery. Information about approximate age and numbers of this machinery is provided by Agrocenzus which was carried out by Czech statistical office in 2000. Another information about mobile agricultural machinery can be obtained in Green reports emitted by Ministry of Agriculture of the Czech republic. This report for example provides information about numbers of tractors and harvester threshers delivered to Czech agricultural companies in specific years.

Numbers of tractors delivered to Czech agriculture



Source : SDZT, ZeT , assembled by Z.Abrham (VUZT)

Numbers of harvester threshers delivered to Czech agriculture



Source : SDZT, ZeT , assembled by Z.Abrham (VUZT)

This information is now partly outdated, therefore Czech university of Life sciences Prague and Mendel University of Agriculture and Forestry Brno started a project which aim is to find and question agricultural companies of Czech Republic. This project should provide information more accurate, updated information about types, quantities and age of mobile machinery in these companies.

Materials and Methods

Approximately 10 000 agricultural companies of larger size were chosen for the purposes of this survey. These companies will be asked to provide information about mobile agricultural machinery they own. The questionnaire was assembled for the purposes of this survey and distributed to companies with enclosed accompanying letter asking for cooperation. Because filling in and then handing in of questionnaire is optional and there is no way to make informants make it, we simplified questionnaire as much as possible. It consists of only one page A4 and requires no additional instructions. This simplicity should ensure maximal backflow of questionnaires. This is also supported by providing prepaid envelopes addressed back to university. In order to additionally increase number of informants willing to respond to this survey there is also internet based application which will serve as alternative method how informants can participate in this survey without using classical paper questionnaires.

Even using all of these precautions we still predict approximate return of 60% questionnaires, this involves printed questionnaires as well as internet application. This prediction is based on experience from similarly conceived surveys from the past which hit approximately this rate of return of qustionaires.

In order to identify conditions under which machinery works we asked companies to provide information about structure of production, area of maintenance land and percentages of various farm plants in a production of the company. Other questions were focused on types, amounts and age of machinery divided into following categories:

- Tractors
- Harvester threshers
- Field choppers
- Pressers
- Sprayers

For this machinery informants will be asked about main technical parameter, type, year of purchase and amount of hours which machine served in the field. Data obtained by this way will be statistically evaluated. The output will be structured information about numbers, age and types of machinery represented in dependency on size of company and structure of its production. Example of questionnaire follows.

Table 1 Questionnaire of statistical survey of agricultural mobile machinery in a company

Structure of production		
Area [ha]:		Cereals[ha]:
		Fodder plants [ha]:
Arable land [ha]:		
Other land [ha]:		Other plants[ha]:

Mobile machinery

Machinery	Model	Main technical parameter	Brand	Type	Year of purchase	Machinery wear
Tractors						
Harvester threshers						
Field choppers						
Pressers						
Sprayers						
Others						

Table 2 Numbers of machinery

Machinery and equipment	2000	2003	2005
Tractors (wheeled, caterpillar) incl. narrow-track ones	94 607	91 648	87 039
under 40 kW	24 440	22 367	17 617
40 to 59 kW	45 058	37 376	33 089
60 to 99 kW	15 970	21 184	24 288
100 kW and over	9 139	10 721	12 045
Tractor ploughs	34 563	34 153	32 408
Soil processing machines	26 560	28 526	30 077
Mowers	23 554	25 010	26 162
Combine harvesters	12 785	12 060	11 606
Potato harvesters	6 875	6 659	6 196
Beet harvesters, combined	751	630	521
Solid fertilizer spreaders	12 317	12 321	12 211
Manure and compost spreaders	13 566	13 303	12 830

Source: Czech statistical office, www.czso.cz
Results of Agrocensus 2000 and Farm Structure Surveys 2003 and 2005

However no updated data are available it is expected that the survey will provide information which will be relevant to last known data from Czech statistical office as it is stated in following table.

After obtaining all questionnaires from companies willing to respond, the data will be statistically evaluated in order to gain final results. Program Statistica will be used for this evaluation. In order to set up recommendations for model companies, data will be processed by Techconsult program which will provide information about costs related to usage of specific machinery.

Results

When this report was written the project was in a phase when all questionnaires were prepared for distribution as well as accompanying letters for informants. Internet application was online and prepared for data collection. Questionnaires were expected to be send in next few days. First specific response if expected in July and August 2007. All outputs will be processed by computer programs of MS – Office. Printed questionnaires and internet database have the same structure of questions and therefore it will be possible to evaluate all answers together and create homogenous database which will provide required information about machinery and its status.

Not only statistical data will become output of this project but also proposals for model business will be assembled. These proposals will be based upon statistical evaluation and will be focused on optimalization of mobile machinery numbers and types in companies in order to minimalize costs. Information gained this way may be influenced by low rate of return of questionnaires but predicted rate of return should be sufficient for setting up statistical thesis.

Also psychological factors may have influence on outputs of this survey. Informants may tend to modify information provided in questionnaires in order to improve image of their company. However this influence cannot be removed.

Conclusion

This project is meant to provide as much as possible accurate information about status of mobile machinery in Czech agricultural companies. Usage of proposed methodology would guarantee that the information will be relevant and collected data accurate. Therefore all proposals based on this data and its analysis should be useful for real companies willing to accept them.

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VERIFICATION RESULTS OF SLAUGHTERHOUSE WASTE ANAEROBIC FERMENTATION PROCESSING TECHNOLOGY

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Biogas production in agriculture is processing of waste agricultural products (particularly excrements of farm animals but also phytomass), rather different but very similar is biogas production from biologically degradable municipal waste and biologically degradable industrial waste mainly from food industry. Frequently discussed issue is processing of slaughter waste and grass (or public green areas at biogas station). Usually, the produced heat and electricity quantity does not cover the waste water cleaning plant operation. Agricultural biogas stations and biogas stations for biologically degradable municipal waste and biologically processing have considerably higher gas yield because they work with higher dry matter content in substratum, i.e. 8-12 % (compared with waste water cleaning plant 2-6 %) and are able to produce high surplus of gas for next application.

Keywords: biogas; biogas station; slurry; slaughterhouse waste; input substrate

1. Intruduction

The materials used for biogas production in agricultural enterprises consist traditionally of livestock faeces and phytomass. The processing of biodegradable municipal waste and biodegradable industrial waste, particularly food production, is another, very similar area of biogas production. Processing such waste in farm biogas stations may improve their economies significantly. It must be noted for clarity that all such biogas stations are different from wastewater treatment plants, where municipal wastewater originating from sewerage systems is processed. Processing of municipal wastewater streams for biogas using anaerobic fermentation is a conventional technology well-established world-wide. A total of 100 wastewater treatment plant utilising such conventional processing of sludge for biogas are estimated to operate in the Czech Republic at present. The electrical power so produced is utilised principally to heat the process, any possible surplus being sold to the grid. The thermal energy is used in heating the farm and office buildings. The heat and electricity produced, however, are typically insufficient to cover the operation of the respective wastewater treatment plant. Farm biogas stations, and biogas stations processing biodegradable waste, are much more gas yielding as they work with higher levels of substrate dry matter (8-12%) as opposed to wastewater treatment plants (2-6%), and are capable of producing considerable surpluses of gas for subsequent uses (Dohányos, Zábranská, Straka, 2003).

Waste from food production, particularly slaughterhouses, are subject to strict public health rules under EC Regulation 1774/2002. The majority of such waste is classified in Category 3, for which treatment processes are prescribed. Their elimination using conventional rendering plant technologies is inefficient and challenging. The aim of our tests was to verify the viability of processing selected slaughterhouse waste using anaerobic fermentation.

2. Materials and method

The tests were carried out on the single-stage anaerobic digestion principle using 5% dry-matter charges under mesophilic and thermophilic conditions in two series differing in retention times (Experiments 1 and 2 respectively).

The following materials were the subject of verification:

- poultry bone pulp (39.8% dry matter),
- pork sinews (15.2% dry matter),
- cattle and pig slurry mixed in a proportion 1:1,
- stabilised non-dehydrated residue after anaerobic digestion, used as inoculum.

The poultry pulp and pork sinews were cut up to particles of 12 mm. The slurry and digestate were mixed in a proportion 1:1 in both the charges for the small reactors (0.002 m^3) and the large reactors (0.1 m^3). The results of verification in the small reactors are quoted in this paper. The substrate proportions for each batch are shown in Table 1;

Table 1: Substrate proportions in batches, for small reactors

Reactor	Proportion [% mass]	Poultry bone pulp [% mass]	Pork sinews [% mass]
1a	100	0	0
2a	90	10	0
3a	80	20	0
4a	70	30	0
5a	60	40	0
6a	90	0	10
7a	80	0	20
8a	70	0	30
9a	60	0	40

Table 2: Material composition of charges in small reactors in both experiments

Reactor	Proportions [g]	Poultry bone pulp [g]	Pork sinews [g]	Water [g]
1a	1250.0	0.0	0.0	750.0
2a	803.6	89.3	0.0	1107.1
3a	555.6	138.8	0.0	1305.6
4a	397.7	170.5	0.0	1431.8
5a	288.5	192.3	0.0	1519.2
6a	1034.5	0.0	114.9	850.6
7a	851.1	0.0	212.7	936.2
8a	693.1	0.0	297.1	1009.8
9a	555.6	0.0	370.3	1074.1

Table 2 shows the material compositions of the batches. The retention times, or times of presence of each batch in the reactor, were 26 days and 37 days during Experiments 1 and 2 respectively.

The biogas production in the small reactors was measured using a gasometer constructed at the Agricultural Technology Research Institute in Prague.

The chemical composition of the biogas produced was detected using an AIR LF analyser (made by ASEKO s.r.o., Vestec u Prahy). The analyser is designed for analysing landfill gas and biogas. The methane and carbon dioxide concentrations are established using infrared radiation. The analyser uses an electro-chemical sensor to establish the oxygen concentration. The chemical composition of the biogas was detected once every 24 hours.

The chemical analyses of the stabilised residue were conducted at the Agrochemical Laboratory of the Agricultural Technology Research Institute in Prague.

Samples of the stabilised residue were tested for the presence of bacteria of the *Salmonella* and *Enterobacteriaceae* genera in microbiological analyses at the Microbiology Laboratory of the National Medical Institute in Prague. The microbiologic methods applied comply to the requirements of EC Regulation 1774/2002 (Salminen, Rintala, Lokshina, Vavilin, 2000).

3. Results and discussion

This paper only presents in detail the results of observations of biogas production.

The biogas production was measured daily; nevertheless, cumulative production related to 1 kg of dry matter is quoted for the sake of clarity. The measurement results are for the small reactors, verifying the concentrations of the additives, the poultry bone pulp, and the pork sinews.

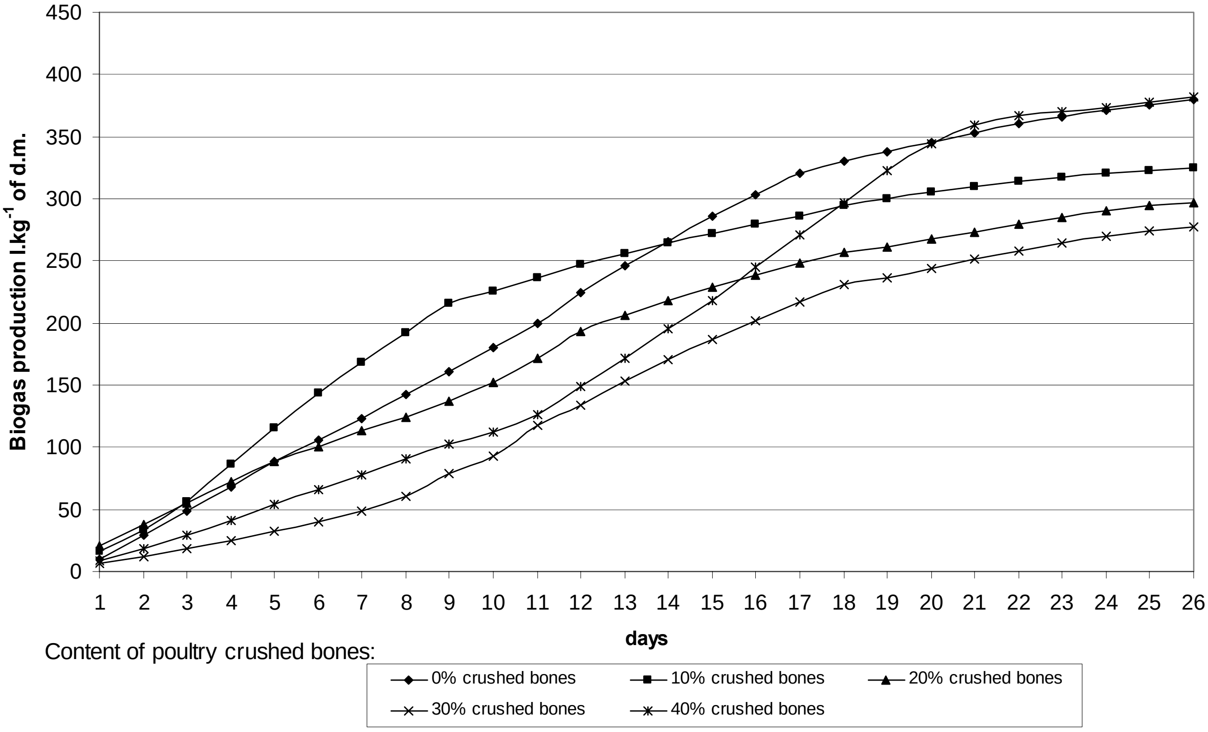

Figure 1 - Cumulative biogas production, poultry bone pulp, Experiment 1
(Biogas production [litres per kg of dry matter])

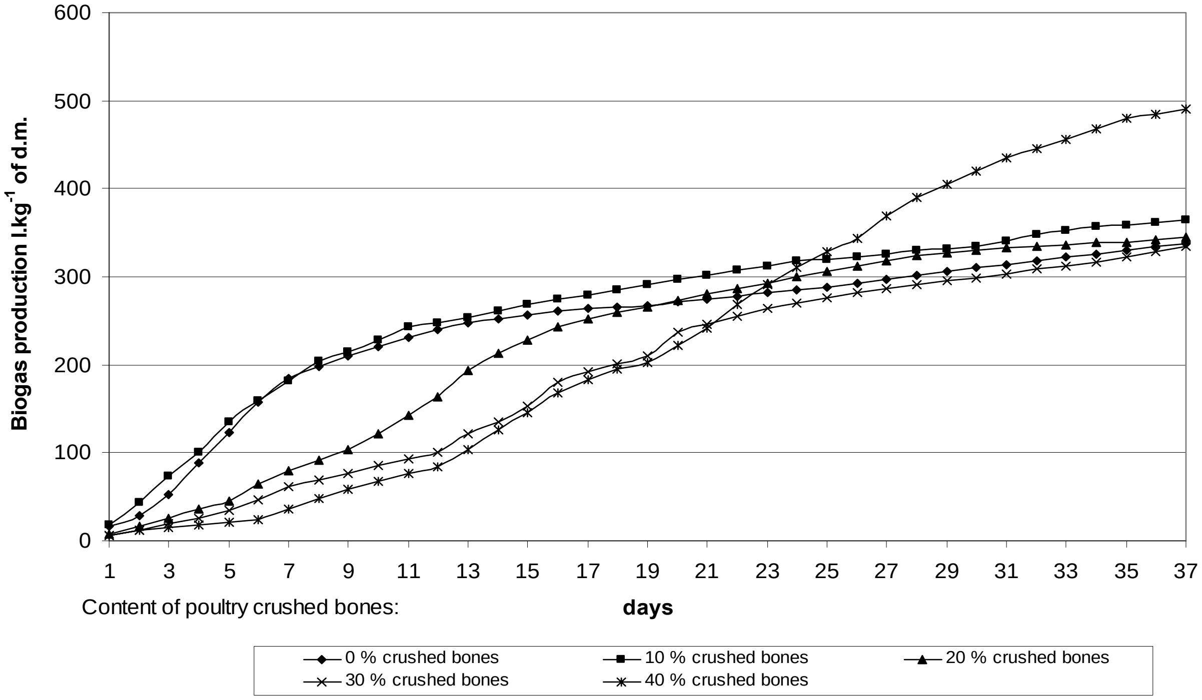

Figure 2 - Cumulative biogas production, poultry bone pulp, Experiment 2

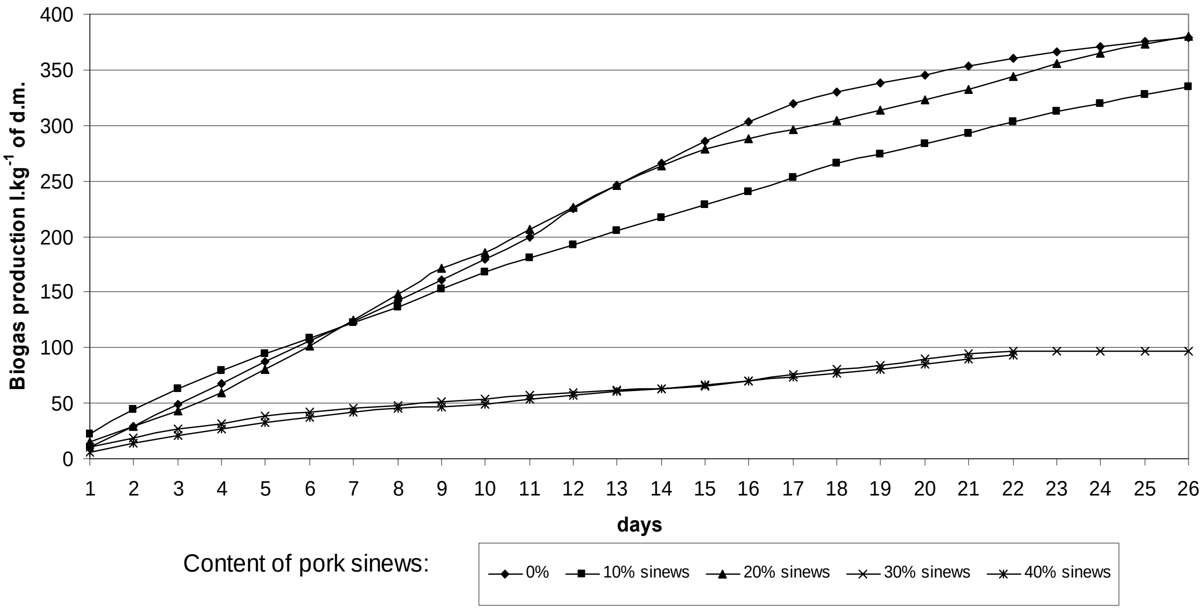

Figure 3 - Cumulative biogas production, pork sinews, Experiment 1

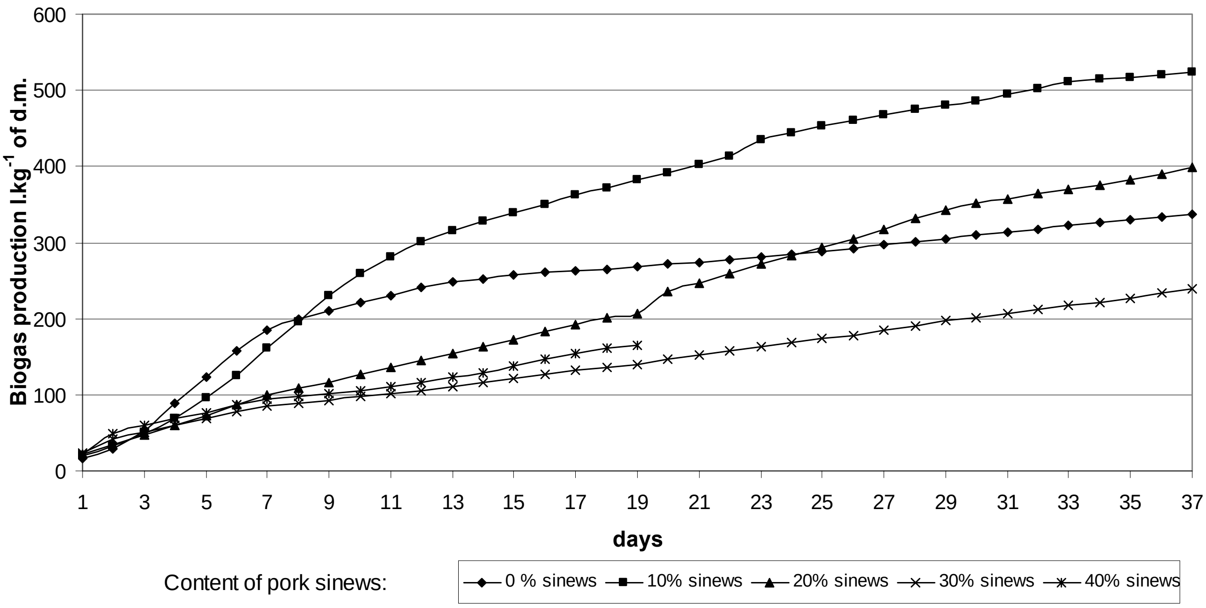

Figure 4 - Cumulative biogas production, pork sinews, Experiment 2

The tested samples contained poultry bone pulp in concentrations of 10 %, 20 %, 30 %, and 40 %, and pork sinews in identical concentrations. Figures 1 to 4 show the results of experiments for bone pulp and pork sinews in the mesophilic range. The experimental developments were very similar to each other, but differed in certain details. The samples were processed in single-stage reactors under mesophilic and thermophilic conditions (the developments under thermophilic conditions are not quoted here as they were very similar, only the retention times were reduced).

The composition of samples containing the bone pulp seems optimal in terms of biogas production and methane content. The highest cumulative biogas production rate was achieved in the sample containing 40 % of poultry bone pulp (381.5 litres per kg of dry matter, and 561.0 litres per kg of dry matter, respectively) after 26 days.

The samples containing 10 % and 20 % of pork sinews showed a satisfactory production of both biogas and methane. The best result was achieved with the sample containing 10 % of pork sinews (460.5 litres per kg of dry matter, and 641.4 litres per kg of dry matter, respectively) after 26-day retention. The samples containing 30 % and 40 % of pork sinews were characterised by low biogas production rates and high methane contents (70-

80 %). These samples posed considerable difficulties in terms of frothing. The large reactors validated the results in the small reactors, only the frothing of the samples was not as marked, and the maximum biogas production occurred ten days earlier in the thermophilic process (Vavilin, 2003).

The stabilised residue after anaerobic digestion was analysed chemically and microbiologically, and its suitability for soil application was ascertained.

It can be stated that poultry bone pulp and pork sinews are suitable materials for anaerobic digestion provided that the appropriate mass proportions in the fermented mixture are maintained.

4. Conclusions

It is effective to use slaughterhouse waste in order to increase the efficiency of biogas stations. Stabilised residue after anaerobic digestion was analysed chemically and microbiologically, and its suitability for soil application was ascertained. However, processing of slaughterhouse waste in a biogas station requires the installation of a unit for thermal treatment of the input substrate, i.e., heating the material to 70 °C for one hour.

This paper has been developed as a result of execution of Czech Ministry of Agriculture projects nos. QG 50039: ‘Processing confiscated and other waste using the biogas process’, and QD 3160: ‘Research into new technological procedures for improved efficiency of agricultural and food processing waste utilisation’.

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CARROT QUALITY ASSESSMENT BY HYPERSPECTRAL IMAGING

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The objective of the work reported here was to predict the change in carrot water content and monitoring of drying process of carrot during the storage by hyperspectral imaging. The absorption signal level was determined between 900 and 1750 nm wavelength. The results show that there is a definite difference between the two carrot cultivars. There was found a definite decrease in the signal level in the waveband range below 1400 nm because of the drying. Relationship was determined between the spectral parameter and the storage time, which is approximately a linear one. Therefore, the spectral parameter is a suitable characteristic for the prediction of water content and monitoring of the drying process of carrots.

Keywords: Carrot, water content, hyperspectral imaging, absorption

Introduction

Quality is very important characteristic of fruits and vegetables. Quality and safety characteristics generally are determined by conventional techniques, such as chemical and microbiological ones. The hyperspectral imaging a new and developing technique in the field of spectroscopy; it is rapid, non-contact and can be non-destructive method (Kaszab et al., 2007). The variation in the dry matter content, sugar content and carotene content were analyzed with different Nantes type cultivars (Nemethy and Feher, 2002). The influence of the climatic and soil conditions were determined. Definite relationship was found between the carrot moisture content and the sugar and carotene content. Near-infrared techniques are commonly used for the measurement of moisture content. It is especially suitable for the measurement of grains. The phloem and xylem parts of carrots were distinguished by near-infrared reflectance during heat treatment, boiled for different times (Belie at al., 2002).

Thus assumable that water content of carrot measurable by near-infrared technique and there is a relationship between the different quality characteristic of the carrot and the water content. The change in the water content of carrot affect the several carrots components is presumed, such as sugar content, carotene content, etc.

The objective of the work reported here was to predict the change in carrot water content and monitoring of drying process of carrot during the storage by hyperspectral imaging.

Material and Method

Experiments were performed with Barbara and Nevis carrot cultivars. The measurements were started with approximately 70 mm length carrots and the middle part of these ones was cut off for the testing. 2 mm thick discs were cut off from the fresh cut surface. Each carrot was analyzed by hyperspectral imaging. Consequently the freshly cut surface was measured to eliminate disturbing effect of surface drying. The carrots were stored under controlled atmosphere conditions to dry, these conditions were as follow: relative humidity 45%, drying temperature 20°C and the storage period was 28 hours.

The hyperspectral imaging system consists of a spectrograph (Imspector), illumination, a near-infrared camera (InGaAs sensor, 12 bit dynamic range, 320 * 256 resolution (x*w), 900-1750 nm spectral range) and a visual camera (400-1000 nm), and a table for the object that is moved by a controlled stepping motor. The figure 1 shows the equipment. This push-broom type instrument scans the surface line by line, having whole spectra of each point of a rectangle. The calibration method and the measurements were computer controlled (Firtha, 2006). Signal corrections were necessary to handle non-homogenous grating efficiency and baseline drift and to enhance signal level. Relative absorption was calculated by comparing signal with the bright and dark field reading for each pixel.

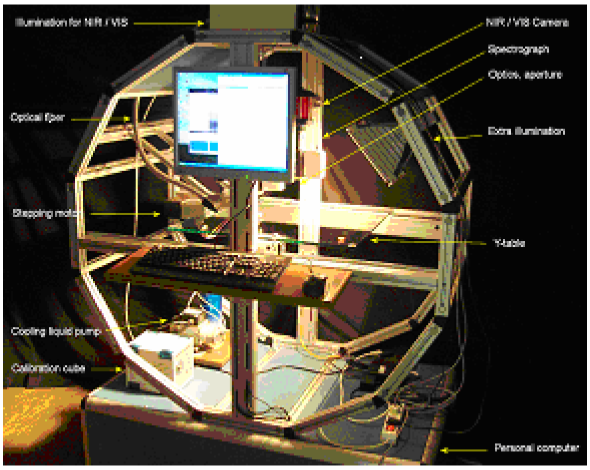

Figure 1 – The hyperspectral imaging system

Measurements were performed on the phloem and the xylem parts of the carrot disks. Actually, the measurements were done along three prescribed lines perpendicular to table motion along the carrot disk diameter and parallel to the diameter with 1.0 mm steps (figure 2). The average values were calculated from the results obtained from these measurements (including the scanning along the three parallel lines). During the evaluation of these measurements the phloem and xylem parts of the carrot were not distinguished. Before the analyzing with hyperspecrtal imaging the mass of each carrot was measured and from these results the mass loss of the carrots were calculated.

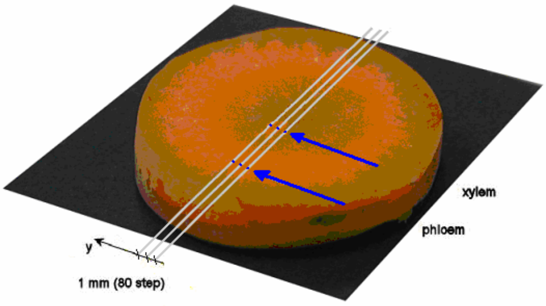

Figure 2 – Three prescribed lines perpendicular to table motion and parallel to the disk diameter

Results and Discussion

Figure 3 shows the three dimensional spectrum of a carrot disk along the freshly cut surface, where x axis means the position and y axis shows the wavelength and the vertical axis is the relative reflectance (Firtha, 2006).

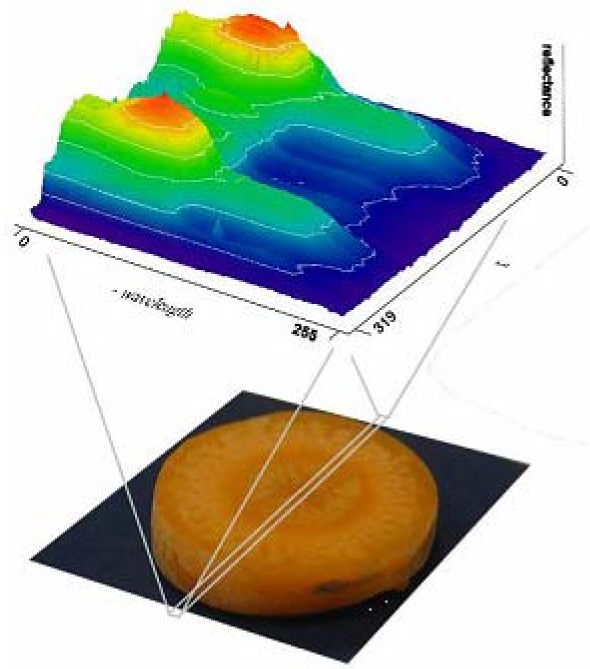

Figure 3 – Relative reflectance of carrot disk along the diameter (Firtha, 2006)

Relative absorption matrix was measured for the three parallel lines denoted as “0”, “1” and “2” on figure 2) on each disk. The absorption spectra of three disks of Barbara cultivar and three of Nevis cultivar were measured. The signal level of the relative absorption versus the wavelength for two different cultivars is shown in figure 4. Three carrots of Barbara and three ones of Nevis cultivar were tested. It is clear from the results that there are no considerable differences between the three different spectra of the same cultivar. However, some difference can be observed between the two cultivars.

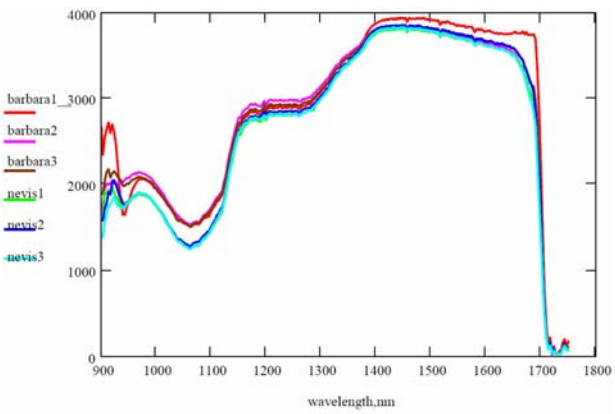

Figure 4 – Signal level of relative absorption versus wavelength for two different cultivars
(three carrot disks of Barbara and three ones of Nevis cultivar)

The figure 5 shows the signal level of the relative absorption in the function of the wavelength. The notations “hour0”, “hour2”, “hour4” etc. mean the fresh carrot disks and the ones stored for 2, 4, 6 and 8 hours, respectively. There is a definite decrease in the signal level in the waveband below approximately 1400 nm because of the drying during storage. Therefore, the reduction in the water content of carrots causes a definite decrease of the absorbance signal level. However, there are no considerable changes in the signal level above 1400 nm wavelength because of the change in the carrot water content.

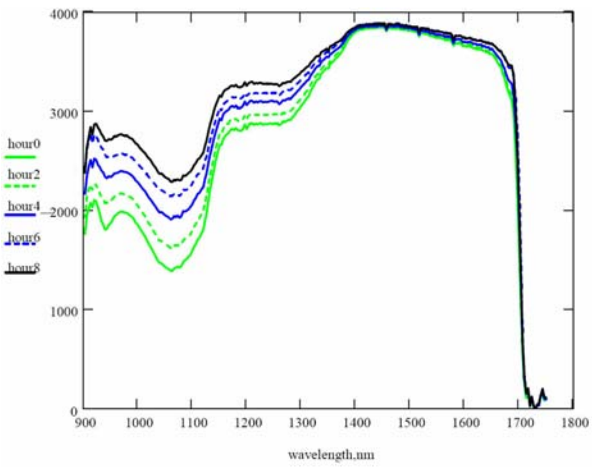

Figure 5 – Signal level of relative absorption of carrot disks in the function of wavelength for carrot disks stored for different periods (“hour0” – fresh, “hour2”, “hour4” etc. – dried for 2, 4, 6 and 8 hours, respectively)

Three carrots of Barbara cultivar and three ones of Nevis cultivar were measured. The variation in the water content was determined by the relative mass reduction of the carrot. This relative mass reduction was expressed in the function of the storage time for the tested carrots (figure 6). The relative mass reduction was found to be proportional to the storage time for a definite mass range. Except for the carrot “Barbara2” there is no definite difference between the tested carrots and tested two cultivars.

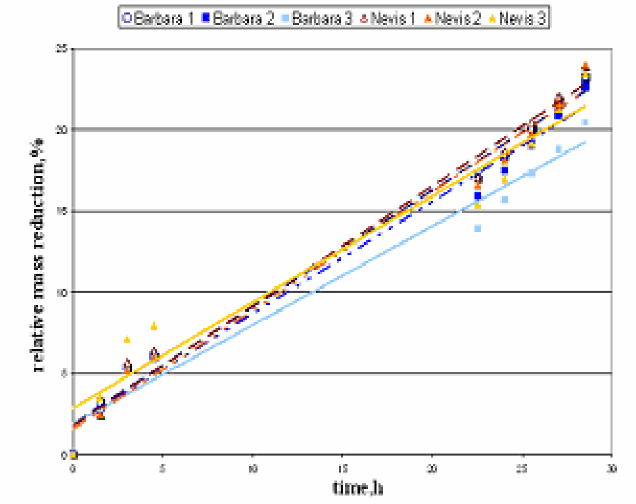

Figure 6 – Relative mass reduction of six different carrots (three Barbara and three Nevis) in the function of the storage time

Relationship was determined between the spectral parameter and the storage time. The spectral parameter was expressed in the function of the storage time for three carrot disks of Barbara cultivar and for three ones of Nevis cultivar. There is a quasi-linear relationship between the spectral parameter and the storage time. The value of spectral parameter was higher in the case of Nevis carrot cultivar. The spectral parameter decreases with the increase of the storage time. Therefore, the spectral parameter can be a good characteristic for the prediction of the water content and the mass reduction of carrots.

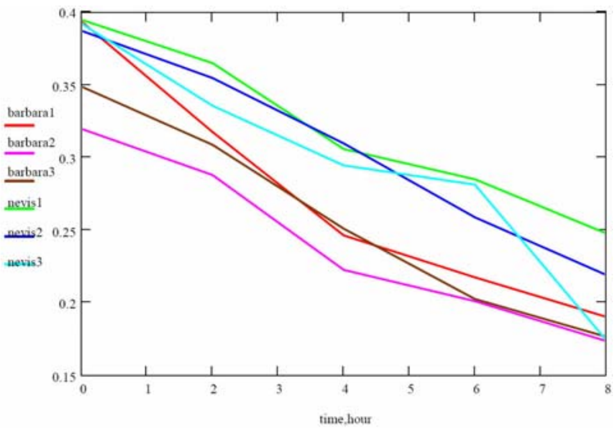

Figure 7 – Spectral parameter in the function of the storage time for two different cultivars (three carrot disks of Barbara and three ones of Nevis cultivar)

Conclusion

The results show that there is a definite difference between the two carrot cultivars. A definite increase was found in the signal level in the waveband range below 1400 nm because of the drying. Relationship was determined between the spectral parameter and the storage time, which is approximately a linear one. Therefore, the spectral parameter is a suitable characteristic for the prediction of water content and monitoring of the drying process of carrots. Consequently the quality of carrot can be characterized with the reduction of spectral parameter during the storage.

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CONTROL OF INDOOR ENVIRONMENT IN HOUSING OF LAYING HENS

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This paper presents experience in the control of indoor microclimatic parameters in housing of laying hens. To compare and evaluate the microclimatic condition together with the production results is possible only with the use of suitable measuring instruments and equipment. The main indoors parameters (air temperature and relative humidity, air velocity, carbon dioxide, oxygen and ammonia concentrations, illumination and noise level were measured and controlled by continues or ambulant measurement during the summer, autumn and winter periods. Special attention was paid to the problems of laying nests and illumination in relation to the quantity and quality of egg production. The obtained results from the experiments increased the knowledge about microclimatic conditions in egg production.

Keywords: hens, microclimate, floor housing, cages

Introduction

Many different housing systems are used worldwide for layers. The most common housing system used on the large commercial farms is accommodation in the compact battery cages. To meet the rules of the Council Directive 1999/74/EC the standard of these housing systems was changed during the last years and many new technological systems with different equipment have been introduced to keep layers in non-cage systems (SKŘIVAN, 2000). The changes of technology in buildings for laying hens housing are based not only on the enlargement of specific floor area which is increased from 450 cm^2 to 550 cm^2 since year 2003, and to 750 cm^2 since year 2012, but also the special changes of technological equipment for housing of laying hens.

To compare and evaluate the microclimatic condition together with the production results is possible only with the use of suitable measuring instruments and equipment. Special attention was paid to the problems of laying nests and illumination in relation to the quantity and quality of egg production. The obtained results from the experiments increased the knowledge about microclimatic conditions in egg production and help us to choose the suitable system for the future farms.

Materials

In the frame of the long time research work the indoors-microclimatic conditions were measured together with the general parameters of egg production (feed consumption and conversion, eggs production and quality, etc.) in two separated experimental rooms with two different housing systems and technologies. The first room with 72 layers has been equipped by the three tiers battery of cages and the second room with 59 hens and floor housing technology (The cut straw with sawdust was used as a litter on the floor). Three breeds of laying hens have been in use for the study: Isa Brown, Moravia BSL and Hisex Brown.

The readings of continue measurements were taken during the summer, autumn and winter periods. The temperatures and humidity of the air were measured with by thermocouples and capacitive humidity sensors FH A6x6, air velocity by thermo anemometer FVA645 TH3, carbon dioxide by gas sensor FY A 600 based on infrared optics, oxygen by electrochemical cell sensor FY 9600, ammonia by sensor ZO 9601-FS6V12, illumination by sensor FL A613-VL, and noise by UNITEST 93411 D. The measuring instrument Therm 2590-9 logged all measured parameters.

The temperature and humidity sensors were installed near to the level of the housed hens; there were three sensors in the case of section equipped by the compact battery, one per each floor level; and three sensors in the case of compact battery in section with floor housing technology, one per each part of section (near window, centre and near door). Special attention was paid to the problems of laying nests and illumination in relation to the quantity and quality of egg production. The colour of eggshell

Table 1 Summary of production conditions and results - Summer

Parameter	Unit	Floor	Cages
Intensity of eggs production	%	67,14	74,13
Feed consumption	$g . FD^{-1}$	112,68	110,32
Hens losses	Hens	12	9
Hens losses	%	20,3	12,5
Colour of eggs shell	%	32,11	34,44
Biological load of housing area	$Hens . m^{-2}$	4,552	32,727
Average outside temperature	°C	15,05	18,71
Average temperature	°C	20,64	23,33
Average relative humidity	%	73,03	62,54
Average concentration of CO_2	%	0,16	0,1
Average noise level (filter A)	dB	59,23	65,9
Average illumination	lx	356,55	146,07

Table 2 Summary of production conditions and results - Autumn

Parameter	Unit	Floor	Cages
Intensity of eggs production	%	76,8	88,9
Feed consumption	$g . FD^{-1}$	129,79	125,58
Hens losses	Hens	8	2
Hens losses	%	17,02	3,17
Colour of eggs shell	%	35,6	35,59
Biological load of housing area	$Hens . m^{-2}$	3,627	28,636
Average outside temperature	°C	7,97	11,5
Average temperature	°C	14,98	15,81
Average relative humidity	%	86,15	67,72
Average concentration of CO_2	%	0,17	0,09
Average noise level (filter A)	dB	59,65	64,72
Average illumination	lx	86,06	39,29

Table 3 Summary of production conditions and results - Winter

Parameter	Unit	Floor	Cages
Intensity of eggs production	%	80,84	78,36
Feed consumption	$g . FD^{-1}$	156,77	120,34
Colour of eggs shell	%	38,3	39,08
Biological load of housing area	$Hens . m^{-2}$	3,009	27,727
Average outside temperature	°C	- 9,36	- 6,2
Average temperature	°C	10,62	10,55
Average relative humidity	%	73,84	53,66
Average concentration of CO_2	%	0,2	0,11
Average noise level (filter A)	dB	46,77	58,21
Average illumination	lx	117	59,9

was measured in the laboratory with TSS-QRC reflectometric equipment.

Results

Complete results calculated from obtained experiments are summarised in the Table 1, Table 2 and Table 3.

Discussion

The use of the room space was compared by the biological load of housing area, which was markedly higher in the cage housing. The production results were evaluated in term of intensity of eggs production, feed consumption and hens' losses. The intensity of eggs production was during summer and autumn periods distinctively higher in housing in cages, during winter slightly higher in the floor housing. The feed consumption and hens' losses were lower in the cages housing during the whole year. It was very distinct especially during the winter period, when the difference of intensity of eggs production was small, but it was obviously covered by the higher feed consumption.

There were not big differences in the microclimatic conditions. The small temperature and humidity differences inside the housing sections were due to difference of outside temperature and humidity. The level of CO_2 was lower in the cages during all research periods in despite of bigger number of hens and higher biological load of housing area. The housing conditions in the floor section were characterised by the distinctively higher illumination during the whole year. The level of noise was lower in the floor housing, which was probably cased mainly as the number of hens was smaller there.

Conclusions

The obtained results from the experiments increased the knowledge about microclimatic conditions in egg production and help us to choose the suitable system for the future farms. The results confirmed conclusions from similar research and experiment (KIC, 2005). The conclusion based on the described experiments is, that following the implementation of EU Directive 99/74/EC, the housing system that produces eggs at the better conditions will be cages. The importance of the microclimatic control is not only in the comparison of different conditions mutually, but also in the research of the influence of individual components on the results during the year.

It is important to continue in the similar research and compare the different housing systems also with the bigger number of hens under the real production conditions in the production farms. The other production factors should be included, e.g. economic evaluation of production costs, labour quality, veterinary and health aspects etc.

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ENERGY SAVINGS BY HEAT RECOVERY IN VENTILATION

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This paper presents the results from the research work focused on the problems of energy savings in the ventilation of buildings. There were compared two recovery systems: heat recuperation and heat regeneration of energy from the outgoing air. The main research activity was focused first of all on the comparison of the influence of dust pollution on the heat recovery function and its efficiency. Heat recuperation was measured in the industrial building. Heat regeneration was tested in air-conditioning of lecture room, and in agricultural buildings. Efficiency of heat regeneration was only slightly influenced by the dust pollution of filters. The tested regenerative heat exchangers with fixed-matrix for agricultural purposes were constructed from non-metallic materials, without needs of filters. It was obvious that regeneration efficiency and gained heat flow were independent of the dust pollution in both experimental buildings.

Keywords: ventilation, recuperation, regeneration, efficiency

Introduction

Many industrial, residential, civic and also agricultural buildings with indoor noxious gases production or high biological load have big heat losses through the structure and by ventilation, so the heating is needed. Using heat recovery systems can reduce the necessary heat capacity of those buildings, which need intensive ventilation. Different types of heat exchangers can be used for this purpose (KAKAC, 1980). The heat recuperators and heat regenerators were tested in different rooms and buildings and the final results were compared from the point of view of thermal efficiency in normal performance conditions.

Materials

Heat recuperation was measured in the industrial building specialised in the metal sheet cutting (laser machines with input power 138 kW), welding, surfacing and other similar production processes (different machine-tools). The indoor processes, especially welding (four welding machines), need the intensive ventilation of the building. The big dimensions of the products do not enable to use the suitable local welding instruments. The production is organised in double-shift cycle (since 6 a.m. to 10 p.m.).

The original construction of the building was not well insulated (heat losses 129 kW), so company decided to improve the thermal properties of the building (52 kW) by the insulation material Kingspan KS 1000 TF, and by the improved the windows. The heating system of the production shed is based on the use of seven infrared heaters (dark heaters with gas burner). The normal production indoor temperature is usually between the 16 and 20 °C. During the night period is the building heated at least on 12 °C. As there is a big airflow, which must be exchanged by the forced ventilation (heat losses by the ventilation during the coldest period of the winter Q_v = 119 kW), the energy saving system in ventilation with heat recovery seems to be a reasonable solution, and therefore tested building was equipped by the heat recuperation unit Beta 9/9 with cross plate heat exchanger.

Heat regeneration was tested in air-conditioning of lecture rooms, and in agricultural buildings (animal houses).

The lecture rooms have the capacity 132 student places. The air-conditioning system was designed with fresh air inflow V_e = 4 520 $m^3.h^{-1}$ and air outflow V_i = 4 083 $m^3.h^{-1}$ (small overpressure). Regenerators used in lecture rooms were industrial products of a disk type, in which the matrix (heat transfer surface) is in a disk form and air flows axially.

The operation of a regenerative heat exchanger was tested on a pig farm and a poultry farm. The practical use of heat regeneration was first tested in a hall for the housing of 240 fattening pigs (KIC, 1999). The ventilation system of the pig-fattening house consists of two ventilation units, based on an axial fan and a vertical ventilation chimney (sheet-metal plates) with cross-section 800 x 800 mm, passing through the roof. Each ventilation unit contains 20 heat-storage boards made from CETRIS 1250 x 750 x 8 mm, which are the matrix of the heat regenerator. Special automatic controls of the ventilation system allow two-way rotation of each fan, so they alternately function as follows. On the first cycle one fan expels air from the building and heats the matrix (storage plates) in its unit, while the other fan heats fresh air. On the second cycle the fans then operate the other way round, and so on. Ventilation units were operating on the following cycle: 300 seconds air expulsion and storage of heat in the matrix - 30 seconds fans at rest - 300 seconds of air intake and heating via the heat exchanger.

The other experimental farm building has two sections of the same 67,95 x 15,60 m and is used for fattening of 18,180 broilers (KIC, 2007). Two hot air heaters heat each section. They are automatic gas heaters with capacity of 70 kW, and of a cylindrical shape with burners of gas and fan. Four regenerative heat exchangers for heat recovery were installed in the experimental section. Each exchanger has an axial fan V465 with automatic regulation of power and with reversion of revolution direction in 180 s intervals. Accumulative mass of fixed-matrix for heat regeneration consists of 16 boards (8 boards in the first trials) made from CETRIS in dimensions of 1200 x 750 x 8 mm and is installed in horizontal metal air ducts of cross-section 400 x 750 mm. The principle of operation was the same as in the pig farm. Control section was equipped with the same technological equipment but without heat exchangers for heat recovery.

The airflows of incoming air to the building (V_e) and of outgoing air (V_i) were calculated. The temperatures of incoming air after the exchanger (t_e') and temperatures outside and inside the building were measured as well. The results of the measurements were used to calculate the real efficiency (CHYSKÝ, 1993) of the heat recovery (η_{RQ}) (1). The heat flow (Q_R) gained from the heat recovery is calculated according to equation (2). It is supposed that the density (ρ_a) and specific heat (c_a) of the outgoing air and incoming air is the same.

$$\eta_{RQ} = \frac{\text{Ve.(te}'\text{-te)}}{\text{Vi.(ti - te)}}\ 100 \quad (\%) \qquad (1)$$

$$Q_R = V_e \,.\, \rho_a \,.\, c_a \,.\, (t_e' - t_e)\ (kW) \qquad (2)$$

Heat flows were calculated using the data from the measurement by ALMEMO 2290-8 completed by temperature sensors (Ni-NiCr thermocouples). Some other instruments for air velocity FV A645 and temperature measurement FHA 6461were used in some cases.

Results

The results from the industrial building equipped by the heat recuperation unit Beta 9/9 with cross plate heat exchanger are in the Table 1.

The relation between the in–out coming airflow was control by the air velocity measurement in the lecture rooms equipped by the heat regenerators. Results are presented in the Table 2. Thermal efficiency and heat flow gained from the regeneration in the lecture rooms for different conditions were calculated according the measured data. Results are presented in the Table 3.

Table 1 Thermal efficiency of heat recuperation in the industrial building

Ventilation conditions	**η_{RQ} (%)**	**Q_R (kW)**
Ventilation with polluted filters	17.6	11,3
Ventilation without filters	52,6	30,9
Ventilation with new filters	50,2	30,4

Table 2 Relation between in-out airflow calculated from the air velocity measurement

-	**M II**	**M III**
V_e / V_i (-)	1,34	1,29

Table 3 Thermal efficiency of heat regeneration and heat flow gained from the regeneration

Lecture room	**M II**		**M III**	
Ventilation conditions	η_{RQ} (%)	Q_R (kW)	η_{RQ} (%)	Q_R (kW)
Ventilation with broken regenerator driving	---	---	34,1	5,5
Ventilation with polluted filters	63	9,0	---	---
Ventilation with new filters	77,2	16,4	79,7	16,2

Table 4 The results of measurement of heat regeneration in the pig farm

Level of pollution	**η_{RQ}**	**Q_R**
(%)	(%)	(kW)
50	12	3,54
100	14	3,37

Table 5 The results of measurement of heat regeneration in the broiler farm after 2 and 5 weeks

Level of pollution after time	η_{RO} (%)	Q_R (kW)	η_{RO} (%)	Q_R (kW)
(weeks)	8 boards	8 boards	16 boards	16 boards
2	13,8	1,67	33,4	3,74
5	13,1	1,59	33,1	3,71

All readings in the pig farm were taken at two levels of dust pollution on the matrix made from the CETRIS 8 mm. The first level of pollution was after a long period of performance without cleaning (about 14 months) and the second one was for partly cleaned plates (about 50% pollution). The results of measuring heat regeneration for different levels of ventilation in the conditions are in the Table 4.

Efficiency of heat regeneration by 8 or 16 storage boards made from CETRIS 8 mm in the ventilation system of the broiler house are content in the Table 5. The first level of pollution of matrix was after 2 weeks of fattening without cleaning and the second one was after 5 weeks of fattening.

Discussion

The level of filters pollution distinctively influences the results from the industrial building equipped by the heat recuperation unit Beta 9/9 with cross plate heat exchanger. Results obtained from the measurement with polluted filters (η_{RQ} = 17,6 %) and after that trial, when the conditions were changed and parameters were measured completely without (η_{RQ} = 52,6 %), and later with new filters (η_{RQ} = 50,2 %), are very different. It resulted also in the big difference in heat flows, gained by recuperation from the outgoing air.

Thermal efficiency of heat regeneration and heat flow gained from the regenerator of a disk type in the lecture rooms depends mainly on the proper function of regenerators. Ventilation with broken regenerator driving resulted in a lower efficiency of regeneration (η_{RQ} = 34,1 %). Efficiency of heat regeneration in the lecture room was about η_{RQ} = 78 %, and it was only slightly influenced by the dust pollution of filters.

Tested regenerative heat exchangers with fixed-matrix for agricultural purposes were constructed from non-metallic materials without needs of filters. The average efficiency of the heat recovery system tested in the hall for fattening pigs was according to the level of ventilation about η_R = 13 %. The average efficiency of heat regeneration in the section for broilers was also about η_R = 13 % and with increased number of regenerative boards from 8 to 16 was about η_R = 30 %. It was obvious that regeneration efficiency and gained heat flow were independent of the dust pollution in both experimental buildings.

Conclusions

The results of measurement demonstrate that significant energy savings can be garnered with the building of an air outlet with the use of heat exchangers for heat recovery from the outgoing air. Very important influence on the efficiency has the proper maintenance of filters and all parts and system components. The highest thermal efficiency was obtained from the heat regenerators installed in the lecture room.

Practical measurement in the farm buildings confirmed, that tested simple regenerators without a switch-over valve constructed from the non-metallic materials can be used for the improvement of the heat balance in animal houses. The low efficiency of the heat regeneration is from the practical point of view balanced by the simple and low cost construction, which can be installed by the farmers as a modernisation of the buildings without a big investment. The other advantage is, that this heat regenerator is not sensitive to dust pollution.

Nomenclature

c_a specific heat of air ($kJ.kg^{-1}.K^{-1}$)
Q_R heat flow gained from the regenerative heat exchanger (kW)
t_e temperature of outside air (°C)
t_e' temperature of incoming air after the exchanger (°C)
t_i temperature of inside air (°C)
V_e flow of incoming air ($m^3.s^{-1}$)
V_i flow of outgoing air ($m^3.s^{-1}$)
ρ_a density of air ($kg.m^{-3}$)
η_{RQ} efficiency of heat regeneration (%)

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INFRARED THERMOGRAPHY TO MONITOR THE INFLUENCE OF DIFFERENT VACUUM LEVEL ON BOVINE TEATS

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The objective of the study was to monitor the influence of different vacuum (45 kPa and 35 kPa) on bovine teats by means of the changes of teat temperature. Teat temperature was measured by infrared thermography. Generally, machine milking increased teat temperature. Teat temperature was dependent on vacuum level and the temperature difference between 45 kPa and 35 kPa (2.73 K) was significant ($P<0.05$). The higher stress of teats at higher vacuum level was verified by infrared thermography. Thermography was considered useful method to non-invasive and non-contact evaluation teat tissue responses.

1. Introduction

The teats are the most stressed part of the udder, because milking changes their condition. Repeated teat compressions may cause mechanical and circulatory changes in teat tissues and hyperaemia in the teat wall (Hamann, 1992, Isaksson and Lind, 1992; Burmeister et al., 1998, Zecconi et al., 2000). Assessment of the teat conditions and udder before and after milking is usually based on visual observations. For such assessments, a cutimeter (Isaksson and Lind, 1992) or a classification system (Rasmussen and Larsen, 1998, Neijenhuis et al., 2000) or ultrasonographic scanning (Neijenhuis, 2004) are used. Infrared thermography is applied less frequently. The objective of the study was to monitor the influence of different vacuum (45 kPa and 35 kPa) on bovine teats by means of the changes of teat temperature. Teat temperature was measured by infrared thermography.

2. Materials

Infrared thermographic measurements were carried out in tandem milking parlour 2 x 5 in 20 dairy cows (Holstein, milk yield 9567 l, 1st stage of lactation). Dairy cows were milked and their teats measured twice a day at 45 kPa per one week and twice a day at 35 kPa per one week. Thermal profiles of teats were obtained immediately before milking and immediately after milking without teat preparation (dry teat surface). Thermograms of teats were evaluated by the special computer program ThermaCAM Reporter 2000. The differences between teat temperatures were calculated and evaluated by Statistica.cz (ANOVA).

3. Results

At 45 kPa level the difference between teat temperature before and after milking was 2.82 ± 2.41 K. At 35 kPa level the difference was 0.09 ± 1.25. The difference between 45 kPa and 35 kPa (2.73 K) was found out as significant ($P<0.05$).

4. Discussion

Thermographic measurements of the milking process have been taken by Hamann (1985), who investigated the temperature responses of the udder to machine milking. This study showed that conventional milking machines may cause an increase of the teat temperature. The findings of Eichel (992), who reported increased teat temperature after milking in 90% of dairy cows, although the evaluation of the milking used did not show any significant damage to the teats. Kunc et al. (2000b) used IRT to monitor udder temperature responses in healthy dairy cows under standard operating conditions in an autotandem milking parlour, in which all technical specifications complied with the standard. A comparison of all thermograms showed that milking caused significant changes in teats, particularly in those which were in direct contact with the milking machine and were subject to a significant stress. Teat temperature was increased by an average of 2.62°C. Similar results were reported by Barth (2000). Our results also showed that machine milking increased the temperature of teats. But the increase of teat temperature was dependent on vacuum level. The lower vacuum evokes lower teat temperature than the higher vacuum. According to Paulrud et al. (2002) and Berry et al. (2003) we can concluded that infrared thermography is useful for studying, monitoring and evaluating the effects of machine milking on mammary gland.

5. Conclusions

Generally, machine milking increased teat temperature. Teat temperature was dependent on vacuum level. The higher stress of teats at higher vacuum level was verified by infrared thermography. Thermography was considered useful method to non-invasive and non-contact evaluation teat tissue responses.

Acknowledgements:

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TRENDS IN CAR CARRIAGE IN THE CZECH REPUBLIC

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The progress of traffic is characterized by overall mild accrual in transportation output realized on transportation network in the Czech Republic in last five years, mild accrual in individual passenger transport, mushrooming in cargo road traffic (above all since year 2002) and decline in cargo railway's transportation. Division of shipping labor midst public and individual passenger traffic is approach to ratio 2:1, in the cargo traffic there is division of labor in ratio 3:1 midst road and railway's traffic. It is possible await that individual passenger traffic will be continuing mushrooming in the next time. Demand is improving along more capacity of the road network in cargo traffic same as in individual passenger traffic. The biggest customers are supplied by logistic providers practically only by road traffic. Railway's traffic is not profitable in that it is not by able flexibly response to market requirements. Cars are mostly carrying by road and railway's traffic in the Czech Republic. Individual kinds of carriage are keen competition in some sphere of action and in other are appropriately supply each other.

Keywords: car carriage, traffic, road transport, railway's, cargo.

1 Carriage trends in CZ and EU

Land carriage covers road carriage, railage, pipe-line and cross country, which is several or less adapted for carriage. Cars are mostly carrying by railway and roads. Railway have not fungible place in the section of haulage car carriage till this time, but road carriage is getting to by keen competition on the longer distances.

Other carriage category, air and water, are used only marginally in the area of the Czech Republic.

Trends of traffic realized on the traffic network in the Czech Republic are characterized by overall accrual transportation putout, accrual individual car transport, mushrooming road cargo (above all since 2002 year) and decline traffic on railway actually in cargo.

Division of shipping labor midst public and individual passenger traffic is approach to ratio 2:1 in the cargo traffic is division of labor in ratio 3:1 midst road and railway's traffic.

Hereinafter period it is possible expect continuance accrual individual passenger traffic. It is run for height quality and more capacity of traffic network from cargo and individual passenger traffic.

Capacity of the traffic networks and efficient logistic systems are first elementary premise for accrual exchange of goods between original states and new member's states. Today is roughly 60 logistical centers which has connection by more then one carriage category in the states of European Union. Logistical infrastructure is however connected above all by motorways and roads in the Czech Republic.

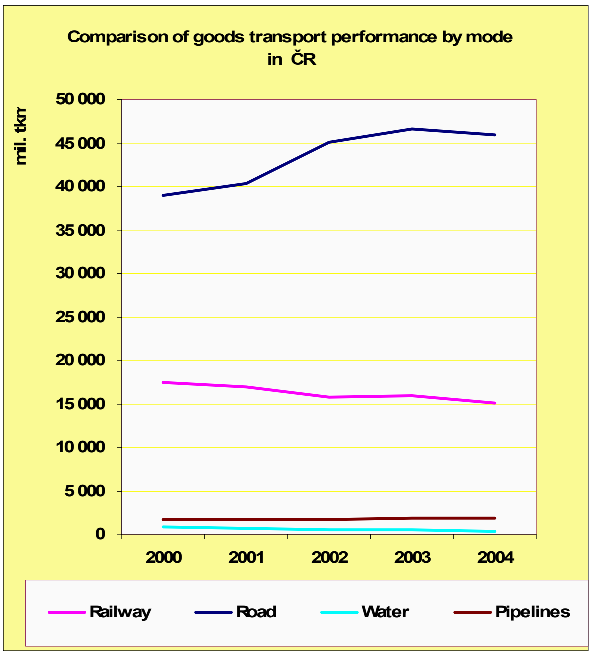

Figure 1: Comparison of goods transport performance by mode in CZ source: transport yearbook Ministry of transport Czech Republic

The biggest customers are supply only by road carriage. Railway is not profitable because it is possible flexibly react to market requirements.

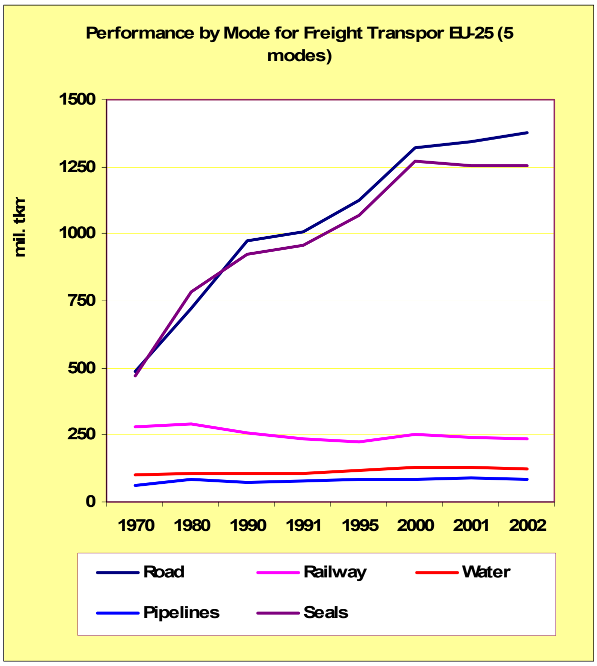

Figure 2: Comparison of goods transport performance by mode in EU source: European Commission, Directorate-General for Energy and Transport

2 Car carriage in the Czech Republic

Cars are carrying by railway and roads mostly in the Czech Republic. Individual categories of carriage are keen competition in some section for itself and in other are supply one another.

Railway car carriage in CZ

Trends are markedly adverse in cargo railway in recent years however railway still has not fungible place in car carriage. Railway profits from that Czech Republic is transit country and from motor car company Škoda Auto a.s. and Tayota Peugeot Citroen Automobile Czech, s.r.o.

Škoda Auto a.s. Mladá Boleslav is expediting 80% from our overall production by railway, which it is corresponding with company export to foreign market and also car carriage export by Czech railway.

New concern conglomerate Toyota, Peugeot, Citroen – TPCA Kolín still use railway slack, but conformably to TPCA Kolín result declaration, that company promise will by expedite 90% our overall production by railway. It is 270 thousand cars in year.

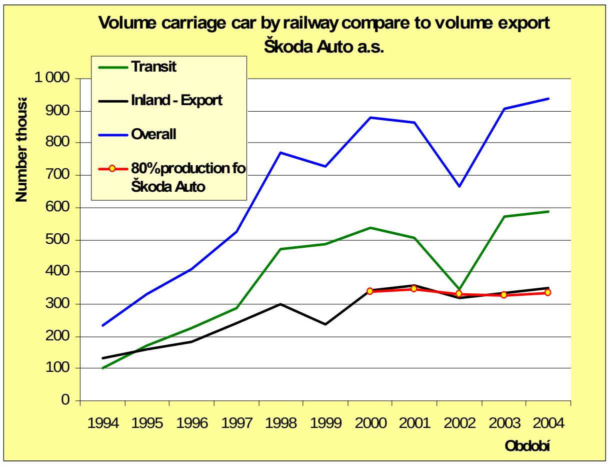

Figure 3: Volume carriage car by railway compare to volume export Škoda Auto a.s. source: MTCZ a Škoda Auto a.s.

3 Compeering wrecking car in chooses cities in the 2004 year.

Towed cars in the capitol city Praha

Police officers locate overall 1 157 009 offences in traffic section in the urban area of the capital city Praha in the 2006 year, which is accrual for 3.4%. One of factors, who influenced this accrual locate offences in safety and fluent traffic section, was progressive accrual number of cars in the urban area. Other factor was especially in stationary traffic section causal relationship with progressive deepening deficient parking places. Towed car was 18 769 in the 2005 year and 14 803 in the 2006 year in the territory of the capital city Praha.

Towed cars in the city Brno

The municipal utility of a traffic section metropolitan police Brno supported towing cars, which counteract regulations and smooth traffic in the urban area corporate town Brno. Verdict is done by metropolitan policeman that cars will by towing.

Towed cars was over head 1 625 in year 2003 and 2004, and 2 129 cars in the year 2004 in the city Brno.

Table 1: Compeering towed car in choose cities in the 2004 year

	Praha	Brno	České Budějovice
Number of registered cars	809 643	217 662	42 284
Number of people	1 170 571	369 299	95 986
Number of towed cars	18 342	2 129	2 396
Number of towed cars to 100 registered cars	2,27	0,98	5,66

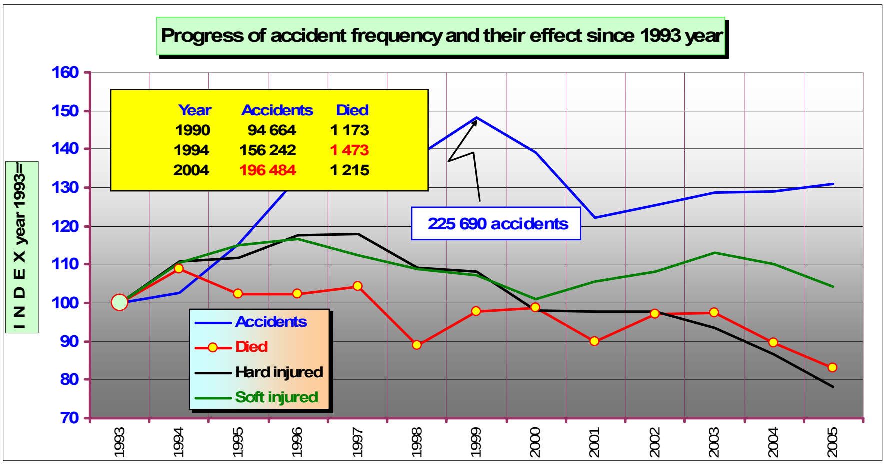

Figure 4: Progress of accident frequency and their effect since 1993 year (source MI CZ).

Towed cars in the city České Budějovice

Towed cars was 2 396 in year 2005 and 2 635 cars in the year 2005 in the city České Bubějovice. Wrecked cars were 377 in the year 2004.

Accident frequency in the Czech traffic

In the year 2006 Czech Police research over all 187 965 accidents, whereat was 956 body count died, 3 990 persons was hard injured and 24 231 persons was soft injured. Valuation happened physical damage is in an amount 9.12million Czech Crown.

Nowadays accident frequency progress is very positive and year-on-year decline of body count died is second the highest since last 26 years (next year 1998, when was regulate speed limit down in urban area).

Soled cars in the Czech Republic in the year 2005

In the Czech Republic was over all 6 231 601 registered cars in all categories on the date 1.1.2006. Accrual year-on-year was 6.2% in the year 2006 this accrual is stationary. We can look forward permanency accrual of registered cars by economical indexes.

The biggest category of registered cars was private cars with rate 70% from over all. The height rate get small cars (48%), consecutiveness central class (19%), lower central (16%) and other classes less 5% rate from aver all commercial car classes. Second the biggest category was light commercial vehicles up to 3 500kg with rate 12%, next motorcycles 7%, commercial vehicles 3% and busies 0.2%.

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VARIABILITY OF UNDESIRABLE SOIL COMPACTION WITHIN LARGE PLOTS

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The main topic of the work was to find relationships between direct and indirect methods of measuring soil compaction and related physical properties. The variability of topsoil properties was evaluated using undisturbed soil samples, cone index, tensile force measurements and aerial photography. The plot showed variability in all parameters investigated. Nevertheless, during cross-evaluation procedure no significant correlations were found. It was proved that the data from the tensile force measurements and taking aerial pictures have a good predicative ability. By means of continuous measuring of the tensile force and full-area aerial images of the observed field surface, it was possible to obtain a comprehensive data file which was able to show the plot variability at high resolution. However, it is necessary to say, that generally, the final values can be affected by more factors which should be completed with more detailed plot research.

Keywords: bulk density, cone index, tensile force

Introduction

In current modern farming systems on arable soil, it is important to react to the local differences of soil environment in the framework of individual plots and try to gain information about soil variability. On the basis of the obtained data, it is possible to control the intensity of each single soil processing step. At present, there is a lack of using feedback from soil property measurements with regard to change of soil agro-physical properties. The application of precision farming technologies requires knowledge about variability in chemical and physical soil properties (Bocchi et al, 2000); in particular, the physical properties influencing water, thermal and air movement cycles in soil (Titi, 2002).

The most common direct method for the evaluation of soil compaction is soil bulk density measurement expressed in the dry state, whilst the most common indirect method is soil penetration resistance measurement. When measuring cone index, the data (soil mechanical resistance) are recorded using a standardized vertical cone penetrometer (ASAE 2002). Both parameters are investigated by means of traditional methods using sampling rings and penetrometers.

The long-term utilization of shallow soil tillage technologies without ploughing causes an increase in undesirable soil compaction at some sites at a depth which is greater than commonly used yearly tillage depths. Undesirable soil profile compaction does not usually occur within the whole area on large plots.

Soil compaction and high soil moisture content, together with the type and intensity of plot cultivation, slows down soil nitrification, prevents soil from aeration and inhibits the decomposition of organic matter in soil. Other negative impacts can be changes in nutrient movement within the soil profile, reduction of root growth and so finally unfavourable effect on crop yield (Lapen et al, 2001). Abu-Hamdeh et al (1999) also pointed out similar problems. The authors in their research deal with the changes of soil physical properties after machine passes in the field.

Material and methods

On the selected plot of 26 ha, with loamy soil, soil penetration resistance at chosen fixed measuring points was measured (Fig. 1). The points were arranged in a regular square net with the side of 18 m. First measurements were carried out during spring period and consecutive measurements were performed after the winter wheat harvest. The cone index was monitored in both the topsoil and subsoil layers. For further data evaluation, the cone index values were divided into two categories according to the depth of measurement; the first category was for 0-0.16 m depth of sampling (tilled layer) and the second one for 0.25-0.40 m sampling depth (subsoil layer). For each category, the average value of cone index was calculated. At the same time, undisturbed soil samples were taken by sampling rings from the depth of 0.10-0.15 m for the determination of basic physical soil properties (bulk density, moisture content). After crop harvest, measurement of the tensile force of a chisel tiller at a tillage depth of 0.15 m was carried out. The exact tillage depth was set by help of a support swivel wheel. Dynamometric measuring method was used to determine the tensile force (horizontal component) of a tiller. The force required for pulling a single blade was measured. The tensile force output data from the dynamometer together with the information about machine position using a GPS unit were recorded each 5 s into the data logging centre. Finally, maps of soil penetration resistance, soil physical properties and specific tillage resistance of the measured blade were created from the data.

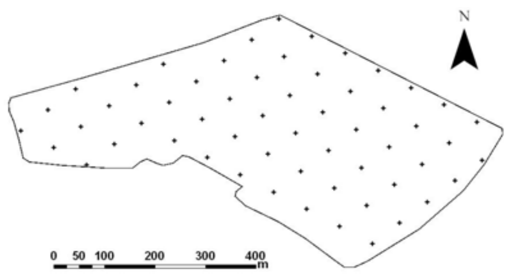

Figure 1 - Map of the experimental field (sampling points).

In the early spring period of the next year, when the soil was left without crop cover, aerial images were captured. After image ortho-rectification, the unsupervised classification was made and the image was divided into 15 shade classes according to different colour shades of the soil surface.

For the statistical evaluation of the data, the tensile force values as well as the shade index values were assigned to their corresponding sampling points. Extreme values from the tensile force data file were excluded according to the method, which was described by Thylén et al (1997).

Results and discussion

All measured values were statistically processed. Table 1 presents statistical indicators which characterize the basic data file, its variability and distribution.

The range of observed variables expressed by minimum and maximum value as well as the values of the coefficient of variance (CV) showed relatively high variability. The skew values proved that the observed data files belong to the normal distribution. The data file belongs to the normal distribution if the skew value ranges from - 2 to +1. Only the cone index values from a depth of 0-0.16 m showed an asymmetry.

Lhotský (2000) specified the maximum limit values of cone index for loamy soil in the range from 3.8 to 4.2 MPa. So it can be seen from the Table 1 that the limit values of the cone index at a depth of 0-0.16 m were not exceeded either in spring or in autumn period. The subsoil layer showed higher values of cone index but not higher than the limit values.

There is a map of cone index in the spring period shown in Figure 2. The soil variability expressed in the colour scale describes the spatial distribution of the individual cone index values measured. From the figure, it is evident that the

Table 1 - Summary statistics of the variables.

	Bulk density*	**Moisture content***	**Cone index* 0-0.16 m**	**Cone index* 0.25-0.40 m**	**Cone index** 0-0.16 m**	**Cone index** 0.25-0.40 m**	**Tensile force**
Units	$g.cm^{-3}$	% vol.	MPa	MPa	MPa	MPa	kN
Mean	1.49	21.24	1.09	2.07	1.01	2.24	3.79
Median	1.48	20.96	1.05	1.99	0.90	2.19	3.76
Standard Deviation	0.10	2.41	0.23	0.38	0.34	0.46	0.63
Sample Variance	0.01	5.80	0.05	0.14	0.12	0.21	0.40
CV %	6.63	11.34	20.91	18.21	33.63	20.54	16.72
Skewness	0.46	0.41	1.60	1.19	2.02	0.67	-0.50
Minimum	1.30	17.19	0.76	1.39	0.63	1.38	1.03
Maximum	1.80	28.46	1.90	3.20	2.48	3.35	6.35
Count	57	57	57	57	57	57	1001

* spring period, ** autumn period

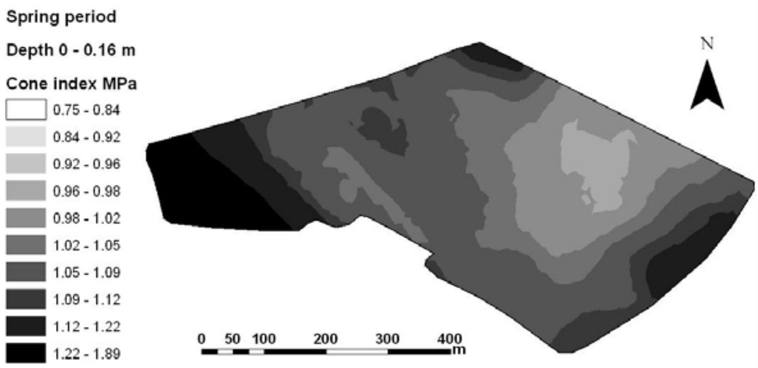

Figure 2 - Map of cone index (MPa).

higher cone index values were measured at the points with repeating machine passes. It refers mainly to the field headlands, entry point into the field and the left narrow part of the field. The tractor equipped with the GPS receiver can be used for area detection with repeating agricultural machinery passes (Yule et al, 1999 in Godwin & Miller, 2003).

The soil mechanical resistance is an indicator of soil mechanical properties. It can be influenced by soil compaction, soil texture, water content and other parameters (Adamchuk & Christenson, 2005). Higher sampling/data logging frequency of these systems gives us much more accurate overview of the soil mechanical resistance variability within the field as compared with the data obtained from the point sampling where the cone penetrometer was used. The measured data obtained in this way can be utilised for example for site-specific soil cultivation which finally leads to great reduction of problems connected with the soil compaction.

The distribution of bulk density values measured in the root layer within the test field showed different results in comparison with cone index values (Fig. 3). The dashed line in Figure 3 makes the boundary of the area with the soil bulk density values exceeding 1.45 g.cm-3, which is the limit value for loamy soil (Lhotský, 2000). The higher values of bulk density were found on the plot periphery.

If the tensile force measurement was able to detect compacted areas and corresponded with level of compaction, it would be possible to identify and describe these places in more detail from the tensile force maps. The tensile force is a factor which could be measured continuously during tillage operations and thus compaction values could be derived from the tensile force which would be measured in crop root zone.

Lapen et al (2002) proved in their experiments that the tensile force measurement during ploughing can be a very useful tool for the identification of undesirable soil compaction causing problems with decreasing crop yield. They found that the tensile force increase was also related to the penetration resistance increase and clay content in the plough profile.

The measured tensile force values also showed quite evident variability within the test plot. The graphic presentation of spatial distribution of the tensile force values measured is charted in Figure 4.

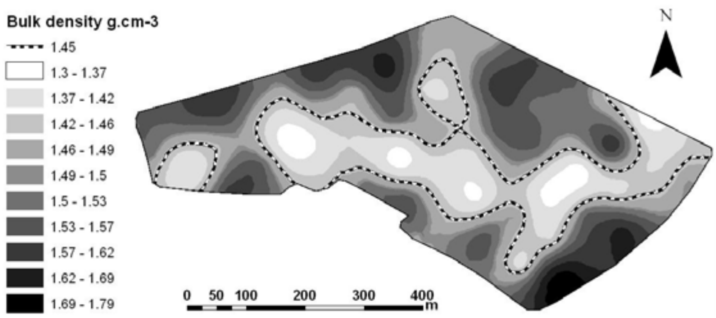

Figure 3 - Map of bulk density (g.cm-3).

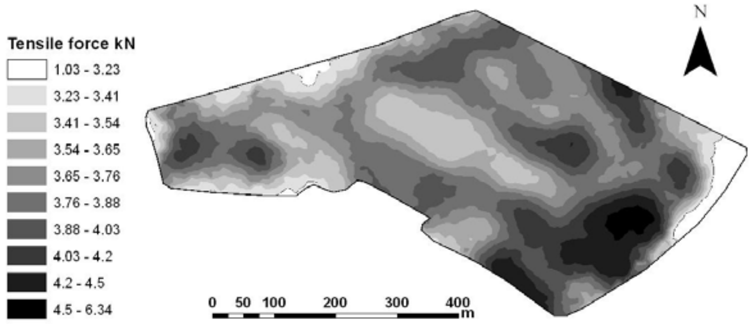

Figure 4 - Map of tensile force (kN).

Taking aerial images offers new possibilities for soil properties and variability monitoring. In terms of complete spatial information gained from the aerial photography, the advantage of such an image is in providing full-area information about a field.

The possible application of these pictures in agricultural practice depends on the season in the year and outside conditions when capturing the images. Furthermore, image availability for a particular field when outsourcing and complex quality expressed as picture resolution are limiting factors for the usage. The analysed aerial image in Figure 5 shows different colour shade image of the soil surface. Darker soil surface without plant or stubble cover corresponds with darker shade and lower colour index (Gridcode) in the picture legend.

Soil moisture content, grain/soil particles size, field surface roughness, iron oxides and organic matter content belong amongst factors most influencing soil reflectance (Lillesand et al, 2004).

Table 2 shows cross- correlation coefficients.

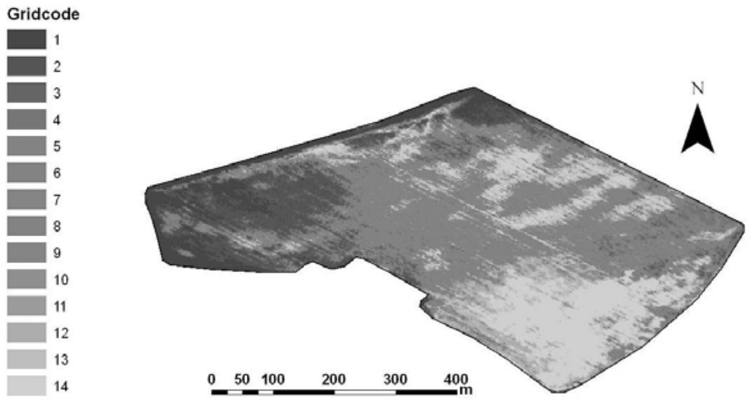

Figure 5 - Aerial picture converted into grey scale.

Table 2 - Correlation coefficients (r) between variables.

	Tensile force	Bulk density*	Moisture content*	Colour index	Cone index* 0-0.16 m	Cone index** 0-0.16 m
Tensile force	1					
Bulk density*	0.18	1				
Moisture content*	0.03	0.54	1			
Colour index	-0.21	0.11	0.02	1		
Cone index* 0-0.16 m	0.20	0.22	0.06	-0.20	1	
Cone index 0-0.16 m**	0.21	-0.01	0.20	-0.14	0.31	1

spring period, ** autumn period

On the basis of the results, a slightly increasing trend of the tensile force requirement can be noted at the points with higher penetration resistance and soil bulk density. The comparison of colour index with other variables showed similar results. A small increase of soil bulk density and cone index was found at the points with brighter shade of soil surface in contrast to the tensile force. With respect to relatively low values of the correlation coefficients, there was no statistically significant dependence found.

Also soil moisture content did not affect values of other parameters. It follows from the comparison of quoted author's results, that many studies show different results. For example, Mouazen et al (2005) present conclusion of their research that the cone index method or sampling rings collection is very difficult and time consuming work. Moreover, the discontinuous data obtained during these measurements based on the measurement network have uncertain accuracy. Heisel et al (1999) describe the time needed for taking soil samples as a range from 10 to 60 minutes per one sample. Adamchuk & Christanson (2005) developed and tested a prototype system consisting of integrated mechanical sensors (frames with blades, shares, and chisels), electric sensors (based on capacity resistance measurement) and optical sensors (based on reflectance measurement). Measuring methods of soil properties, influencing the soil mechanical resistance, and those methods evaluation is described in their paper. When they compared mechanical resistance values with the measurement using the traditional cone penetrometer, both data sets showed good correlation (R2=0.56). McLaughlin & Burtt (2000) measured the tensile force on a tractor three-point hitch during ploughing and created maps of soil cultivation (Canada-Ontario). These measurements provided information about soil physical properties, soil texture, organic matter content and soil compaction.

By means of a cone penetrometer, it is possible to estimate the soil compaction. However, it represents just point sampling and for the soil compaction accurate description of the whole plot, it is necessary to carry out a lot of sampling.

Godwin & Miller (2003) stated that the tensile force mapping was an inaccurate method when there are a lot of compacted places from machine passes in the field.

The results presented from our measurements show that each method used proved the soil properties variability. The individual results from cross-evaluation were influenced by other factors. So it is possible to say that the plot soil variability can be evaluated on the basis of indirect methods but the evaluation has to always take into account more layers and factors.

The results could be influenced by the soil environment micro-variability caused by machine passes, presence of stones and other factors which can be measured in place of single cm unit. For that reason, to achieve a sufficient accuracy, it is necessary to increase considerably the sampling frequency (number of samples per hectare). For the soil compaction evaluation, it is also necessary to use greater depths for sampling. The sampling depth should go under the level of the applied soil cultivation depth. The tensile force measurement of the whole tiller (not just one tool observation) in combination with supplementary variable values acquired from sensors would help to reduce problems connected with the soil micro-variability.

Conclusions

Indirect measuring methods in general will play an important role in the precision farming system development. High density of the data measured, time accessibility, low cost and undemanding measurements are the crucial points for the possible application of precision farming tools into common practice, namely for our research - soil properties mapping.

Carried out measurements showed the following results:

1. The observed plot showed a significant variability in soil physical properties, cone index and tensile force. Also the aerial photography of the plot without a crop cover has revealed a significant heterogeneity of soil.
2. Cross-evaluation procedure proved that there was a slightly increasing trend of the tensile force requirement at the points with higher penetration resistance and soil bulk density. However, no significant dependencies were found.
3. Statistically insignificant dependencies between observed variables could be influenced by the soil properties micro-variability.
4. Taking of samples by means of sampling rings and cone index measurement within the chosen regular network seemed to be insufficient concerning the accuracy.
5. The tensile force measurement of the whole tiller (not just one tool observation) in combination with supplementary variables acquired from sensors could help to reduce problems connected with the soil micro-variability.
6. The future research should be focused onto the multifunctional measuring systems giving more complex information about the soil environment.
7. The results presented in this paper could be used as the basic data for the soil physical properties and soil variability evaluation within a field. The data could be also used as input data for

further way of soil processing - decisions on intensity and kind of tillage.

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AMMONIUM NITRATE COMMERCIAL FERTILIZER GRANULOMETRIC EVALUATION VARIANT II.

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Physical properties of commercial fertilizers play important role from precision application point ofview. Granulometric evaluation is usually performed by sieve separation according ČSN 01 50 30 standard. The main subject of this work is the presentation of separation results when vertical airflow is used.The statistical analyses was confirmed on proccess agreement of relative frequencies with N-distribution. It is clear from achieved values that in fertilizer samples are involve 23,77 % granule with dimension from 2-3,5 mm and 73,93 % with dimension from 3,5-5 mm. The granule at the required dimension was 97,70 %. Other dimension of particles are negligible. It is possible to determine the critical airflow speeds for different dimension weights of particles groups. The critical means speed for saltpeter ammoniac is 13,43 m.s^{-1}, std. deviation 3,71 m.s^{-1} and variability 0, 2 %.

Key words: commercial fertilizers, granulometric evaluation, airflow sorting

Introduction

On precision farming application in agricultural technologies the application of solid commercial fertilizers play important role. Application quality is depending on chemical composition and physical properties of fertilizer. Important from physical properties is grading of aggregate evaluation performed by standard ČSN 01 50 30. The dimension of particulars only is characterized by this way.

Granulometric evaluation is possible to perform with advantage by using of vertical airflow in laboratory grading machine as well. It is possible to sort investigated fertilizer to groups according to particle weight using the principle of airflow velocity changing. The number of groups is depending on the number of used airflow quantities (m^3.h^{-1}). In sorted groups it is possible to count number of particles, to weigh all particles and analyze the particles by sieve separation. It is possible to achieve the data for more complex analysis by this procedure. It is possible to collect relative frequency of particles in sorted groups and their dependence of airflow parameters.

The averages of relative weight frequencies f_{im} (%) of sample (0,5 kg) and after sieve separation f_{id} (%) are in Table 1. The airflow quantity ranged from 65 to 155 m^3.h^{-1}. The averages were calculated fro eight repeats of measurement.

The dependence of relative weight frequencies f_{im} (%) and f_{id} (%) on the airflow quantity V (m^3.h^{-1}) is in Fig. 1. It was achieved by statistical evaluation that relative frequencies are in agreement with N-distribution. It is clear from achieved values that in fertilizer samples are 23,77 % of particles with dimension from 2 to 3,5 mm and 73,93 % with dimension from 3,5 to 5 mm. It means that 97,70 % of particles are in the demanded range. Other dimensions of particles are negligible. It is possible to determine the critical airflow speeds for different dimensions and weights of particles groups.

Tab.1 Averaged relative weight frequencies of ammonium nitrate fertilizer.

	V [m^3.h^{-1}]	65	75	85	95	105	115	125	135	145	155
F_im %		0,17	0,76	1,57	4,22	12,42	25,89	33,00	18,54	3,25	0,17
	< 2	34,78	13,88	6,73	1,66	0,35	0,08	0,09	0,03	0,01	0,00
	2 - 3,5	64,30	70,40	80,28	79,12	62,64	34,81	19,01	1,31	0,28	0,00
	3,5 - 5	0,92	15,72	12,99	19,15	36,55	64,47	80,11	95,72	87,64	62,00
	> 5	0,00	0,00	0,00	0,07	0,46	0,64	0,79	2,94	12,07	38,00
F_id%	< 2	0,06	0,10	0,11	0,07	0,04	0,02	0,03	0,01	0,00	0,00
	2 - 3,5	0,22	0,97	1,41	3,31	7,01	8,03	2,82	0,00	0,00	0,00
	3,5 - 5	0,00	0,28	0,82	1,27	6,30	17,62	32,23	15,20	0,21	0,00
	> 5	0,00	0,00	0,00	0,01	0,17	0,32	0,46	0,50	0,34	0,06

Conclusion

It is possible to express that solid granular fertilizers separation by vertical airflow make possible complex granulometric analysis. Besides the size information it offer evaluate weight and aerodynamic attributes of fertilizer as well.

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BIOMASS – RAISING OF FASTER GROWING SPECIES

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Biomass is periodically renewing resources with minimal demands on investments, technical and service sources. Thanks to progressively expansion of species types and plants, biomass is not exclusively underlie localities and it is possible to economically exploit fallow farmland. Nowadays starts spreading of production in faster growing species. e. g. Japanese poplar.

Keywords: Faster growing species, biomass, Japanese poplar

Introduction

The biomass usable for energetic tasks is a significant inland fuel source in the condition of the Czech Republic. In the development of primary energetic sources, its part will rise in dependence on the price level of energies and of used economical and legislative tools for support of particular sources.

The biomass proportion to total consumption of the renewable sources (CRS) in the year 2000 represented 66,95, ie. 17,4 PJ from the total of 26 PJ. For the year 2010 (according to the data of CZ Biom, the Czech Council for Biomass), a proportion of biomass to total CRS consumption is expected to be 81,7%. Further to that it is expected that the biomass (first of all the phytomass) will have a main proportion on the CRS for the heat and electrical power production, it has to be up to 85% in the year 2030.

More realization of phytomass in power energetic would mostly influence of course the agriculture and forestry as well as the production of technologies needed for planting, processing and energetic use of this mass. By estimation of CZ Biom, the proportion of targeted energetic growth planting has to make approximately 47% from the total offer of the available energetic potential of biomass.

Growths of special crop-plants on the agricultural land are a relatively new biomass sources, their target is purposeful biomass production intended for the energetic or industrial use. They are categories and sorts of species, perennials or herbs which are able to give a high yield. Their growth and especially then the volume yield (tons/hectare/year) at the intensive planting is remarkably exceeding the average figures of other crop-plants on the researched area.

Materials

New way of economy, so called short rotation (coppice) plantations, or eventually energy plantation of short rotation coppice (SRC), is starting to be used on ever vaster and vaster agricultural land area within the last time. For comparing of the forestry ligniculture of poplars are cropped within a very short silvicultural rotation (so called mini-rotation) of 3 to 7 years. The SRC crop is possible to be repeated ins several sequences without have needed a new planting. The (wood) biomass used as fuel (heating, electrical power joint production) or even as an industrial raw material (production of liquid fuels, construction materials etc) is a product.

A high wood volume yield rated on more than 10 m^3/ha/year, it is corresponding approximately to 4.5 tons(dry substrate)/ha/year in average for the stand lifetime (UFRO criterion), a quick growth during the first years after being planted out – it means more than 0.5-0.7 m/year, easy establishing of stand, especially then by the vegetative way as for example by cuttings, withies and osiers at the most of poplars and willows but also generatively, especially then by plants as for example at alders and some osiers and poplars, are belonging to SRC fundamental features.

The Japanese poplar is a new cropper which is started to be cultivated in the Czech Republic. It is a clone of black poplar and Maximovicz poplar designed as J-104 and J-105. This species are achieving very good results when the planting fundamentals are followed. Shoots are delivered cut into individual cuttings 15 to 25 cm long and at the minimum, four vital buds are available on each of them.

Table 1: Main characteristic of the short rotation coppice SRC (1.)

	SRC reproductive plantation reproductive growth according to the government act NV 308/2004 (Digest).	Sprout plantation – productive growth according to the government act NV 308/2004 (Digest).	Forestry ligniculture or silviculture
Usual rotation	1 year	3 - 6 years	15 - 20 years
Repeated crops	Yes: 8 - 15 times	Yes: 4 - 7 times	No
Establishing on the land	Agricultural	Agricultural	Forestry land only, when in the Czech R.
Category of species for out planting	Poplars, osiers, according to the Agricultural Ministry Bulletin	Poplars, osiers, according to the Agricultural Ministry Bulletin	Poplars according to the List of Approved clones, issued by the Dept. of Forestrial Economy, Ministry of Agriculture
Out planting density	10 000 - 20 000 pcs/ha	8 000 - 15 000 pcs/ha	270 - 630 pcs/ha
Targeted product	Cuttings for establishing sprout plantations	Chips for energetic or eventually industrial use	Assortments for timbering use
Yields in average within the lifetime	100 - 500 thous cuttings/ha/year	5 - 19 t/ha/year (dry mass*) in average within the growth existence	500 - 600 m3/ha/20 - 25 years (5 - 11 t/ha/year dry mass*)

* water content 0 %

Planting SRC

Out planting of SRC intended for the energetic use is one the possibilities how to use the agricultural land for non-food processing tasks. For the climatic and sol condition in the Czech Republic, the plantation of poplars and willows is of the most advantage. When establishing SRC, suitable clones for a concrete site and region are selected. Water regime in the soil and the average temperature during the summer months is of remarkable influence has remarkable influence.

High weeding of fields and meadows is a very big trouble when out planting, this weeding is necessary to be removed just one year before the out planting stage.

Establising growths

The preparation of land is very important, being necessary to be initiated one year forward before the own out planting in order to get an optimum of conditions for the out planting and for the growth of species within the first 2 - 3 moths after have realized the out planting. It is especially the case of a maximum limitation of weed growing during this period and of optimization of physical features of the soil for rooting of the species. In the weeded localities, an intensive weed killing is necessary to be started 1,5 - 12 years before the out planting in dependence on the prevailing weed type and on the selected weed killing.

Generally, the repeated mechanical weed killing combined with herbicides or by means of planting a preparative cropper (e.g. rape, cannabis, bere) is preferred. On weeded grasslands and meadows, the growth is necessary to be mowed or feed off so that the weed growth could be limited. The autumn tillage and soil preparation is the best to be realized by such a way that the land will not need to be ploughed on spring but to be aerated only with a cultivator or eventually to be leveled.

Specifying of the out plating time is depending on the local soil and climatic conditions within the spring months. Poplar and osier cuttings are usually planted (betted) from the half of March up to April (or maximally up to the half of May). The most often betted cuttings are those cut from annual shoots on the reproductive SRC plantations. An optimal cutting length is 20 to 30 cm and diameter from 0.5 to 2.5 cm.

The so called vertical plantation of cuttings is used in a case when the betting is realized manually, when the cuttings are dibbled straightly or at a slight angle, it means that the cutting may stick out maximally 3 cm over the surface. A principle that the cuttings must not stick out more than 5 cm over the soil is necessary to be followed as well as that the soil around them must be well hardened.

Setting up the spacing is depending on the available mechanization which will be used for out planting as well as especially then for weed killing. At the present time, the out planting in one row spacing (0,5 - 0,3 m) x (1,5 – 3 m spacing between the rows) is used, as well as into two rows spaced to (0,75 m) × (0,75 m) and (1,5 - 3 m) when into dual rows. The dual rows are contracting the area kept by mechanization means but they are demanding more manual or semi-mechanized weed killing inside a dual row. They are used mainly for polar and osier productive plantations.

Biomass crop

The SRC plantations are cropped between their 3rd – 6th years, in the so called very short rotation. If a total plantation lifetime is calculated to be 15 to 20 years, then it is assumed that it should be cropped 4 - 7 times.

The winter moths (December – March) are the most advantageous season for cropping SRC on chip, when the water content in tissues is the lowest one and when unattached machines and human sources are available.

The multiphase crop and one phase crop are the main crop types. The multiphase crop, also named pruning, locking and chipping may be realized manually, it means the manual cutting of trees with a brush-cutter and manual moving aside the plantation. This practice is good for the small area plantation only. On bigger areas, it is necessary to use a tractor with an additional equipment (for example, an adapted tractor power saw for cutting trees down) or a specialized cropping machine cutting down the SRC sheaving them in locks which are either left behind the plantation or are immediately transported on a place of final processing, where after have been dried on air – the cropped biomass is to go to be chipped. At the one phase crop, both mobile and pulled cropping machine are used. They are capable to make immediately the wood chips on the field.

Conclusion

It is expected that the landscape management and conservation in the localities where the conditions for growth of osiers and poplars, mainly on the banks of streams and on the tidal lands, and creating new working places, especially in specialized production companies will be of asset. The plantation cars is demanding more working man-power, ca 1,5 worker for 10 ha, than planting of energetic herbs, oil crops and stalky plants, ca 0,1 worker for 10 ha.

The Japanese poplar reaches the height of 10 - 15m under optimal conditions after five years. This fact is possible to be used for example for screening various unwanted views in the neighborhood of real estates (family houses, golf courts, natural escape cover for breeding and so on). The SRC growths are suitable also as acoustic walls alongside the busy roads of railways.

An economical analysis of the SRC plantation (orchards) as well as of the whole process of production and use for biomass for energetic is remarkably complicated because it involvers the own production costs economic which is depending on the local conditions, and even the demand and market prices in the business with energies, which are dotted by state authorities but not involving all the so called externalities (e.g. using of environmental components and of their damaging).

An effective agricultural land exploitation with lower production potential for non-food production and at the same moment for providing extra-productive functions of agriculture (e.g. landscape cultivation), development of the agricultural regions (new working places, consolidation of local economy – money yielded from energy are staying in the appropriated region, investment into the new technologies are coming), reducing of pollution into atmosphere and producing of greenhouse gases as to replace the fossil fuels (reducing penalties for air pollutions, matching with the international agreements, strategic reduction of dependence on imports of fossil fuels and improvement of the state business balance or respectively of the European Union) belong to main reasons for energetic growth in the economically advanced countries and in the whole EU.

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FRACTALS IN AGRICULTURE

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Many pattern of nature are either irregular or fragmented to such an extreme degree that Euclidean geometry cannot describe their form. Thus, fractal geometry based analysis has received increasing attention as a number of studies have shown fractal based measures to be useful for characterizing complex biological structures. Fractal scaling is evident in natural objects from the micro-scale to the macro-scale. The review of the fractal methods applied in agriculture is also presented. The application in study of structural properties of apples of cultivar Pinova during long term storage is realized.

Keywords: fractal, agriculture, dimension

1. Introduction

Fractals are of rough or fragmented geometric shape that can be subdivided in parts, each of which is (at least approximately) a reduced copy of the whole. They are crinkly objects that defy conventional measures, such as length and are most often characterised by their fractal dimension. They are mathematical sets with a high degree of geometrical complexity that can model many natural phenomena. Almost all natural objects can be observed as fractals (coastlines, trees, mountains, and clouds). Their fractal dimension strictly exceeds topological dimension. (Zmeškal, 2001). Fratal dimension is the number, very often non-integer, often the only one measure of fractals It measures the degree of fractal boundary fragmentation or irregularity over multiple scales It determines how fractal differs from Euclidean objects (point, line, plane, circle etc.) Fractal is strictly self-similar if it can be expressed as a union of sets, each of which is an exactly reduced copy (is geometrically similar to) of the full set (Sierpinski triangle, Koch flake). The most fractals looking in nature do not display this precise form. Natural objects are not union of exact reduced copies of whole. A magnified view of one part will not precisely reproduce the whole object, but it will have the same qualitative appearance. This property is called statistical self-similarity or semi-self-similarity.

2. Materials

Fractal analysis is a collection of mathematical procedures used to determine fractal dimension (or any other fractal characteristic) or set of fractal dimensions (in the case of multifractals) with the smallest error. Very often is used to characterise properties of natural objects.

Box-Counting method

One of the methods used to establish fractal dimension. It determines the fractal dimension of black&white digitised images of fractals. It works by covering fractal (its image) with boxes (squares) and then evaluating how many boxes are needed to cover fractal completely. Repeating this measurement with different sizes of boxes will result into logarithmical function of box size (x-axis) and number of boxes needed to cover fractal (y-axis). The slope of this function is referred as box dimension. Box dimension is taken as an appropriate approximation of fractal dimension.

Mass method/radius dimension method

Method used to establish fractal dimension. It determines the fractal dimension of black&white digitised images of fractals too. It is based on determination of the dependency between count of black and white pixels (picture elements) on the square (circle – radius dimension method) shaped plane, with the varying area. The slope of this dependency is the mass/radius dimension, it is a good approximation of fractal dimension. Resulting mass/radius dimension should be almost the same or the same as the box dimension.

Description of method

To implement Box-Counting method software called HarFA was used (Zmeškal, 2001). Dimension determined by this method is called Box Dimension D_{BBW}. This method has simple principle: a square mesh of various sizes $1/\varepsilon$ is laid over the image object. The count of mesh boxes $N_{BBW}(\varepsilon)$ that contain any part of the fractal are counted (e.g. squares which are completely filled up by the fractal N_B and squares which contains just part of fractal N_{BW} are summed together). The slope of the linear portion of a function

$ln(N_B + N_{BW}) = ln(N_{BBW}) = f(N_{BBW}(\varepsilon))$, (1)
where
$lnN_{BBW}(\varepsilon) = lnK_{BBW} + D_{BBW}\, ln(\varepsilon)$, (2)

gives D_{BBW} the fractal (box) dimension. Dimension D_{BBW} is referred as classical box dimension and can be easily find in many literature sources. When modify this method (counting black N_B, white N_W and partially black squares N_{BW} separately) three new fractal dimensions D_B, D_W, D_{BW} can be achieved. D_B and D_W characterise fractal properties of black and white plane, while D_{BW} characterises properties of black&white border. So, we can say that HarFA can compute five independent fractal dimensions. The most important are dimensions D_{BW}, D_{BBW}, D_{WBW} (arises by summing squares N_W which are not filled up by the fractal so they remain white and squares which contains just part of fractal N_{BW}), while D_B and D_W are accidental, they are meaningful just for Euclidean objects (line, circle, square etc.). It's called Linear Regression Analysis. To determine fractal dimension precisely is necessary to find linear portion of function (1). HarFA dispose of powerful tool to accomplish this goal. It's called Single Slope Analysis.

As said earlier, Box-Counting method works with black&white images of fractals. But agricultural or biological images are mostly displayed as grey-level images or even colorized. So we need to transform these images into black&white. Procedure to accomplish this goal is called Masking. HarFA provides four colour spaces conversion routines (RGB, HSB/HSV, HLS and Intensity), which enables user to select desired tint intuitively. Selected tint will be transformed into black colour and all the others tints will become white. By this way black&white fractal structure arises.

But sometimes we cannot say which colour of image is important for our purposes. For these cases there is a tool called Fractal Analysis – Range. Fractal dimension is automatically determined for all levels of chosen channel of colour information (Red, Green, Blue, Hue, Saturation, Brightness and Intensity). Resulting fractal dimension is displayed as a function of masked level of colour information. This dependency is called Fractal Spectrum. It is a new and not published method of fractal analysis (Zmeškal, 2001).

3. Fractal application in agriculture

Mancuso (2001) verified the possible application of fractal analysis to describe grapevine leaves (Figure 1) belonging to different genotypes with the hope to add an objective, clarifying dimension to the excessively convoluted field of ampelography. The term ampelography comes from two Greek words: ampelos for vine and graphe for description. Ampelography is the field of botany concerned with the identification and classification of grapevines. Traditionally this has been done by comparing the shape and colour of the vine leaves and grape berries, more recently the study of vines has been revolutionised by DNA fingerprinting.

At the veraison, 50 fully expanded, healthy leaves, from 15 plants per accession, located between the 7th and 11th shoot node from the apex were selected according to uniformity of appearance, growth habit and exposure. The steps of the box-counting algorithm were as following. The original grayscale image was thresholded to create a binary image, where leaves were represented by black pixels. An edge detection algorithm was applied to the binary image to create an image containing only the edge of the leaf. The box-counting dimension was the negative of the slope of the regression line (Figure 2). The fractal dimensions of a homogeneous sample of leaves from different *Sangiovese* related genotypes had the mean values of box counting dimension ranged from 1.204 for *Casentino* to 1.499 for *Piccolo precoce*, showing a rather ample interval.

Fractal geometry is a useful tool for the analysis of landscape data (Pachepsky and Ritchie, 1998). In this study fractal scaling was applied to high-resolution landscape data collected with a

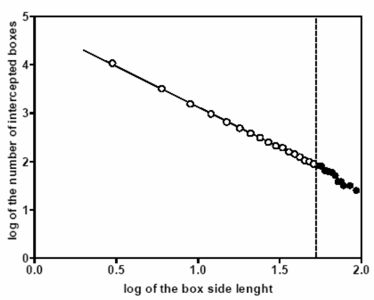

Figure 1 - An image of grapevine leaf analysed (Manusco, 2001) Figure 2 – Determination of fractal dimension (Manusco, 2001)

profiling laser altimeter. The objective of this work was to assess the persistence of scaling differences over time. Data were collected at the United States Department of Agriculture (USDA), Agriculture Research Service (ARS) Jornada Experimental Range in New Mexico, USA in May and September 1995 and February 1996 over a grass-dominated site, a shrub-dominated site, and a transitional area between shrub- and grass-dominated sites along four transects at each site for each date. Root-mean-square (RMS) roughness was scale-dependent and had more than one range of self-affine scaling. Different numbers of self-affine scaling intervals, boundaries of intervals, and fractal dimensions over these intervals were associated with different land covers. A linearity measure was applied to find intervals of fractal scaling. The number and boundaries of fractal scaling intervals appeared to be persistent over the year. Grass and shrub sites had two and four linearity intervals respectively. The transitional site had a pattern of scaling that was intermediate between grass and shrub sites. The lowest fractal dimensions at small scales of 6 - 30m corresponded to the maximum vegetation in September.

Jeyarani and Jayaram (1996) assessed the use of fractal dimension as a discriminator in Indian Remote Sensing Satellite (IRS) images for different forest and crop patterns. In this study, a kernel of pre-defined size has been moved on a single band image and the corresponding fractal dimension is found using the triangular prism surface area method. The measured dimension is used as a classification factor and applied over the kernel. A preliminary study is performed using IRS LISS II Band-4 data. The results are motivating and significant improvement has been obtained in this procedure for the case of a homogeneous pattern.

Critten (2003) described experiments designed to obtain fractal dimensions (d_k) associated with different plant canopies. The method involves 2 or 3-dimensional Fourier analyses of grey levels within photographic or video images of square sections of the canopy, viewed vertically downwards. From these analyses amplitude/wavenumber relationships are used to obtain fractal dimensions (d_k). He found plausible values of between 1 and 3 for space-filled vector dimensions (n) that correspond to the measured fractal dimensions (d_k). A linear relationship between the exponent (s) from the amplitude/wavenumber relationship and vector dimensions (n) is discovered. This relationship is shown not to match the non-linear (bijection) equation which defines (n). A theory which brings these results into concord is then presented, generating a correction factor (L) for the linear relationship. The factor recognises the restriction of 'information' which must occur when a single defining vector dimension is used to represent isotropic patterns from 2 or more vector dimensions. If d_k is the corresponding fractal dimension associated with the analysed scene, then the number of harmonics N(k) with wavenumber less than k is given by:

$$N_k \approx k^{d_k} \tag{3}$$

Boudon, F. et. all., (2006) presented a method to estimate the fractal dimension of plant foliage in three dimensions (3D). This method is derived from the two-surface method introduced in the 90s to estimate the fractal dimension of tree species from field measurements on collections of trees. Here we adapted the method to individual plants. The multiscale topology and geometry of the plant must first be digitized in 3D. Then leafy branching systems of different sizes are constructed from the plant database, using the topological information. 3D convex envelops are then computed for each leafy branching system. The fractal dimension of the plant is finally estimated by comparing the total leaf area and the convex envelop area of these leafy modules. The method was assessed on a set of four peach trees entirely digitized at shoot scale. Results show that the peach trees have marked self-similar foliage with fractal dimension close to 2.4.

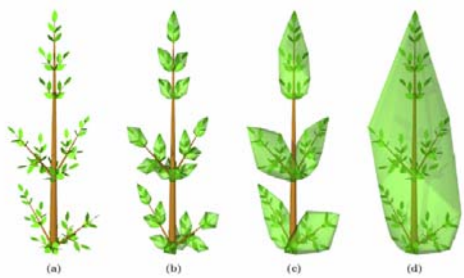

Figure – 3 Leafy modules at different scales in a theoretical tree (a). Leafy modules are define here by biological cuts corresponding to branching order 2 (b), 1 (c) and 0 (d). Their convex envelop were computed emphasizing how the overall plant geometry depends scale (Boudon, F. et all, 2006)

4. Fractal and sensoric analysis of apple structure of cultivar Pinova

We dealt with study of structural and sensoric properties of apples of cultivar Pinova during long-term storage in standard conditions. Structural properties are characterized by the fractal dimension and sensoric by intensity of sensoric descriptors. The fractal dimension complexly expressed the quality of the apple flesh structure in the relation to the distribution of the macropore structure of the flesh. The digital analysis of the images was realized and the fractal dimensions were determined by means of software HarFA ver. 5.2. The sensoric descriptors as optimal juiciness, fragility of the flesh and malleability to chew were determined. Dependencies of fractal dimensions on sensoric descriptors were realized.

The method of sample elaboration and fractal dimension determination is described in Kubík (2005).

Sensoric analysis

We are interested in relation of fractal dimension to the polarity descriptors intensity of apple flesh structure and texture during the period of storage also. The polarity descriptors are the quantities which represent the structure and texture state of apple flesh. The descriptors create the polarity couples which represent the quality of the apple flesh. The couples of the polarity descriptors are shown in Table 1. The intensity of polarity descriptors was in the range from 0 to 6, where the values near 0 represented negative properties of the flesh structure and texture and the values near 6 represented positive properties of the flesh structure and texture.

The intensity of polarity descriptors was always determined by team of trained workers on the base their subjective feeling. This method is known as sensoric analysis. The team was examined by statistical methods and the workers who did not achieve asked appreciation were eliminated.

Samples and storage properties

Experimental measurements were realized during of apple storage from 3rd October 2005 to 23rd March 2006. Thirty values of fractal dimension were evaluated for each sample and cultivar. The measurements were realized in seven time points. 210 experimental values of the fractal dimension for all time point were realized together. The new samples of apples were used for each measurement. The storage was provided in the storage boxes at the temperature 1°C and 90 % of the air moisture content and with 1 % O_2 and 3 % CO_2.

5. Results and Discussion

Fractal dimension represents the structure properties of apple flesh. The dependencies of fractal dimensions D_{BW}, D_{BBW} and D_{WBW} on descriptor intensity of sensoric descriptor are showed on the Figures 4, 5 and 6.

Table 1 - The polarity descriptors of apple flesh structure and texture and intensity their polar components

Intensity of polarity descriptors							
Descriptors (-)	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-6**	**Descriptors (+)**
4 abnormal juiciness	negative		neutral		positive		4 optimal juiciness
5 firmness of the flesh							5 fragility of the flesh
6 tenacity to chew							6 malleability to chew

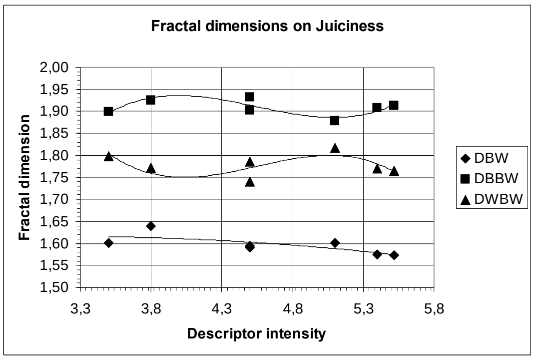

Figure 4 - Dependency of fractal dimensions D_{BW}, D_{BBW} and D_{WBW} on juiciness descriptor intensity of cultivar Pinova

Table 2 - Regression equations of dependencies of dimensions D_{BW}, D_{BBW} and D_{WBW} on the juiciness descriptor intensity of cultivar Pinova

Dimension	Regression equations	Correlation coefficient
D_{BW} (Pattern)	y = -0.0075x^2 +0.0475x+1.541	0.75
D_{BBW} (Grains)	y = 0.076x^3-1.0359x^2+4.6365x-4.9017	0.83
D_{WBW} (Pores)	y = -0.091x^3+1.2426x^2-5.582+10.022	0.71

Dimension D_{BW} express the properties of the boundary of grains and pores of apple flash micro-structure. Dimension D_{BBW} express the properties of grains of the microstructure of apple flesh and dimension D_{WBW} express the properties of pores of the microstructure of apple flesh. The time of storage is included in the data and the dependencies are able to offer prediction of sensoric descriptor intensity on the base of known fractal dimension or conversely the fractal dimension expressed micro-structure properties of apple flesh on the base of known sensoric intensity descriptor. The regression equation of dependencies and correlation coefficients are presented in the Tables 2, 3 and 4. Dependencies of D_{BBW} and D_{WBW} dimensions were complementary. When D_{BBW} increased D_{WBW} decreased.

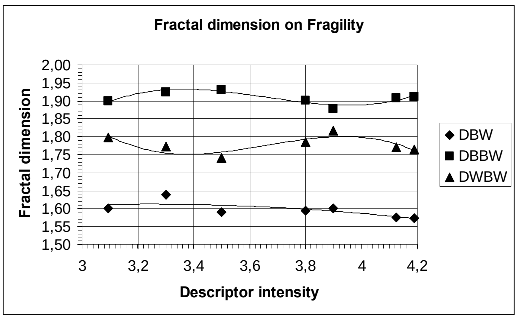

Figure 5 - Dependency of fractal dimensions D_{BW}, D_{BBW} and D_{WBW} on fragility descriptor intensity of cultivar Pinova

Table 3 - Regression equations of dependencies of dimensions D_{BW}, D_{BBW} and D_{WBW} on the fragility descriptor intensity of cultivar Pinova

Dimension	Regression equations	Correlation coefficient
D_{BW} (Pattern)	y = -0.0443x^2+0.2869x+1.1475	0.75
D_{BBW} (Grains)	y = 0.4377x^3-4.88043x^2+17.463x-19.108	0.93
D_{WBW} (Pores)	y = -0.5678x^3+6.2323x^2-22.671x+29.104	0.84

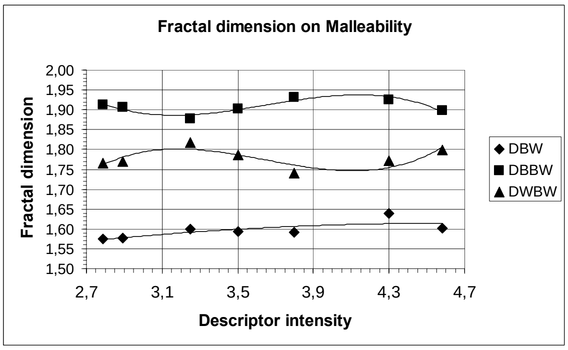

Fig. 6 Dependency of fractal dimensions D_{BW}, D_{BBW} and D_{WBW} on malleability descriptor intensity of cultivar Pinova

Table 4 - Regression equations of dependencies of dimensions D_{BW}, D_{BBW} and D_{WBW} on the malleability descriptor intensity of cultivar Pinova

Dimension	Regression equations	Correlation coefficient
D_{BW} (Pattern)	y = -0.0126x^2+0.116x+1.3478	0.76
D_{BBW} (Grains)	y = -0.1125x^3+1.2318x^2-4.4164x+7.0915	0.93
D_{WBW} (Pores)	y = 0.1413x^3- 1.5455x^2+5.5461x-4.7495	0.83

6. Conclusions

The method of fractal analysis of the apples of the cultivar Pinova was used at the study of the apple flesh micro-structure and its modification in the period of the long term storage in standard conditions. The fractal dimensions of the apple flesh expressed the degradation of apple structure caused by modification of representation of the pores and grains during the period of storage. D_{BBW} dimensions, which characterized the properties of the grains of the apple flesh structure oscillated about value 1.9 in dependency of time of storage. D_{WBW} dimensions, which characterized the properties of the pores of the apple flesh structure oscillated about value 1.8 in dependency of the time of storage. The extremes of regression functions of dependencies fractal dimensions on malleability are inversed in comparison with dependencies of juiciness and fragility on fractal dimensions. This is caused because dependencies of juiciness and fragility on the time of storage were decreased but malleability is increased.

The dependencies of fractal dimensions on sensoric polarity descriptors are able to offer prediction of sensoric descriptor intensity on the base of known fractal dimension or conversely the fractal dimension expressed micro-structure properties of apple flesh on the base of known sensoric intensity descriptor.

The fractal methods in agriculture are useful methods, which allow to determine the fragmentation of structure and texture of agricultural materials and their qualitative a quantitative evaluation.

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DYNAMIC LABORATORY MEASUREMENT WITH DIELECTRIC MASS FLOW SENSOR FOR FORAGES

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A parallel plate capacitance sensor consisting of two metal sheets was built. The sensor - capacitor and the whole oscillating circuit was driven at 27 MHz frequency. Dynamic laboratory experiments were performed with grass from natural meadow in order to evaluate the possibility of forage mass flow determination by means of this sensor. The results showed that there was a relatively strong linear relationship between the feed rates of wet forage crop material passing through the sensor between its plates and measured capacitance sensor circuit output frequency. The coefficients of determination (R2) varied from 0.9 to 0.96. Further improvement of electronic circuit connection and further investigation of the sensor can be recommended.

Keywords: precision agriculture, yield mapping, capacitance sensor, mass flow, grass and forage

Introduction

Capacitance sensor technique can be used for the determination of different properties of plant materials. The function of capacitance sensors depends on the fact that the dielectric constant of the air/material mixture between two parallel plates increases with material density. Capacitance sensors could be used for plant material moisture content determination (Lawrence et al., 2001).

Eubanks and Birrell (2001) determined moisture content of hay and forages by using multiple frequency parallel plate capacitors. The frequencies used were in the range between 900 kHz and 13 MHz. They found out that the prediction error was greater for the grasses than for the two legumes measured (alfalfa and clover). Another important finding was that the amount of material in the sensor does not have an effect on the moisture content prediction for the materials tested. This sensor was capable of predicting moisture content of a material with unknown density. On the other hand, the developed moisture sensor was specific for each crop measured and had to be calibrated for each particular crop.

Osman et al. (2002) built a parallel plate capacitor with variable spacing for hay and forage moisture measurement. An integrated circuit timer (LM555) was used, in which the parallel plate capacitor acted as an external capacitor. The timer worked as an unstable multi-vibrator. The sensor's output was recorded as the difference between the capacitor's operating frequency with no material between the plates (833 kHz) and the actual frequency when forage was placed between the plates. Results indicated that the sensor could not directly estimate the moisture content. However, a good correlation was observed between the sensor's output and the amount of water within the capacitor's volume. The frequency drop and the amount of water were more correlated at low moisture content than at high moisture content.

Snell et al. (2002) used radio-frequency application device for sensing dry matter content of various agricultural products. They found out that the density of material had a significant influence on the precision of the estimate. Using a mass and density independent measuring system, water mass can be estimated much more precisely that dry matter content using described method of measurement. For that reason, different sensors measuring different parameters (e.g. total mass, water mass and temperature) should be combined. According to these results, it was possible to estimate the dry matter of unknown lots (variety, machine capacity, distribution of particle size, etc.) with sufficient precision by means of existing calibration.

Wild and Haedicke (2005) found out that the accuracy of moisture content determination by using a parallel plate capacitor was greatly affected by the contact pressure.

Stafford et al. (1996) used a capacitance sensor for determination of grain mass flow. According to their research, the effect of moisture content can be compensated by measuring capacitance at two widely spaced frequencies. One section of the sensor was driven at 10 kHz and the other at 2 MHz frequency.

Martel and Savoie (1999) observed a capacitance controlled oscillator placed at the end of the spout of a forage harvester to measure changes induced by the forage particles. The oscillator was a high frequency timer (880 kHz, model TS555CN, SGS Thomson Microelectronics). This equipment showed a linear drop of the oscillator's frequency as the wet mass flow increased. A number of calibration parameters would be required to cover a broad range of crop species, maturities and chop lengths. Savoie et al. (2002) used similar capacitance controlled oscillator for their measurement. This device proved a proportional frequency drop in dependence on the amount of moisture flow between the capacitor plates. Nevertheless, the frequency drop of the capacitance controlled oscillator was poorly correlated with mass flow rate (R^2=0.486). Described device was better correlated with water flow rate (R^2=0.624).

Kvíz et al. (2007) designed a parallel plate capacitance sensor for forage weight determination. The sensor was operating at 27 MHz frequency. Results showed that there was a relatively strong linear relationship between the weights of material and the data obtained from the measuring circuit. The coefficients of determination (R^2) mostly reached the value of 0.95. The results of the measurement were not influenced by type of harvested material while material moisture content as well as material compact pressure between the plates influenced those results.

On the basis of these findings previously published, the main aim of our research was to find a non-contacting method for forage material mass flow measurement. Because of its relatively low purchase cost and quite promising results obtained and described before, the capacitance type sensor appears to be suitable for that purpose. The measurements described in this paper were realized in order to find out whether there is some relationship between mass flow of wet plant material passing through the capacitance sensor and its output signal. This possibility of mass flow determination could be useful for the aim of forage maps creation.

Material and Experimental Method

On the basis of the results obtained (Kvíz et al., 2007) it was decided to improve the design of the sensor and to arrange dynamic laboratory measurements with the improved sensor. A new parallel plate capacitance sensor was designed for that purpose. The parallel plate capacitance sensor consisted of two metal sheets 2 mm thick and with the dimensions 830 mm in length and 260 mm in width. The distance between the plates was 300 mm. The inside parts of metal sheets were insulated by two plastic sheets 1 mm thick with the same dimensions which were stuck on metal sheets. Sides of the capacitance sensor were made from 10 mm thick acrylic glass. A shielding 2 mm thick metal plate with the dimensions 830 mm in length and 280 mm in width were fixed to mentioned acrylic glass sides in the distance 430 mm from the capacitor's shielded plate (see Figure 2). This metal plate shielded the capacitance sensor from surrounding influences which could affect the measurement.

The dimensions of the sensor were calculated with the aim to keep the electrical parameters of previously proved older sensor used for static laboratory experiments. Another goal was to design a new sensor just ready for practical using on small rotary mower equipped with conditioner (ZTR 186, Agrostroj Pelhrimov Company). The new sensor - capacitor and the whole oscillating circuit was driven at 27 MHz frequency as well. The exact connection of the measuring circuit is in the Figure 1.

The capacitor was fed with AC-voltage from the oscillator via resistor or another capacitor with the same reactance. The resistor together with two measuring capacitor plates made up a voltage divider and thus the output voltage of that divider depended on the capacity on the measuring capacitor and that capacity is dependent on the dielectric matter between the plates again. The dielectric constant of the measuring capacitor varied according to the amount and type of material paced between the plates, it means according to proportion material/air. The AC output voltage of the divider was then rectified in an AC/DC rectifying module and amplified with an amplifier. Then, the rectified voltage was converted into frequency by an electronic measuring apparatus developed in our laboratory. The output frequency was directly proportional to the measured voltage. The pulses from the converter were counted during the time interval equal to 0.5 s by means of a one-chip microcomputer and results were transferred into a PC.

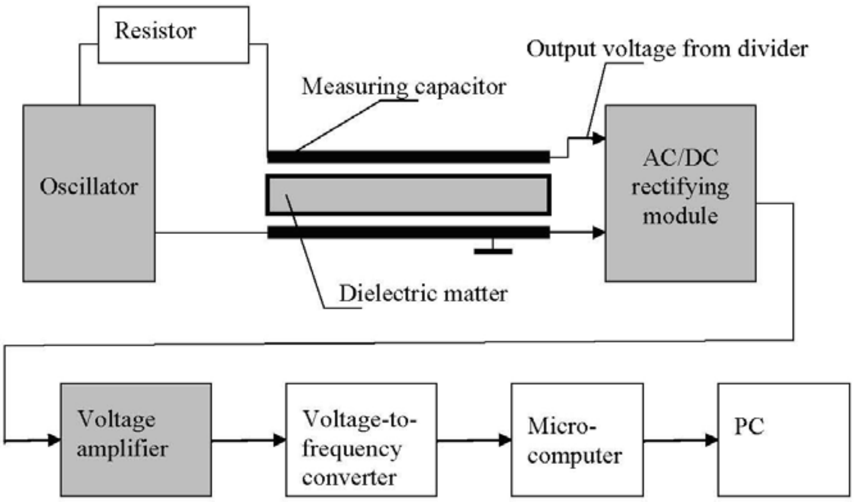

Figure 1 - Block diagram of electronic apparatus arrangement for material feed rate measurement. Oscillator worked at 27 MHz frequency. The capacitor (Measuring capacitor with Dielectric matter between its plates) was fed with AC-voltage via Resistor. AC output voltage was then rectified in AC/DC rectifying module and amplified by Voltage amplifier. Amplified voltage was proportionally converted into frequency in Voltage-to-frequency converter. The counted pulses were transferred by Microcomputer to PC and saved.

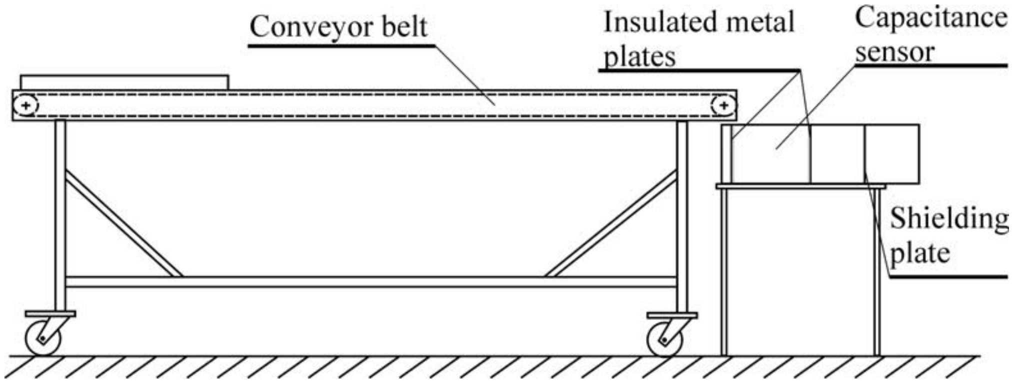

Figure 2 - Arrangement of measurement device for laboratory tests. Conveyor belt carried weighted amount of material into the Capacitance sensor between its plates for five seconds. Shielding plate insulated capacitance sensor from surrounding influences.

The laboratory set-up consisted of a conveyer belt carrying a measured quantity of material into improved sensor equipped with the electronic measurement apparatus (Figure 2). Material from the conveyer belt passed through the sensor between its plates. Material was transported through parallel plate capacitance sensor for approximately five seconds for each test run.

Grass from natural meadow was used for the purpose of determination of the relationship between the output frequency of the capacitance measuring device and material feed rate through the capacitor. The signals from the capacitance measuring device were measured every half second, so 10 values were obtained from one single test run. Measurements started with material feed rate equaled to 0.8 kg WM s^{-1}. The test run with the same defined amount of material was then repeated at minimum three times. For the next measurements the transported amount of material was then increased by the increment approximately 0.3 kilogram per second, up to 4.5 kg WM s^{-1} feed rate. Ten values from each test run were averaged to obtain the final result for a particular feed rate value. Calculated data were used for further statistical processing using of MS Excel and Statgraphics for Windows.

Material moisture content was determined by means of a standardized method for each material tested. One sample of material was taken at the beginning of each day of the measurement for that purpose.

The measurements were carried out during 5 days, July 11th, 12th, 13th and 21st and October 17th,

2006. During the measurements from July 13th the signals from the capacitance measuring device were measured every 5 s instead of 0.5 s used for all others measurements (will be discussed later).

Results and Discussion

First measurements with the improved capacitance sensor were carried out on July 11th. The main aim of these measurements was to get familiar closer with the function and characteristics of the new designed capacitance sensor. The measurement procedure was as described above. Just the first tests on July 11th were realized up to 3 kg WM s^{-1} material feed rate only. Material moisture content was 77.2%. Measurements proved linear relationship between the capacitance sensor frequency and wet material feed rate as it was predicted. The coefficient of determination was R^2=0.91 (see Figure 3, dashed and doted line).

On the basis of the results obtained it was decided to repeat the measurements next day, July 12th, with the grass from the same natural meadow but up to higher value of material feed rate. The final transported amount of material was then increased up to 4.5 kg WM s^{-1}. The dimensions of the capacitor, as well as the arrangement of laboratory device, did not allow us to use higher value of material feed rate. Nevertheless, the amount of material tested was comparable with the amount under common harvesting conditions using mentioned mower (ZTR 186). Material moisture content was 77.5% in that case and the coefficient of determination was improved to R^2=0.96 (Figure 3, continuous line).

Because the results obtained from both previously described measurements were quite satisfactory, new measurements with partly modified measurement device were made on July 13th. The modification of measured device was as follows. The signals from capacitance sensor were recorded every 5 s, which better corresponded with the real situation in case of infield measurement. Only one value was recorded from each test run in that case. Those values were used for charting after subtraction of zero value (Figure 4). It followed from this graph that calculated coefficient of determination was a bit lower (R^2=0.90) in comparison with previous measurements. On the other hand the values obtained were within the same range from 2 to 16 Hz as previous measurements (comparing Figure 4 with Figure 3). Because of lower final coefficient of determination it was decided to return to recording time 0.5 s used before. The values fluctuation during one single test run was possible to observe in that case which seemed to be advantage in the comparison with later modified measurement device.

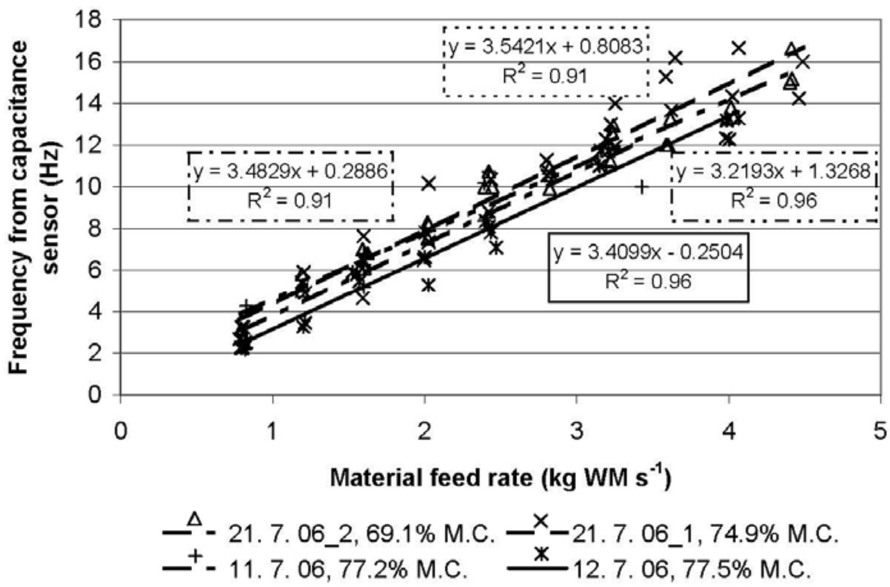

Figure 3 - The dependence of measured circuit output frequency on plant material mass flow (11th, 12th and 21st July 2006). Recording time 0.5 s.

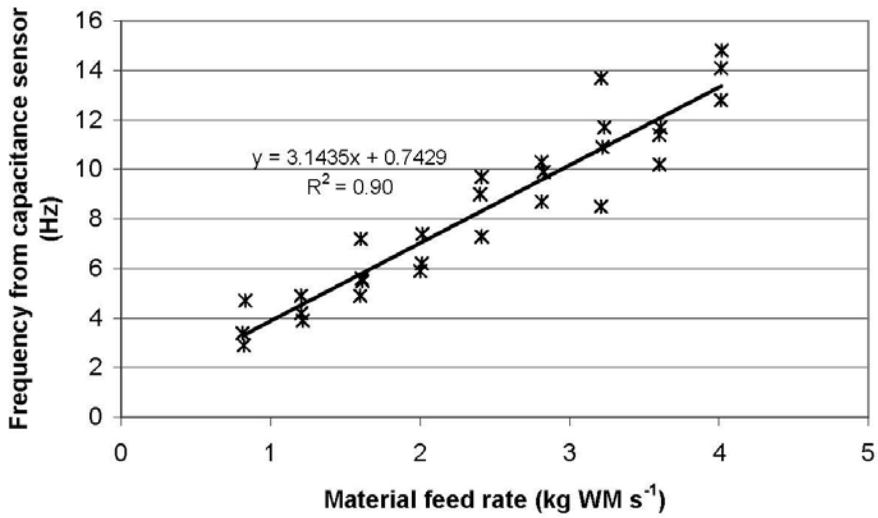

Figure 4 - The dependence of measured circuit output frequency on plant material mass flow (July 13th, 2006). Recording time 5 s.

Two tests were made on July 21st. Material with moisture content 74.9% was used for morning measurements and the same material after moderate wilting with moisture content 69.1% was used for afternoon measurements. Morning measurements resulted in the value R^2=0.91 and afternoon measurements R^2=0.96. Because the output values from those measurements had the same range as the previous two measurements, it was decided to chart all four measurements together in one chart (Figure 3).

Morning measurement (Figure 3, dashed line), which had lower value of coefficient of determination, was with the early morning freshly mowed grass with the drops of dew on the leaves. That additional moisture could be the reason of smaller resulting value of this coefficient. Some drops of dew could have stuck on the capacitor metal plates and their influence on the measurement accuracy was very difficult to estimate. It could be one of the disadvantages of this type of capacitance based material feed rate measurements.

Afternoon measurements (Figure 3, dashed and double dotted line) with considerably higher coefficient of determination were made with partly flaccid grass where no drops of dew or water were on leaves. In spite of this that material moisture content was a bit smaller in that case in comparison with other measurements, the resulting curve was in good agreement with the previous ones. This underlines the previous findings (Kvíz et al., 2007). Mainly, that small difference in material moisture content (about 6% only) did not influence the results. The influence of material moisture content was observable only when the difference between two measurements was higher than 30 - 40% of M.C.

Because of relatively warm July in the year 2006 the outside air temperature in our laboratory reached the values from 29^{0}C to 33^{0}C in all cases.

The problem accompanying all measurements carried out was with zero value – when no material was in the sensor. The measuring apparatus used recorded relative values, which is quite common for these types of measurements. Absolute values had to be calculated as the difference between the values recorded and zero value. Zero value was necessary to set up before the measurements. The problem was that the zero value was unfortunately changing during the measurements and it was necessary to re-check it or set up again before each particular test run. From the laboratory measurements point of view this problem is not so serious because it is no problem to re-check correct zero value and than use it for precise calculation. Nevertheless, under real harvesting conditions it represents a serious problem because re-checking of zero value is almost impossible and thus the zero value should be as stabile as possible. It was the reason for future improvement of the electronic circuit connection.

Conclusion

Forage mass flow determination by means of new designed parallel plate capacitance sensor driven at 27 MHz frequency appeared to be a promising way. The results showed that there was a strong linear relationship between the feed rates of wet forage crop material passing through the sensor between its plates and tested measuring capacitance sensor circuit output frequency. However, the obtained results showed that an improvement of the electronic circuit connection and further investigation of the sensor can be recommended.

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EFFECT OF VACUUM LEVEL ON FORE AND REAR BOVINE TEATS

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The objective of the study was to find the effect of vacuum level (42.6, 40 and 35 kPa) on fore teats and rear teats by means of the changes of teat temperature. Teat temperature was measured by infrared thermography. The non significant temperature differences were found between fore teats and rear teats within vacuum levels. The significant differences were recorded in fore teats and rear teats depending on used vacuum level. Fore teats showed the significant difference ($P<0.05$) between 42.6 kPa and 35 kPa. In rear teats the significant differences ($P<0.05$) were found between 42.6 kPa and 40 kPa and between 42.6 kPa and 35 kPa.

Introduction

Milking is an important process in farming. Different milking routines, and the very fact of using machine milking, can affect the health and welfare of animals because in this process an extremely sensitive organ, i.e. the mammary gland, comes into direct contact with the milking machine. The teats are the most stressed part of the udder, because milking changes their condition. Repeated teat compressions may cause mechanical and circulatory changes in teat tissues and hyperaemia in the teat wall (Hamann, 1992; Isaksson and Lind, 1992; Burmeister et al., 1998, Zecconi et al., 2000). Such changes may even lead to pathological traumatisation manifested by, for example, congestion, oedema, cracks in mucous membrane, induration. There are a number of factors in milking that influences the condition of the teats. Literary sources emphasise the importance of the milking vacuum, and also the pulsation rate pulsation ratio and the quality of the teat cups. Assessment of the teats and udder before and after milking is usually based on visual observations. For such assessments, a cutimeter (Isaksson and Lind, 1992) or a classification system (Neijenhuis, 1998; Rasmussen and Larsen, 1998, Neijenhuis et al., 2000) or ultrasonographic scanning (Neijenhuis, 2004) are used.

The objective of the study was to find the effect of vacuum level (42.6, 40 and 35 kPa) on fore teats and rear teats by means of the changes of teat temperature. Teat temperature was measured by infrared thermography.

Materials

Thermographic measurements were carried out in tandem milking parlour 2 x 5 in 12 dairy cows (Holstein, milk yield 9567l, 1st stage of lactation). Cows were milked and their teats measured twice a day at 42.6 kPa per one week, twice a day at 40 kPa per one week and twice a day at 35 kPa per one week. Thermal profiles of teats were recorded immediately before milking and immediately after milking (without postdipping). Thermograms of teats were evaluated by the special computer program ThermaCAM Reporter 2000. The differences between teat temperatures were calculated and evaluated by Statistica.cz (ANOVA).

Results

At 42.6 kPa level, temperature of fore teats increased in 1.52 ± 1.23 K, temperature of rear teats increased in 1.92 ± 1.35 K. The difference between fore and rear teats was not significant. At 40 kPa level, temperature of fore teats increased in 0.46 ± 2.54 K, temperature of rear teats increased in 0.61 ± 2.12 K. The difference between fore and rear teats was not significant. At 35 kPa level, temperature of fore teats increased in 0.05 ± 1.19 K, temperature of rear teats increased in 0.12 ± 1.31 K. The difference between fore and rear teats was not significant.

Fore teats showed the significant difference ($P<0.05$) between 42.6 kPa and 35 kPa. In rear teats the significant differences ($P<0.05$) were found between 42.6 kPa and 40 kPa and between 42.6 kPa and 35 kPa.

Discussion

Milking in tandem milking parlour showed an increase of teat temperature at all used vacuum levels. This supports the findings Hamann, (1985), Eichel (1992) or Paulrud et al. (2002). But a rise of temperature after milking depended on used vacuum level. The highest rise was recorded at 42.6 kPa vacuum level. Rear teats showed higher temperature compared with fore teats. But the differences between fore teat temperatures and rear teat temperatures were not found out significant at that same vacuum level. The significant differences were found out between vacuum levels.

Conclusions

Generally, the non significant temperature differences were found between fore teats and rear teats within vacuum levels. The significant differences were recorded in fore teats and rear teats depending on used vacuum level.

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MODELS OF TENSION CONTROL IN TEXTILE MATERIALS

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The article is focused on physical and mathematical models of textile materials during their tensile straining on a base of experimental testing. Properties of materials are important for formation of model of winding technological process on a beaming frame. Block diagram is mentioned together with differential equations of bobbin unwinding, fiber deceleration, winding and tensile force sensor. Structures of control circuits are proposed for tensile force control. Object of this effort is to provide an analysis of technological value relations and improvement of winding quality in a field of textile materials.

Keywords: tension control, textile material, mathematical model

Preface

The paper shows a creating method of simulating model of strain control at warp unwinding on a laboratory sizing machine Sucker MZ. A formulation of mathematical model under simplified condition and a way of gathering data for quantification of this model by means of measurement are stated. The simulation has been realized in the MATLAB environment. The model application in the textile practice are indicated in the final part.

Material and methods

The model formulation of the technological process as well as of its solution is running in several steps. If the model is not sufficiently precise, iterating feedbacks are appearing until a corresponding coincidence of model and physical reality come true.

Object of knowledge

Elongation (deformation) given by static and dynamic tensile stress in the sizing process is being risen in the textile material when the warp is unwinding from the warping roll on the sizing machine Sucker MZ. On the sizing machine, we can identify various technical systems, for example that of unwinding warp from the warping roll, a system of measuring and tension control in the warp, a system of measuring and concentration control of size viscosity. Measuring and temperature control of the sizing bath, control system of dewatering thrust, unwinding control on the machine output. [1] Either the **rheological features** of processed textile material are an important input parameter of the created model.

A description of mechanical features of the textile fibres is complicated because of indefinable proportion of amorphous and semicrystalic structure. Therefore, at the first approach, we will consider the textile material sample as a linear one – as a totally elastic material, for which the Hook principle is available (for $\varepsilon < 1\text{-}3\%$ a $d\varepsilon/dt \approx 0$,, static state) in the form

$$\sigma = E.\varepsilon \qquad F = C.x \qquad C = \frac{S.E}{l_0} \tag{1}$$

Where:
σ [Pa] – fiber tension
E [Pa] – Young elasticity module of the warp threads
l_0, l [m] – original and instant material sample length
$x = l - l_0$ [m] – absolute deformation
$\varepsilon = x/l_0$ [-, %] – relative deformation
F [N] – tension in the textile material
S [m^2] – material section
C [Nm^{-1}] – textile material static stiffness

Note: Regarding a small mass *m* and sections *S* of fibers, we use a concept of fiber fineness ***T***, defined by the relation (2) in the textile terminology

$$T = \frac{M}{l} \quad [kgm^{-1}] \tag{2}$$

the unit *tex* is determining the fineness *T*, at which the fiber 1000m length has the mass of 1g, ie. 1tex = 1g/1000m = 10^{-6} kgm^{-1}. The cross section area S is possible to be formularized as

$$S = \frac{T}{\rho} \quad [m^2] \tag{3}$$

where ρ [kgm^{-3}] is the textile fiber specific mass. The tensile force inside the fiber is sometimes related to fineness and represented in cN/tex.

With respect to dynamical stress of textile materials, the approximation of real fiber features with rheological models is used at the higher processing velocity. These features are described with the so called relaxation module, which is approximated by parameters of ideal springs (E_i) and damping elements (η_i). The parameters of equivalent model create so called relaxation spectrum. From the point of view of the theory of systems, either the textile material sample behavior is possible to be formularized with generalized transfer function of complex stiffness (or eventually complex elasticity module) in the Laplace transformation (p is a Laplace operator).

$$C(p) = \frac{F(p)}{x(p)}$$

$$E(p) = \frac{\sigma(p)}{\varepsilon(p)} \qquad (4)$$

for example for three-elements model (so called Zener´s mass) in accordance with the Fig. 1, a corelation for the dynamical stiffness, it is true

$$C(p) = \frac{F(p)}{x(p)} = C_1 \frac{T_2 p + 1}{T_1 p + 1} \qquad (5)$$

where $T_1 = r/C_2$,
$T_2 = (1 + C_2/C_1).r/C_2$

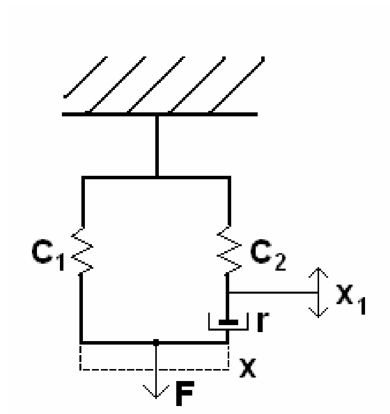


Figure 1 – Equivalent mechanical diagram of three. Elements model

From this equation, by means of reversed transformation, we can find the force (F) response to arbitrary deformation signal x(t). As it is shown on the Fig. 2, the textile material **dynamical** stiffness is possible to by formularised either with amplitude and phase characteristic in the complex plane or in the logarithmic coordinates.

- **Simulated system identification**

Sizing is a preparatory operation for waving; a quality warp preparation is given firstly with the optimum of warp stress in the course of whole sizing process. Therefore the tension in the warp is necessary to be controlled when unwinding from the warp roll. From the whole laboratory sizing machine, we will observe this problem only. From the point of view of the available machine layout we can formularize the mentioned control system with a block diagram according with Fig 3. .

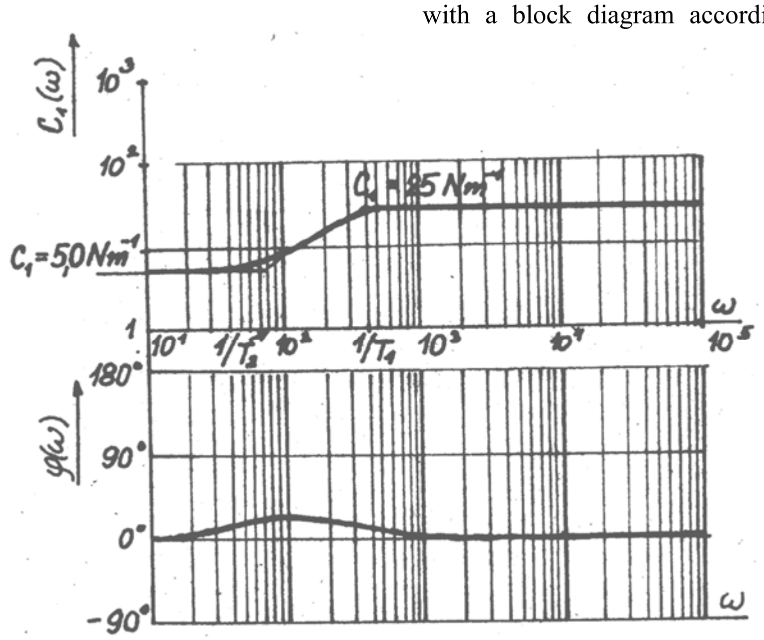
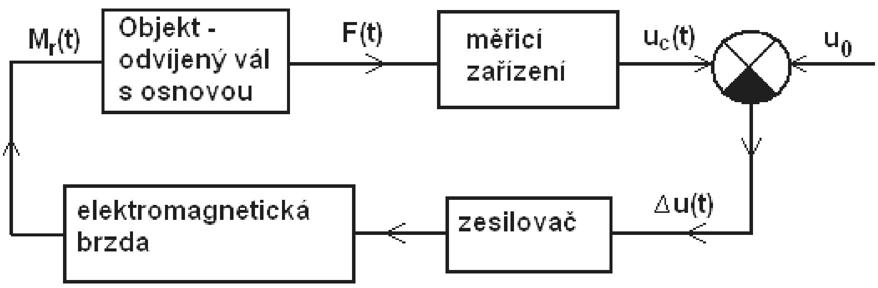


Figure 2 – Amplitude and phase module stiffness characteristics of a three element model



Desription: Object - unwinded roll with warp — measuring equipment — electromagnetic brake — amplifier

Figure 3 – Tension control block diagram

Results and discussion

On a base of the known principles of mechanics and electrotechnics, we will create a differential equation system:

- **Simulation model synthesis**

The mathematic model formulation consists in the system of following equations, completed with auxiliary relations:

$$T_1^2 \frac{d^2F(t)}{dt^2} + T_2 \frac{dF(t)}{dt} + F(t) = \frac{M(t)}{r(t)}$$

Unwinding process – v = const. (6)

$$T_3 \frac{dU_c(t)}{dt} + U_c(t) = K_2.F(t)$$

Measuring equipment (7)

$$T_4 \frac{dM_T(t)}{dt} + M_T(t) = K_3.\left[U_c(t) - U_0\right]$$

Action element (8)

Auxiliary relations:

$$T_1^2 = \frac{2LJv}{S_0 r^2.100.E} \quad T_2 = \frac{2vJv}{S_0 r^2.100.E} \qquad (9)$$

Equation or roll diameter change within the unwinding course

$$\frac{2\pi.r_0^2}{hv}.\frac{d^2r(t)}{dt^2} - \frac{dr(t)}{dt} = 0 \text{ ; při } r(0) = r_0,$$

$$r'(0) = \frac{hv}{2\pi.r_0} \qquad (10)$$

Signification of units and parameters:

t [s] – time
F(t) [N] – textile material tension
M(t) [Nm] – loading torque
r_0 [m] – warping roll initial radius
r(t) – instant winding radius
$T_{1,2,3,4}$ [s] – time constants – given by the machine desing and with the textile material sort
K_2 [V/N], K_3 [Nm/V] – gain
$U_{s,o}$ [V] – voltage on the measuring device output – and voltage proportional to the warp tension value
L [m] – zone length
J [kgm^2] – roll moment of inertia
υ – Poisson coefficient of warp threads
S_0 [m^2] – cross section area of the warp threads
v [m/s] – warp moving velocity
E [Nm^{-2}] – Young elasticity module of warp threads
h [m] – average winding radius incremental to one warping foll turn

- **Model quantification and verification**

We have known some parameters from the machine producer, other ones must be measured in laboratory (material constants *E, S, υ*) or immediately on the machine (*r_0, L, v, F(t), $U_s(t)$, $M_t(t)$, $T_{3,4}$, $K_{2,3}$*). Other parameters are possible to be calculated, being taken from the measuring base, for example *$T_{1,2}$, h, J*. In addition to that we must specify the intervals of changes of selected physical units and parameters in which the process of **warp winding control** would be observed. A precise and correct measuring of parameters, and especially then that of tension time behavior in the course of machine operation, are a condition for effective realization of this model, corresponding to a real object on a given resolution level. This behavior in verifying of the model correctness is to be compared with the behavior of simulation model in accordance with the selected control process quality criterion [2, 3].

- **Results of rheological experiments:**

Relaxation of tension has been measured at the isothermal conditions and under constant humidity (υ = 20°C, φ = 65%) on the tensile testing machine Instron TT-DM-L loaded with uni-axial tension for ε_0 = 1, 2 a 3%. It has been shown that the most advantageous approximation of measured relaxation function is created with a parallel wiring of ideal spring and of tow Maxwell elements in accordance with the fig. 4.

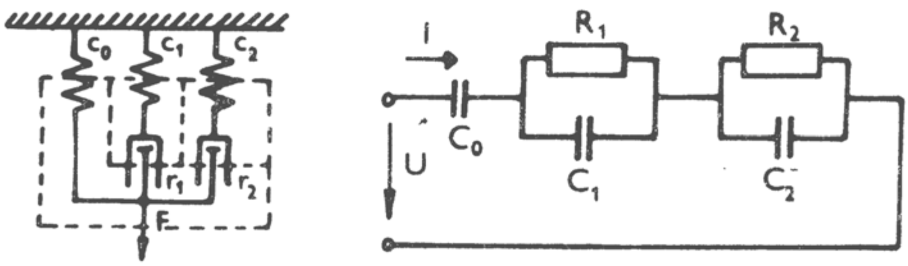
$$E(t) = E_0 + \sum_{i=1}^{2} E_i . \exp\left(-\frac{t}{\tau_i}\right) \tag{11}$$

where

$\tau_i = \eta_i / E_i$ [s] – so called relaxation period of i-th element

Comparing experiments and calculations made on PC as it is shown on the fig. 5.

Another addition of Maxwell elements does not bring an essential approximation improvement. The short relaxation time τ_1 is modeling the initial relaxation function drop, a long relaxation time $\tau_2 \approx 10\tau_1$ is approximating well the area of steady function behavior. The calculated parameter values, for example for woolen fibers, are moving within the following limits:



a) b)

Fig. 4 – a) Equivalent mechanical model for approximation of the relaxation function b) equivalent electrical diagram of fiber model.

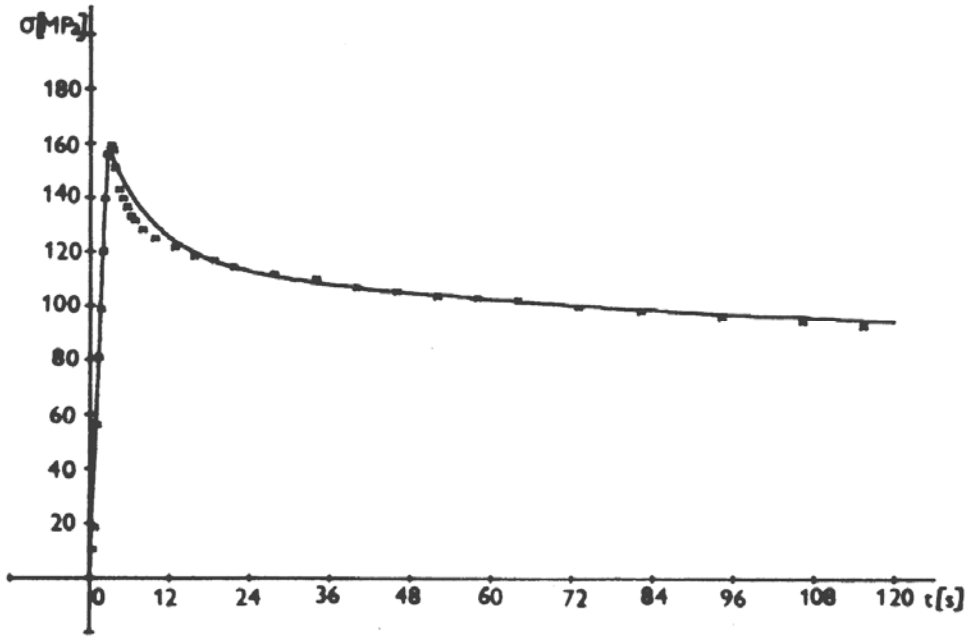


Fig. 5 – Approximation of the relaxation function with two Maxwell elements

Tab. 1 – Equivalent woolen fiber model parameters

E_0 = (1,7 – 3,4)GPa		
τ_1 = (5 - 10)s	E_1 = (0,5 – 1,5)GPa	η_1 = (5 - 11)Gpa.s
τ_2 = (60 - 90)s	E_2 = (0,4 – 0,9)GPa	η_2 = (20 - 60)Gpa.s

- **Model application**

The simulation has been realized on PC on the MATLAB environment. Following behaviors in the graphical and tabular form have been obtained by means of this solution for various categories of textile materials:

Tension dependence as a function of time with the parameters *L, r, v, J,* M_t (process parameters) and S_o, *E, υ* (material constants)

- Optimum parameters for measuring and action element setup
- Optimal machine speed behavior from the point of view of admissible warp stress when moving
- Behaviors at the machine and material parameter limits.

Conclusion

The approximation of woolen fiber relaxation function has been discussed. A relatively big variability of the mentioned parameters of Maxwell elements is caused probably with a different measured fiber diameter value (when the tension calculated, the tension force has been referred to the statistic average value of the mentioned fiber type). Orientation values of the rheological features of the textile fibers are by order in a very good accordance both with the theoretically derived values and with the sporadically published experimental values. A simulation model of unwinding process of the textile material and the tension force control.

The details and concrete results of the simulation experiments will be presented verbally within the frame of lecture.

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TRENDS IN AGRICULTURAL MACHINERY MAINTENANCE

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The article considers changes in agricultural machinery (AM) maintenance systems and points out the goals of AM maintenance nowadays. It presents the method of the maintenance results measurement and the importance of the maintenance costs and promptness comparison. The main factors influencing maintenance costs and the machinery promptness are summarized. The last part presents findings of a survey, that examined the present state of the AM maintenance management among Czech agriculture companies. The survey data represents a basis for the first benchmarking of the maintenance management standards in the Czech agriculture sector.

1 Introduction

Current AM requirements on maintenance and repairing slightly differ from requirements of production machinery. It is given not only by seasonal character of agriculture operations, but also in many cases by more demanding operational conditions, whether climatic and soil conditions as far as the plant production is concerned or very aggressive conditions of livestock production.

AM producers are currently better responding to difficult operating conditions with help of new technologies and materials. This concededly **leads to an increase of machinery dependability**. However despite that, in fact none of the producers were not and will not be able to construct totally maintenance and failure free machinery. Therefore the **optimal maintenance level needs to be provided**. This objective is permanent, future changes can only be expected as a result of new machine design concepts, used technologies and materials or economic changes. **AM maintenance demands will not disappear**, because besides the above mentioned factors we can expect further growth of complexity and introduction of electronic devices, which increases demand for high level of failure-free operation (low failure rate) and generally creates requirements for maintenance and its assurance.

Operational maintenance system of AM has changed significantly in last ten years. Mainly it is caused by a transfer of maintenance engineering responsibility from the owners (users, operators) of AM to its producers and dealers that follow the global trends. Presently, **producers are liable** for the life cycle of the product, not only for its construction, development, production and installation. They also recommend and in some cases provide (generally through dealers and services) optimal method of operating, **maintenance** and lately also ecological disposal of AM.

The objective of maintenance is not only to keep up inherent (given characteristics) quality and reliability characteristics (especially promptness) throughout effective lifetime of AM, but in certain cases also to improve the characteristics by various renovations, reconstructions and modernizing.

The reliability management (failure-free operation, maintainability a maintenance support performance) creates **the theoretical background** of correct AM maintenance together with the preventive maintenance optimization and its management. **Maintenance management** has to solve the questions of maintenance strategy and concept (see Fig. 1), maintenance resources management, execution of maintenance itself (maintenance, diagnostics and repairs) as well as measurement and improvement of maintenance.

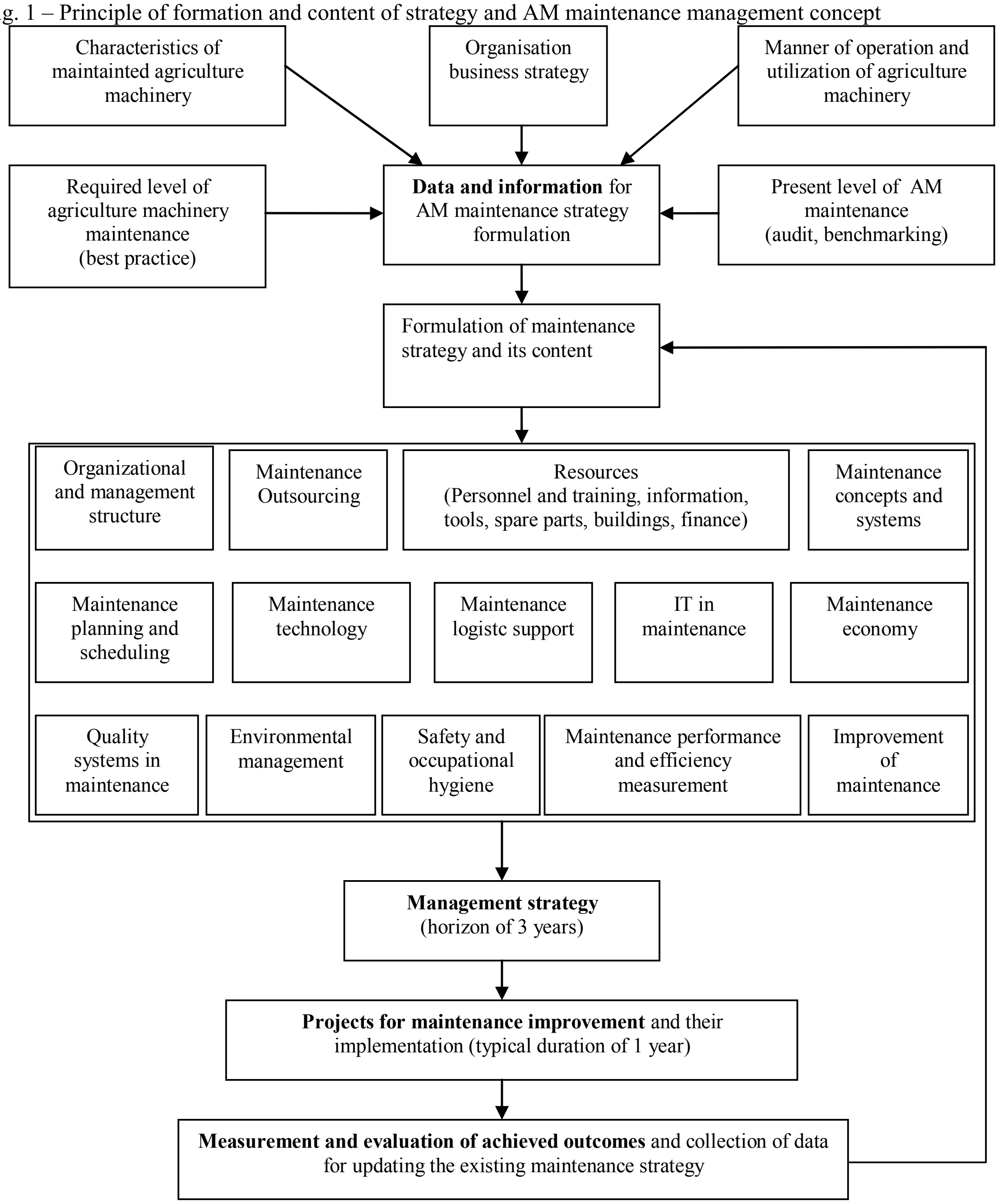
2 Methods

Maintenance performance measurement is slightly more difficult than a manufacturing outcomes measurement. Manufacturing has generally unique technological processes given, piece lists, production time consumption standards etc., while in a field of maintenance there is a large scope particularly in the area of instant of time determination and area of maintenance implementation (we can leave the used part in a machine for further operation, renovate it or replace by a new one). Despite of that we measure maintenance effectiveness most often by the **availability coefficient** of AM:

$$A = \frac{MTBF}{MTBF + MTTR} \qquad (1)$$

MTBF in the equation means mean time between failures, MTTR is mean time to repair (maintenance, repair) and A represents the availability. Therefore the best maintenance system would be the one, for which the availability coefficient approaches 1. However, undesirable trend of maintenance costs growth has an impact on positive trend of availability increase. Therefore the maintenance management presents a **trade off between maintenance costs and availability** of AM. Not only knowledge, skills and management abilities of maintenance managers and servicemen, but also necessary financial resources are prerequisites for proper adjustment and sustainment of the compromise.

Fig. 1 – Principle of formation and content of strategy and AM maintenance management concept



Let`s ask the question – **what maintenance procedures and processes influence the availability of AM and the maintenance costs?** This is definitely the key question every maintenance manager and serviceman asks, but top managers and owners of AM should also be concerned. Certainly there is a number of factors involved in AM availability and maintenance costs. The most important ones are:

A. Selection and purchasing of powerful, dependable and capable AM

a) Create a list of quality standards of purchased AM.
b) Specify required quality characteristics standards of purchased AM.
c) Set down importance scale of each quality characteristics and their parameters.
d) Select at least 3 suppliers (for renovation or purchase of new AM), that meet the required parameters of quality characteristics, obtain declared valued of the parameters from the suppliers.
e) Evaluate the suppliers' offers as far as all the specified quality characteristics and their parameters are concerned with regards to their importance.
f) Select particular AM supplier especially with regards to minimum life cycle costs.

B. Formation and providing of optimal resources for needed maintenance support

a) Education, training and practice of maintenance staff (managers, technicians, servicemen, operators and engineers).
b) Set up a technical information database of production machinery and other properties (operating instructions, maintenance instructions, lubrication plans, service hand-books, schemes, spare parts and materials catalogue etc.)
c) Equipped with tools, measuring instruments, diagnostics tools etc.
d) Assurance of proper spare parts and materials logistics
e) Construction and equipment of maintenance properties (fitting-rooms)
f) Assurance of optimal level of quality external maintenance (outsourced)
g) Owners and top managers should provide optimal financial resources to assure the above mentioned personal, intangible and tangible resources

C. Exercising of proper maintenance management

a) Exercise the standardized quality maintenance management focused particularly on the maintenance management responsibility, management of the resources, specially the human resources, realization of maintenance processes and measurements, analyses and maintenance improvements,
b) Utilize all possible tools to motivate operators, servicemen and service technicians based on the methodology of total productive maintenance (TPM)
c) Exercise the reliability centered maintenance (RCM) for the key production machinery
d) Pay extra attention to analysis of causes and effects of failures (FMEA, FMECA) and following proactive maintenance,
e) Monitor the operational dependability (reliability, maintainability and maintenance support performance) aimed at the following optimization of preventive (periodic and diagnostic) maintenance,
f) Work out and exercise standard technological procedures of maintenance (maintenance, diagnostics, renovations, repairs etc.)
g) Exercise the diagnostics (monitoring) of production machinery technical condition and failures aimed at planning of preventive (predictive) maintenance improvement and faster elimination of failures,
h) Measuring the maintenance productivity and effectiveness based on AM total effectiveness
i) Keep detailed records of each maintenance expenditure
j) Evaluate the maintenance contribution to the company profit
k) Exercise the internal and external benchmarking in maintenance, e.g. utilize 13 indicators of European Federation of National Maintenance Societies (EFNMS, see www.efnms.org/efnms/publications/benchmarking asp) to improve own maintenance.
l) Specify optimal proportion of planned and unplanned maintenance, of preventive maintenance and maintenance after failure, of internal and external maintenance (outsourced, service)
m) Exercise the optimal replacement of production machinery as a whole
n) Exercise the fundamentals of safety and health protection at the workplace, ensure required level of AM safety by revisional inspections and precautions
o) Exercise the environmental maintenance management system aimed at elimination and reduction of maintenance and production impacts on environment
p) Utilize the computer support for more efficient maintenance management.

3 Results

What is the current state of AM maintenance in conditions of the Czech Republic? This is another question that is not possible to give an explicit answer to in this paper, because the exhaustive answer would need an extensive survey to be conducted. We carried out a short, questionaire-based survey (together with the diploma thesis author [1]) of certain AM maintenance performance indicators among 80 interviewed agriculture companies. 48 of them responded to all the questions, which represents only a small sample. Nevertheless, certain maintenance level benchmarking indicators were obtained – see Tab. 1.

Presented data have only an indicative character of orientation (in the Tab. 1 are mean values, each of the gathered indicators had a different variability), therefore it is possible to use the data for the first benchmarking of AM maintenance level within the agriculture companies. Systematic benchmarking of AM maintenance level would indeed provide more exact comparison not only of each indicators, but also time series monitoring and evaluation. Suggestions and themes of AM maintenance level improvement have to be

Tab. 1 – Mean values of AM maintenance level indicators rated from 48 informants data

Indicator	**Indicator definition**	**Indicator characteristics**	**Mean value**
U_1	Total maintenance costs (% from the AM value)	Describes financial demandingness of company estates maintenance	**24,52 %**
U_2	Value of spare parts and maintenance material (% from the AM value)	Describes relative size of spare parts and maintenance material stock	**3,33 %**
U_3	Costs of external maintenance (% from the total maintenance costs)	Describes relative external maintenance costs and a level of external maintenance participation.	**22,66 %**
U_4	Internal maintenance costs (% from the total maintenance costs)	Describes relative internal maintenance cost and a level of internal maintenance participation.	**77,34 %**
U_5	Preventive maintenance cost (% from the total maintenance costs)	Describes relative costs of preventive maintenance and exercise of preventive maintenance.	**69,62 %**
U_6	Time consumption of maintenance (% from the total serviceman work time)	Describes relative time consumption of maintenance and exercise of preventive maintenance.	**34,69 %**
U_7	Current maintenance cost after failure (% from the total maintenance costs)	Describes relative costs of current maintenance after failure and exercise of current maintenance.	**29,51 %**
U_8	Time consumption of current maintenance (% from the total serviceman work time)	Describes relative time consumption of current maintenance after failure and exercise of current maintenance.	**12,74 %**
U_9	Total number of training man hours (% from the total serviceman work time)	Describes relative intensity of servicemen trainings	**0,42 %**
U_{10}	Average age of AM	Describes total technical condition of AM	**13 years**
U_{11}	Average spare parts delivery lead time	Describes time availability of spare parts	**24 h**
U_{12}	Agriculture area size per 1 serviceman	Describes human resources for maintenance execution	**314 ha/serviceman**
U_{13}	Fitting-room area per 1 serviceman	Describes utilization of fitting-room areas	**85 m^2/serviceman**
U_{14}	Year maintenance costs per 1 ha of agriculture area	Describes expenses-to-revenue ratio of maintenance	**3200 CZK/ha**

the output of the benchmarking in particular, besides numerical values.

4 Conclusion

As a conclusion of the paper, we can describe current level of AM maintenance as follows:

1. More efficient and dependable AM, with much better maintenance support and lower requirements on the total volume of maintenance, is becoming a part of Czech agribusiness
2. On the other hand, there is still a lot of dated, worn-out machinery with high demands on maintenance used in the Czech companies
3. There is a proper branded network of services within each AM dealers with trained and qualified staff.
4. The agriculture companies knows better, how to manage the maintenance resources; indeed, in some low productive areas are costs savings to the prejudice of worse technical condition of AM, the repair after failure predominates, that decreases availability.
5. There is a significant improvement in spare parts and materials logistics, level of stock decreased as well as spare parts' lead times.
6. The proportion of internal and external (purchased service activities) after-guarantee maintenance matches the European situation; farmers try to maintain and repair all the machinery they have capacity and capability for and purchase the other as maintenance services.
7. The level of apprentice education in the field of AM maintenance needs stronger support to get to the level of, for instance, Netherlands.

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RESEARCH IN PHOTOVOLTAICS AT THE CULS PRAGUE

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We increase the amount of produced energy from photovoltaic (PV) panels by the new construction of the solar PV system. The usage of our tracking stand TRAXLE™ was appropriate. Passive solar tracker TRAXLE™ was developed in co-operation of the CULS Prague and fa. Poulek Solar, Ltd. The small solar PV system was constructed and installed at the Czech University of Life Sciences Prague. Two identical PV panels vere compared. One panel was fixed and the second panel was located on the tracking stand TRAXLE™. The solar tracking system yields the energy surplus up to 30% during sunny days (50° of north latitude). The energy surplus corresponds with the lower price of the solar energy. Economic calculation shows, that the solar system with tracking stand and soft ridge concentrator is cheaper, when we compare two systems which produce the some amount of the energy. The tracking stand is more expensive than the fixed, but we can save some PV panels, and the price of the PV panels is the most significant part of the price of the whole solar PV system.

At the present time a research proect is solved and a new larger PV system with tracking axle TRAXLE™ and soft ridge concentrator is installed. The concentrator was developed in co-operation of the CULS Prague and fa. Poulek Solar, Ltd. as well. The combination of the tracking stand and soft ridge concentrator will yield the energy surplus up to 80% during sunny days.

Keywords: Photovoltaics, solar energy, solar tracker, PV panel,

Introduction

Sustainable development is a frequently discussed topic nowadays. Future technological development cannot continue to be based on growth of production and consumption of fossil fuel based sources (oil, coal, natural gas) because deposits are gradually being exhausted. They also represent a considerable burden for the environment. At present the consumption of energy from fossil fuels is much faster than its accumulation. Hopefully, there is general recognition that adoption of renewable energy sources is the only viable alternative for growth of our civilisation. International political and scientific conferences have been organised to deal with this problem, including the key Kyoto conference in 1997. Total energy production on Earth is growing exponentially; in the year 2000 it already exceeded $E = 10^{14}$ kWh/year. If this trend continues it would reach $E = 10^{17}$ kWh/year within less than a century [1]. This would be a catastrophic scenario which global ecosystems would probably not survive. Alongside power production itself many well-known and much discussed side effects need to be taken into consideration, such as emissions of dangerous or even poisonous gases, production of fly-ash, radioactive waste, emissions of greenhouse gases, acid rain, global warming, and melting of glaciers. It should be stressed that during the last Ice Age the average temperature was only 4°C lower than today and that, based on recent estimates, average temperature could grow by 4°C within next 50 years. This increase would have a catastrophic impact on global ecosystems. The most pessimistic scenarios estimate average temperature growth of as much as 9°C within next century. The concentration of atmospheric CO_2 grows by 0.4% annually and the concentration of methane grows even faster. The greenhouse effect is probably the cause of current high-risk climate change. Greenhouse gases absorb infrared radiation from the Earth's surface, partly reflecting it. This effect disturbs the balance between energy absorbed and radiated by the Earth. So far it has not been proved beyond doubt that these climate changes are caused by human activity. Rapid climate change and fluctuation of sea level by as much as 100 m in periods of the order of a thousand years have occurred historically.

10^{10} kg of CO_2 annually, to say nothing of other gases such as SO_2 and fly-ash (often slightly radioactive). These emissions occur even from plants with high-quality desulphurization units and fly-ash separators, causing acid rain and reduction of soil and water pH.

Some hope comes from prognoses that we cannot extrapolate recent trends, and that energy production will saturate, e.g., by implementation of power saving technologies, and that the curve of energy production in time will approach the asymptotic level of $E = 10^{16}$ kWh/year, which will never be exceeded. Such a trend might perhaps be acceptable from the point of view of sustainable development. But prognoses vary to a great degree, as shown on Fig. 1, and only time will tell which is the correct one.

The solar energy is not yet a concurrent of the high capacity power stations, but it is effectively used as an additional energy source. The solar energy is used more and more nowadays and we can see the rapid increase of the world production of the solar photovoltaic (PV) panels. PV conversion of the solar energy should be the most important energy source after the year 2040.

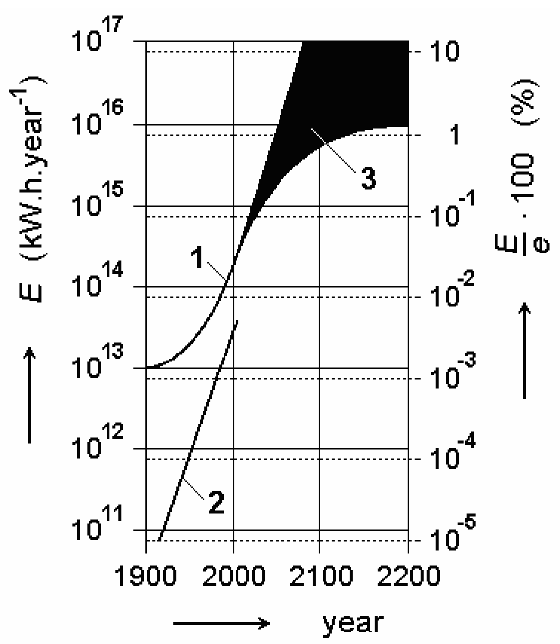

Fig. 1 Global production of energy, 1 - total production of energy, 2 - electric energy production, 3 - prognosis (e - energy coming from the Sun)

Methods

The direct energy transformation in semiconductor photovoltaic cells is the most widely used transformation of the solar energy. The photovoltaic solar power plants (and small solar PV systems) are installed all over the world. The photovoltaic systems can be constructed as an off-grid or on-grid system. Both versions were used in our PV system which is shown on the Fig.2.

Our off-grid system is used for storage battery charging. The energy consumption is limited by the amount of produced (PV transformed) energy. It is necessary to know the local average values of the solar radiation and the efficiency of the PV system.

Our on-grid PV system is connected to the grid. It can supply the grid during the higher energy production (transformation). The modern DC/AC inverters synchronize the phase automatically with the grid and they are also automatically disconnected from safety reasons when there is no voltage in the grid. The data output allows monitoring and data saving of the instantaneous power or other parameters by the computer. Fig. 3 shows the scheme of the on-grid PV system.

In the on-grid PV system we used tracking and fixed PV panels and we compared the amount of produced energy. The tracking strategy is following. The Sun is moving across the sky during the day. In the case of fixed solar collectors the projection of the collector area into the plane, which is perpendicular to the radiation direction, is given by the function of cosine of the angle of incidence. The higher is the angle of incidence φ, the lower is the power. The solar tracker, a device that keeps photovoltaic or photothermal panels in an optimum position perpendicularly to the solar radiation during daylight hours, can increase the collected energy by up to 30%.

Theoretical calculation of the energy surplus in the case of tracking collectors [3, 4] shows the energy surplus of 57% when we do not consider the atmosphere influence. We would really obtain this surplus for example on the Moon surface. On the Earth surface the sun is shining through a thick atmosphere layer after sunrise and before sunset. In the morning and in the evening, the radiation intensity acting on the area which is oriented perpendicularly to the radiation direction is much lower than at noon. On the other hand, the day can be longer than 12 h at higher latitude. That is the reason, that the energy surplus can be really as much as 30% on the Earth surface. The obtained power decreases when the angle of incidence of the radiation increases in the case of fixed panels. The higher amount of the produced energy corresponds with the lower price of the energy.

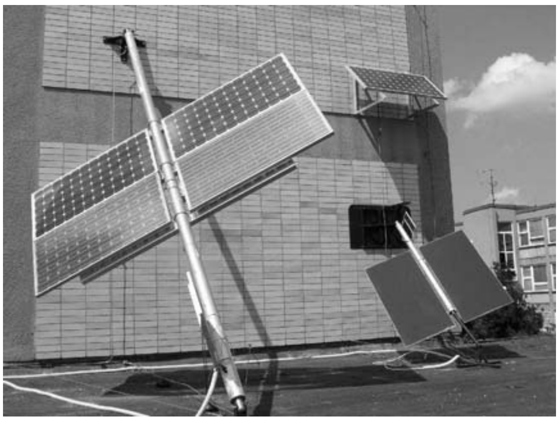

Fig. 2 PV system installed at the CULS in the year 2006

Photovoltaic system at the CULS Prague

The authors designed and constructed the solar PV system. The usage of the tracking stand TRAXLE™ was appropriate for our requirement. Passive solar tracker TRAXLE™ was developed in co-operation of the CULS Prague and fa. Poulek Solar, Ltd. and it was described in detail in the past [2-4]. The construction of this tracker is original and simple. It does not need complicated electronic components and external energy source. The solar energy move with the system, if the system is good balanced.

In the autumn 2004 a small PV solar system was installed in the Faculty of Engineering CULS Prague. This PV system involved three PV panels where two of them were placed on the automatic tracking stand TRAXLE™. The first PV panel was standard based on thin layers of amorphous silicon with maximum power 40W$_p$. The second panel was bifacial [3,4] based on polycrystalline silicon with maximum power 100 W$_p$. The last standard panel based on thin layers of amorphous silicon with maximum power 40 W$_p$ was placed on a fixed stand and it is used as a reference panel. Both versions (on-grid, off-grid) were tested.

In the case of on-grid version the direct currents from the PV panels were changed to the alternating currents in DC/AC inverters OK4E-100 (NKF-Electronics); the inverters were connected directly to the grid. The data output to the computer allowed to read and save data about instantaneous power from the PV panels, about amount of produced energy and about instantaneous direct voltage of the panels and alternating voltage in the grid. The DC/AC inverters synchronised the alternating voltage with the grid. We compared mainly two above mentioned identical PV panels based on thin layers of amorphous silicon with maximum power 40 W$_p$. One panel was placed on the fixed stand and the second panel was placed on the tracking stand. The third PV panel based on polycrystalline silicon was used in off-grid configuration for charging of the storage batteries.

In the autumn 2005 a larger PV solar system was installed (Fig. 2). The PV panels were based on monocrystalline silicon. In this case we compared two identical standard PV panels (tracking and fixed) with maximum power 110 W$_p$ and one bifacial panel (tracking) with maximum power 100 W$_p$.

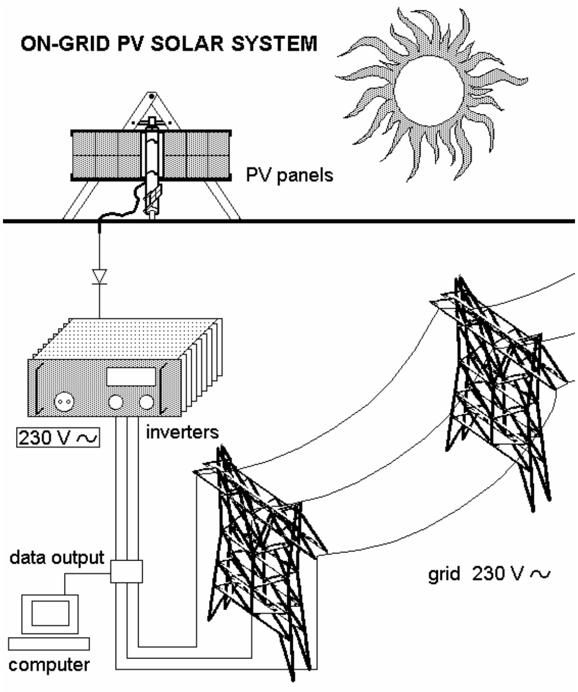

Fig. 3 PV on-grid solar system – scheme

Results and discussion

The monitoring and measurement in this solar PV systems has been running during the years 2005 and 2006. The instantaneous power and the quantity of produced energy were compared in the local conditions of the Prague – Suchdol. The results from the autumntime and wintertime are not assumed as objective because of short daytime and small angles range of the Sun moving cross the sky. Also the higher quantity of the produced energy in the local conditions of 50° north latitude in the case of the tracking system in comparison with the fixed system was observed during the spring and summer. The differences more than 30% in the amount of the produced energy were observed in sunny days. Fig. 4 shows examples of our measurements in the case of PV panels based on thin layers of amorphous silicon, Fig. 5 shows examples of our measurements in the case of PV panels based on monocrystalline silicon. There are graphs of the dependence of instantaneous power of compared PV panels on the daytime during the selected days. The produced energy is equal to the integral $E = \int_{\Delta t} P.dt$, where P is the instantaneous power and t is the daytime.

During the spring 2007 the research project ČEZ, a.s. “Zelená energie” (Green Energy) was started. We constructed and installed a larger PV system with tracking axle TRAXLE™ [2-4] and soft ridge concentrator [3-7] and reference panels with fixed stand. Soft ridge concentrator was developed in co-operation of the CULS Prague and fa. Poulek Solar, Ltd. and it was described in detail in the past [3-5] as well. The data collection started in the summer 2007. We expect the energy surplus up to 80% in the case of combination of the tracking axle and soft ridge concentrator in comparison with fixed panel. Fig. 6 shows this new PV system.

Conclusion

The solar PV systems were constructed and installed at the Czech University of Life Sciences Prague. There were tested both versions - on-grid, off-grid. Identical PV panels were compared in the on-grid version, one panel was fixed and the second panel was located on the tracking stand TRAXLE^{TM} developed in **Fig. 5**

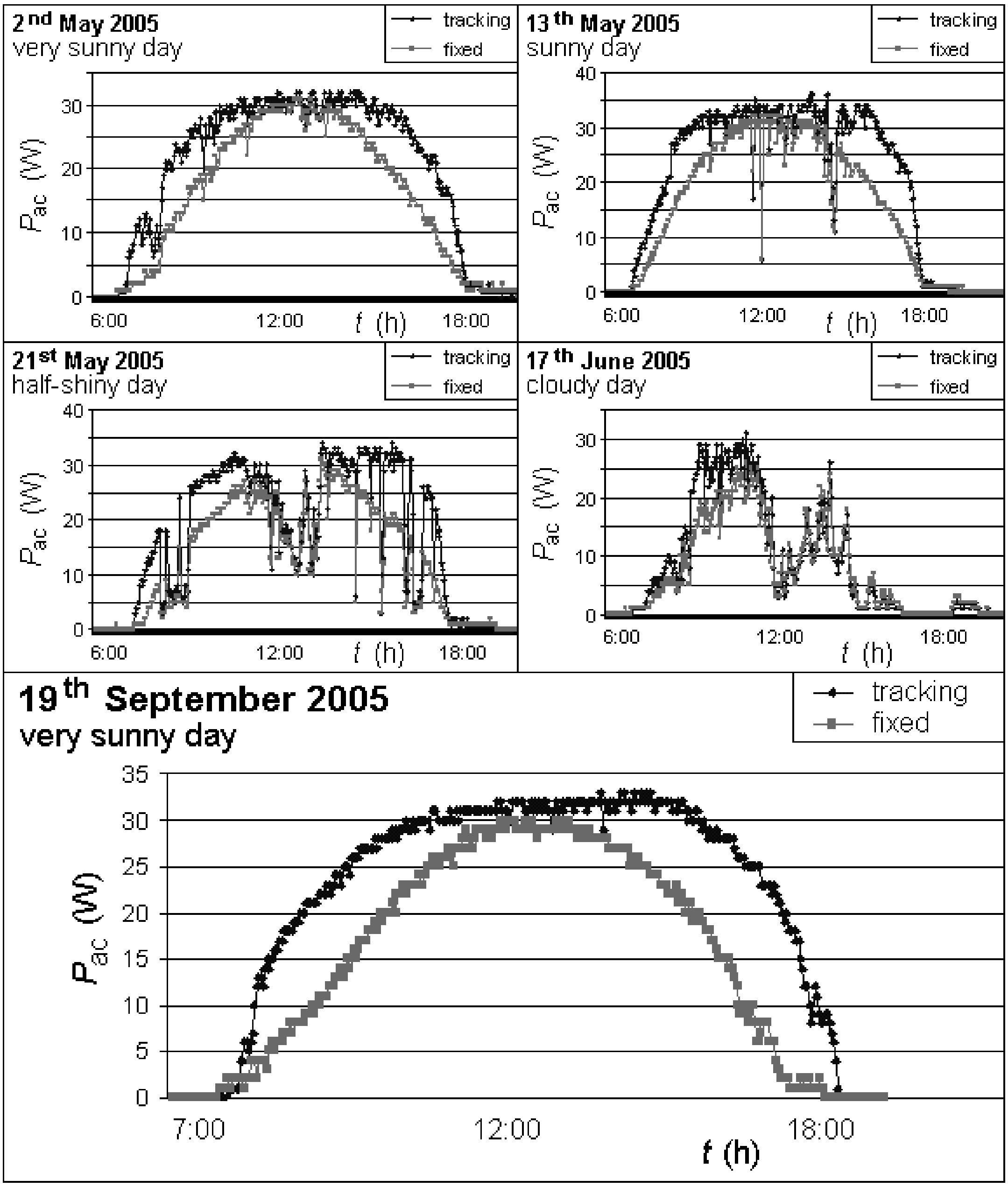

Fig. 4 Examples of our measurement during selected days in the year 2005. Dependences of the instantaneous power on the daytime for PV panels based on thin layers of amorphous silicon

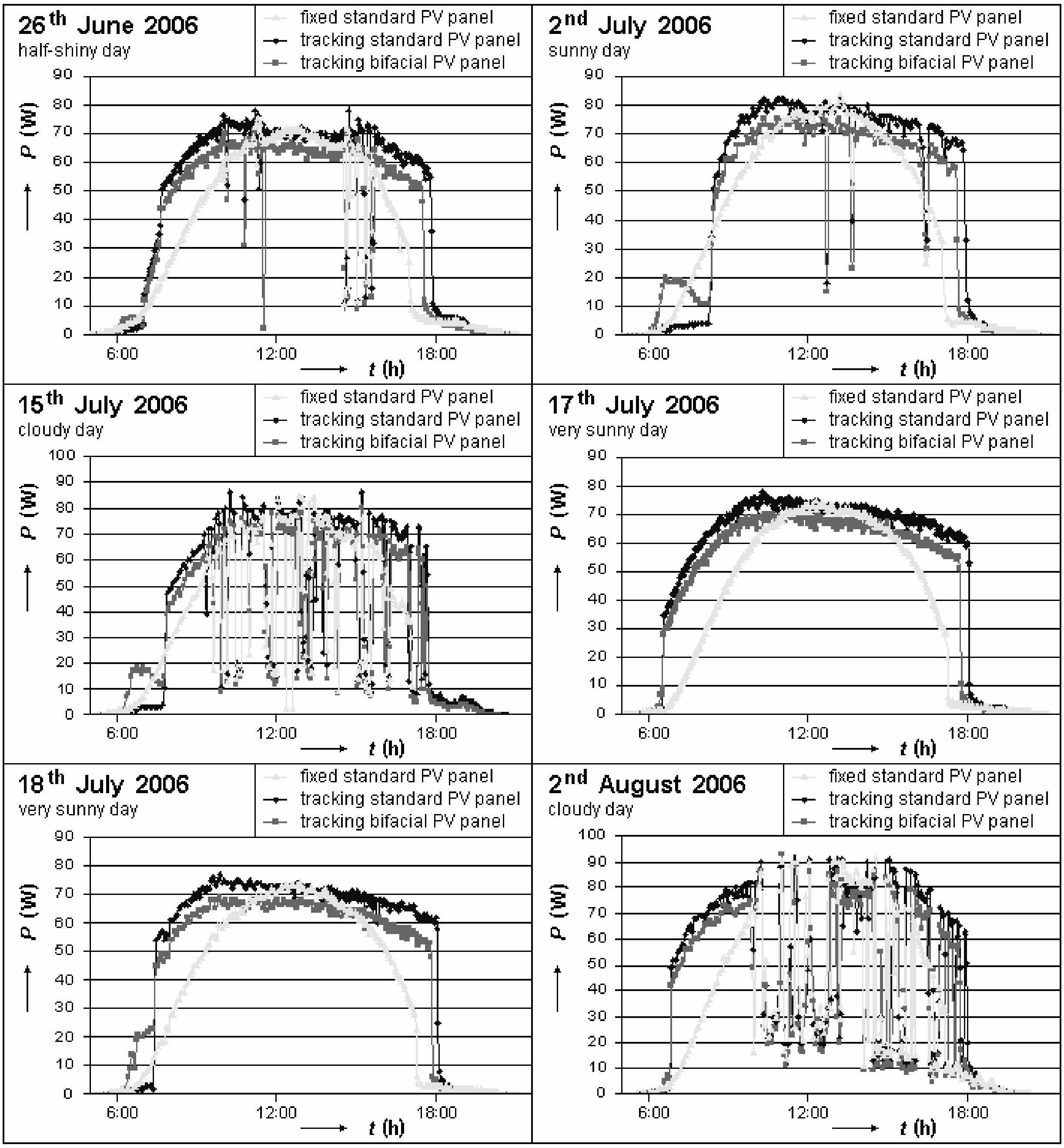

Fig. 5 Examples of our measurement during selected days in the year 2006. Dependences of the instantaneous power on the daytime for PV panels based on monocrystalline silicon. Cooperation of the CULS Prague and fa. Poulek Solar, Ltd.

The solar tracking system yields the energy surplus more then 30% during sunny days in the local conditions of Prague (50° of north latitude). Results of our experiments with the small PV solar system correspond with theoretical calculation [3-4].

The energy surplus corresponds with the lower price of the solar energy. Economic calculation shows, that the solar system with tracking stand is cheaper, when we compare two systems which produce the same amount of the energy - one system with tracking stand and one system with fixed stand. The tracking stand is more expensive than fixed, but we can save some PV panels, and the price of the PV panels is the most significant part of the price of the whole solar PV system [3].

The work is supported by research project ČEZ, a.s. “Zelená energie” (Green Energy).

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Fig. 6 The new PV system at the CULS Prague

THE ACCURANCIES RATING OF PARALLEL TRACKING ON THE FIELD

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The increasing economic cost in agriculture: Seeds price, chemical sprays price, mineral fertilizers price, fuels price, but the human labours price too have a main impact on the creation and on the development precision farming. Impact these factors is showing on the request of accurancy parallel tracking. It means decrease economic cost. The limit element by reached requested accurancy is the driver of farms machiner therefore are choosing the technique of navigation that are operated automatically or only with assisted of driver. The most widespread type steerage of farm machinery on the field is the satellite guidance. The accurancy is dependent on the automatizations level and on the quality DGPS. From the reached results is evident that the satellite guidance subserves requested criterions on the accurancy parallel tracking.

Keywords: DGPS, parallel tracking, accurancy

Introduction

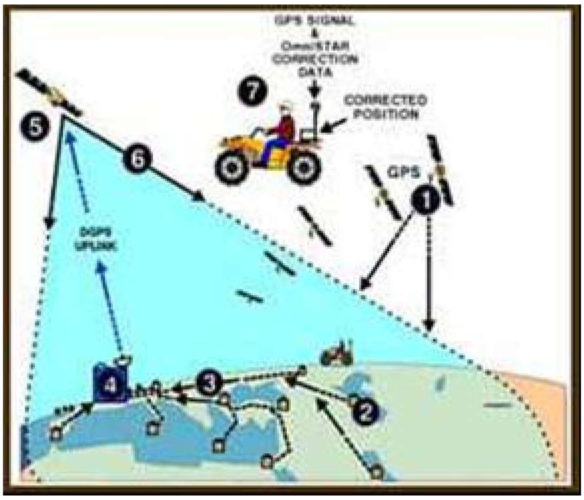
GPS is used for many purposes in Agriculture. Main aim is for regulation of regular increasing inputs. Mapping of fields, register of yield, application of variable ratio of fertilizers and seeds, local weeding, local soil loosening and switching of sprayer sections is leading to navigation by parallel tracking. These systems are continuously extending and improving up to the accuracy of ± 0,01 m. And are still occurring new opportunities to apply GPS in agriculture. Land management on level curves on ground of lowering the soil erosion, controlled transit on the fields with the aim of decrease the soil compaction and emissions of $CO2$ (Vermeulen, 2007). That is why the verification of navigation accuracy by the parallel tracking is the integral part of precision agriculture.

Material and Methods

Signal GPS OmniSTAR HP

Significant increase of positioning in real time accuracy is achieving with help of DGPS (Differential Global Positioning System). DGPS is method, which uses for calculation of position of unknown point the correction of referent station (Wilson, 2000). Improvement in location determination we could achieve with correction of position coordinates or with correction of apparent distance. Differential GPS eliminates small but still existing inexactitude of atomic clock in individual satellites, deviation in position on orbit and small signal alterations when spills through the ionosphere (Rapant, 1998).

Salve the company OmniSTAR features in the signal High Precision (HP) accuracy pass-to-pass 0,05 to 0,1 m in 95% of measurements. Vehicle with GPS antenna is receiving GPS signals from GPS satellites. OmniSTAR service has GPS receivers on known positions, that send over correction news to the control stations, These stations transmitting the news uplink to the geostationary satellite (OmniSTAR). Geostationary satellite (OmniSTAR) sending then te coretion news to the GPS antenna on the vehicle, which uses the correction (www.omnistar.nl).

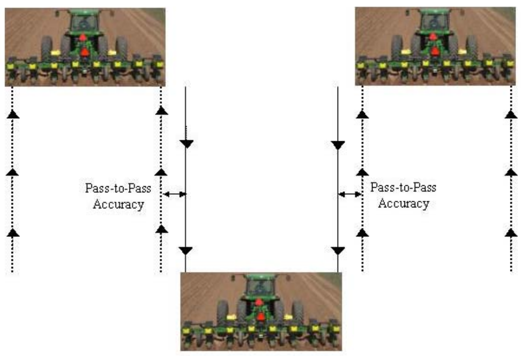


Picture 1The OmniStar DGPS system (www.omnistar.com)

1.GPS satellite net
2.Monitoring (referent) station
3.Sending the correction to the centre
4. Central Control Station
5.Geostationary satellite
6.Broadcast field of satellite
7.Recieving of DGPS and application in Real Time

Methods of verification of results

For objectively examination and post statistically evaluation of accuracy of working drive continuation is necessary to measure at least 36 values for every single measurement. Values are determinate by help of laser rangefinder with so called matrix method. This means to measure at least 36 values in virtual square with 6 measurement on the side. They are measured 6 working sections between 7 drives in the perpendicular direction to the working drives and in parallel direction another 6 measurements clear of each other of the distance of working section.



Picture 2 The Pass-to-Pass method

www.johndeer.com

The method of accuracy measurement of two next working drives sequence is called “pass-to-pass” method. This method service for measurement of next working drives pitch accuracy created by movement of working set on the field (Beel, 2000). It could by applied right after the working application, if there are visible trails after the drive through of working set or if there are visible other identification signs, such as trim lines by the seeding.

Other possibility of measurement is method “year-to-year”. This method represent repeatability of working drives, in this case it is after one year, where are measured the accuracy of present working drive and working drive done in the past, whereas the curve created in the past is saved into the navigation system And after peremptory time is this curve used for repeated navigation of the working set. Already from the definition of this method is obvious, that it longer time method. A main criterion for the continuous working drives accuracy is maximal and average absolute abnormality from the required drives pitch.

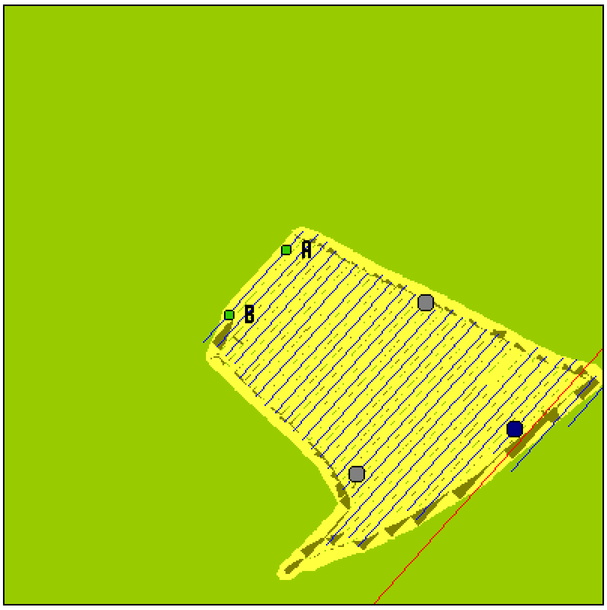
Other possibility of measurement is method for evaluation of continuing parallel drives accuracy could be examination of application maps. These maps created by parallel drives by help of GPS could serve for evaluation of accuracy of given device, but not for evaluation of accuracy of GPS signal. Resulting accuracy of working sets is compounded of other partial factors. Between the factors we could count the accuracy of DGPS signal, ability of automated operation to monitor certain curve (assisted operation, autopilot) or ability of driver to observe the given curve (manual light bars) and by navigation of working set mainly by tractors with carried or pulled tools, is it the clearance of connection pin. Whereas is DGPS receiver in stan-by connection with a energetic source (Tractor), is recorded on the application map only it´s movement. Application map is than only showing the accuracy of navigation tracking of the given curve. It is not showing the accuracy of DGPS signal not even precise movement of working set, that could move not only on the horizontal axis of energetic source, especially when moving on slopes.

Results and Discussion

The Mensuration has been design on working unit of the tracked tractor CAT MT780 and hitch-bar spreader KUHN. The tracked tractor was equipment automated GPS steering system Trimble AgGPS Autopilot HP that is modification for receiving differential signal OmniStar HP. The Manufacturer Trimble indicating the resulting accurancy (mensuration pass-to-pass method) ± 0,05 v 95 % of all measuring. The measured values, recorded in the Table 1, were obtained at work tracked tractor and spreader with setting implement witdth 30 m. On the field about area 45 ha was seeding the wheat.

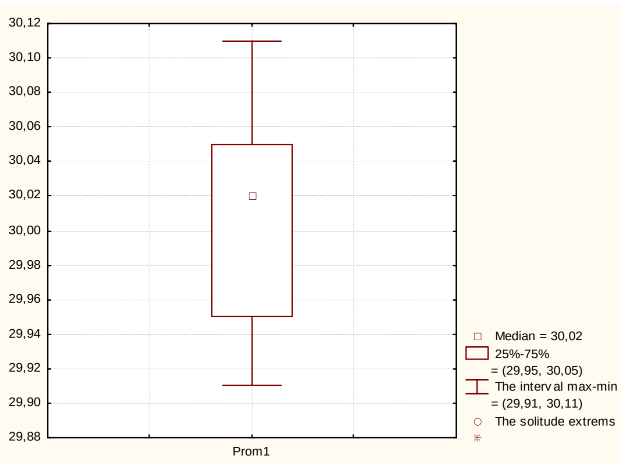
Table 1 The table of measured values

	The distance among single implement width					
	1.rut	**2. rut**	**3. rut**	**4. rut**	**5. rut**	**6. rut**
1. measuring	30,04	30,11	29,92	30,00	29,99	30,04
2. measuring	30,03	30,06	29,91	30,04	29,92	30,11
3. measuring	30,08	30,08	29,93	29,92	29,91	30,08
4. measuring	30,02	30,02	29,97	29,95	30,02	30,02
5. measuring	29,96	30,08	30,03	30,02	29,93	30,08
6. measuring	29,99	29,95	29,95	30,01	30,03	30,09



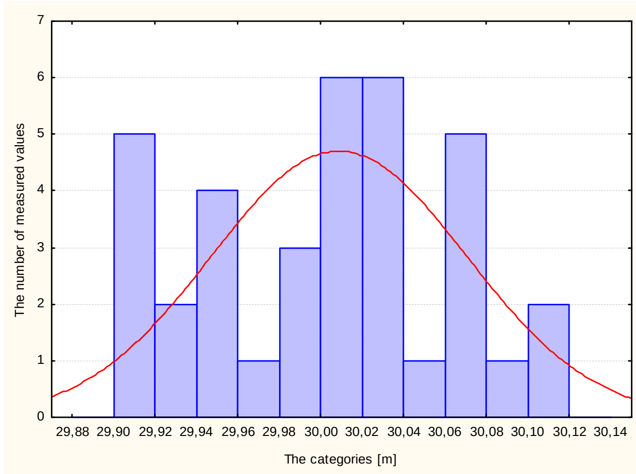
Picture 3 The aplications map CAT MT780 and spreader KUHN, Implement width 30 m

The measured values they are further statistically processed. From the table of the measured values, see Table 1, they are perceptible minimum swing from real implement width 30 m. The calculated value of the confidence level α = 0,05 indicating the confidence interval between 29,98739 and 30,02872 m in that shall find on 95- the percentual probability the arithmetic mean all mensuration.



Picture 4 The box diagram of measured values (Table 1)

The box diagram, the picture 4, indicating the medians value. This is the mean value measured funds. This value is 30,02 m. They are perceptible funds upper and lower quartile from the box diagram. The interval between them is from 29,95 to 30,05 m. The maximum value is 30,11 m and the minimum value is 29,91m.



Picture 5 The histogram of measured values (Table 1)

The picture 5 represent the histogram measured values. This is indicating the numerical substitution of measured values in singles distributions classes.

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Conclusions

The accuracy of the parallel tracking by the help of satellite navigation depend upon to many factor. If negotiation on navigation working on tenet assisted or quite automated steering system, we can neglect human factor. At these sort of steering systém the operator concentrats only on determination first ride and turning on headlands. The second factor is by herself the accuracy guidance system. We can divide this accurancy in the accuracy received signal DGPS (if need be RTK) and the accuracy system control of direction working unit. The last factor forms by herself working unit. The guidance systém is always linked with steering machinery, the tractor, the self-propelled sprayer, the harvester or the universal tool carrier. In these single machines are not the problems that can be caused by the working of the tractor with mounted, articulated or hitch-bar implements. These machines would be set according with the tractor in its horizontal axes, without major marks pin play in series. It goes the problem not only at older punishment implements, but also at working unit moving in contour lines. Even if is the steering machine equipment the compensation slope, the interfaced implements can trend skin down the gradients outside the horizontal axes of steering machine. All of these factor then forms the resulting accuracy guidance system used in the practice.

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SELECTED AGRICULTURAL WASTES FOR THERMAL UTILIZATION

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The main purpose of the article is to provide necessary information about the energy production from the heat processed of selected agricultural wastes. There are described ways of solid biomass and alternative standardized firings use such as fuels for heat power equipment.

In the framework of research project, analyses of thirteen selected agricultural wastes were done, especially in pellets. It means the possibility to use the wastes, solid biomass, and alternative and standardized firings as the fuels for heat power plants. Each analyze was followed by stoichiometric calculations as well as chemical composition and energy balance.

The choice ad design of combustion equipment is influenced by the fuel stechiometry and other fuel parameters such heating power, water content and energy density. Carried out analyses of selected samples are confirming the wide range of nitrogen, sulphur and chlorine concentrations in the wastes. Oxygen is a problematic part of the fuel because of hydrogen and partly carbon binding, creating hydrated oxides, water and other oxides. Oxides are mainly connected with nitrogen (N - in a form of amines and proteins contained in fuels) and chlorine. Chlorine oxides have interaction with conversion equipment especially with combusting equipment.

Key words: biomass, alternative fuels, agricultural wastes, elemental analyses, stoichiometric calculations

1 Introduction

C, H and O are the main components of solid biofuels and are of special relevance for the gross calorific value, H in addition also for the net calorific value. The fuel N content is responsible for NO, formation. NO, emissions belong to the main environmental impact factors of solid biofuel combustion. Cl and S are responsible for deposit formation and corrosion and are therefore relevant for high plant availability. Furthermore, Cl causes HCl as well as PCDD/F and S SO, emissions and both elements are involved in the formation of aerosols (submicron particle emissions). The ash content influences the choice of the appropriate combustion technology and influences deposit formation, fly ash emissions and the logistics concerning ash storage and ash utilization/disposal [1].

Water and ash matter are non-flammable parts of fuel, described as the ballast or deadwood. Both of them decrease heating power of fuel. Their presence has a direct effect on combustion equipment construction and they often cause some problems during operation.

A flammable part of the fuel consists of carbon, hydrogen, sulphur and nitrogen. Only carbon, hydrogen and sulphur are involved in exothermic reactions with air oxygen, i.e. in burning. Oxygen in fuels works as an oxidant and nitrogen is the only component which is not involved in burning [2,3].

All of the main three fuel components (water, ash matter and combustibles) are very important factors in combustion process. Their properties influence construction of combustion equipment as well s its operation regime.

Determination of elemental analyses, stoichiometric analyses, and emission parameters of selected wastes is carried out on compressed or loosely spread agricultural wastes. These can be compressed into the different shapes by using various pressures.

There are also used compressed materials in a form of pellets. If biofuels are not compressed, they take too much space and increase transportation, manipulation and storage costs. During firing, they reach a fast ignition and only a small amount of specific heat is transmitted. On the other hand, parameters of compressed biofuels are more profitable and they last longer in a hearth during combusting as compared to uncompressed fuels.

The solved problem has the worldwide importance due to the rapid increase of fuel use, renewable energy sources, and biomass. Solution will bring a definite classification and specification principles of using agricultural wastes. This classification and specification provide them acceptability on the fuels market and increase in public confidence. It also precipitates compulsory

Tab. 1 Agricultural wastes

Sample no.		Diameter (mm)
1	rye straw (pellets)	10
2	cultivated flax straw (pellets)	10
3	rape straw (pellets)	10
4	cereal straw and energy sorrel in a ratio 1:1 (pellets)	10
5	cereal straw and energy sorrel in a ratio 1:1 (pellets)	10
6	cereal straw and Phalaris arundinacea in a ratio 1:1 (pellets)	10
7	meat and bone meal (pellets)	20
8	cereal straw a rapeseed straw in a ratio 1:1 and treacle (pellets)	15
9	mustard straw (pellets)	20
10	cleaning cereals residues (pellets)	8
11	cleaning cereals residues and grass in a ratio 1:1 (pellets)	20
12	meat and bone meal and energy sorrel in a ratio 1:1 (pellets)	20
13	cereals cleaning residues and energy sorrel in a ratio 1:1 (pellets)	20

approval procedures, exchange of information about the use of solid biofuels and alternative fuels from renewable sources, and associated environmental problems.

When using the agricultural wastes for energy recuperation, it is necessary to accentuate ecology of operation of these plants. Therefore it is necessary to take the chemical composition analyzes, operation parameters, ash matter and stoichiometric calculations of the combustion equipment as a basis.

2 Material and Methods

A particle analysis of selected agricultural wastes was done within the framework of the research project. These agricultural wastes are described in table 1.

The elemental analysis was done for selected wastes in order to set the basic parameters of fuels. Mostly focused on: water content (weight %); ash matter (weight %); volatile and unvolatile combustibles (weight %); combustion heat ($MJ.kg^{-1}$); heating power ($MJ.kg^{-1}$); $CO_{2\ max}$ (weight %); carbon (weight %); hydrogen H (weight %); nitrogen N (weight %); sulphur S (weight %); oxygen O (weight %); chlorine Cl (weight %).

Particle composition of fuels has an influence on all stoichiometric calculations. These include heat efficiency, heat loss of combusting equipments, and other parameters. The mentioned parameters also have significant influence on thermal work of combusting equipment [4].

The fixed elemental analysis was set by the elementary analyzer multi-EA for determination of C, N, S and Cl (producer ChromSpec), by chromatograph GC-MS for detection of combustible components (producer Perkin Elmer), and calorimeter IKA-C4000 (producer IKA Laboratory and Analytical Equipment) for determination of combustible heat and heating power samples. Final values are presented in table 2.

An important task of the article is to set agricultural wastes stoichiometric. Stoichiometric calculations of combustion processes are supplementing fuel's characteristics and are also foundation for any heat calculation. These are very important for heat system design problems solving as well as during the heat equipment control.

Following parameters are set by calculations:

- fuel heating power
- theoretical amount of oxygen and air necessary to ideal combusting real air amount of ideal combustion,
- mass and volume amount of waste gases (wet and dry),
- theoretical amount of mass and volume dry waste gases,
- mass and volume amount of CO2, SO2, H2O, N2, O2 and Ar,
- theoretical weight and volume concentration of CO2 and SO2 in dry waste gases,
- each waste gas particle, explicated in % weight and vol.

Agricultural wastes heating power is set by calculation based on the measured combustion heat and elemental analyses. Combustion heat is measured in calorimeters [5].

Stoichiometric calculations are recalculated by the weight of total water amount contained in selected samples. Values are also recalculated by the air surplus coefficient for normal conditions (at the temperature t = 0oC and pressure p = 101.325 kPa) as well as for the referential oxygen amount in combustibles Or = 11 %.

Tab. 2 Final values of selected agricultural wastes elemental analyses

Sample no.	W^r_t	A^r	V^r	$(NV)_r$	Q^d_s	Q^r_i	CO_{2max}	C^r_t	H^r_t	N^r_t	S^r_t	O^r_t	Cl^r_t
	% vol.				MJ.kg^{-1}		% vol.						
1	6.47	7.75	85.81	-	16.6	15.38	20.75	40.99	4.87	0.51	0.07	39.11	0.22
2	7.97	2.35	74.57	14.96	17.68	15.84	19.22	40.62	7.57	0.7	0.057	41.61	0.007
3	9.37	4.98	68.85	16.8	16.70	15.34	20.57	41.38	5.2	0.57	0.11	38.09	0.149
4	5.02	7.48	71.20	16.30	17.21	15.95	20.10	41.88	5.35	0.65	0.12	39.40	0.10
5	5.29	6.74	71.48	16.49	17.41	16.1	19.74	42.96	5.42	0.67	0.11	38.70	0.11
6	5.64	8.14	70.65	15.57	17.03	15.65	19.78	41.95	5.71	0.68	0.09	37.65	0.14
7	7.33	19.90	63.56	9.21	17.75	16.31	18.95	41.32	6.63	8.85	0.66	14.93	0.38
8	7.66	7.27	69.99	15.08	16.57	15.08	19.25	42.24	5.99	0.95	0.14	35.55	0.20
9	7.69	7.50	68.29	16.52	17.32	15.82	19.01	43.10	6.05	1.48	0.13	33.96	0.09
10	8.33	6.49	71.16	14.02	17.86	16.25	18.3	42.62	6.48	3.67	0.16	32.05	0.20
11	8.49	9.5	66.63	15.38	16.54	15.04	18.47	41.02	5.95	1.44	0.13	33.37	0.10
12	8.86	12.39	65.10	13.65	17.36	15.94	16.12	42.82	6.53	4.79	0.48	23.89	0.24
13	10.69	5.59	64.53	19.19	16.09	14.69	18.30	42.57	6.44	1.36	0.21	33.01	0.10

Parameters of elemental analyses.

W^r_t – water kontent; A^r – ash matter; V^r – volatile combustible; $(NV)^r$ – involatile combustible; Q^d_s – combustion heat; Q^r_i – heat power; CO_{2max} – carbon dioxide; C^r_t – karbon; H^r_t – hydrogen, N^r_t – nitrogen; S^r_t – sulphur; O^r_t – oxygen; Cl^r_t – chlorine

3 Result and Discussion

The most determining factor of thermal use of fuels is water and ash matter content. Water content in wastes ranged from 5.02 weight % in cereal straw and energy sorrel mixture up to 10.69 weight % of total water in cereals cleaning residues and energy sorrel.

Ash matter is other non-flammable component. Ash matter is a solid residue, obtained by ideal burning of solid fuel at the temperature of 800 ± 25°C in oxidizing atmosphere. The ash matter content is low, as can be seen from elemental analyses (tab. 2). Plant trash has the lower content of ash matter than the brown coal – by 86 % less. It has the following positive effects: the amount of solid ash particles emission during burning is smaller and the amount of solid residues is also significantly smaller. The smallest amount of ash matter was obtained by the burning of cereal purification residues and sorrel mixture. The highest amount was obtained by the burning of fermentation sediments with biomass. These large fluctuations in water and ash matter contents are significant characteristics of selected wastes. The other differences of fuels are obvious from table 2. Especially amounts of volatile and involatile combustibles, carbon, nitrogen, oxygen, and frequently discussed chlorine. These differences in fuels compositions influence both the use and the setting of combustion equipment.

From the results of stoichiometric analysis (tab. 3), the differences in air consumption and in the amounts of produced dry emissions, when burning selected wastes, are obvious. Most significant emission factors are sulphur and chlorine amounts, contained in selected agricultural wastes.

Significantly high increase of nitrogen emissions can be seen at the mixed wastes based on plant biomass since. These energy plants have higher values of nitrogen (N^r_t) in the fuel. This is a cause of their limited use. Also the most of chlorine amount comes to vapor phase during combusting. This element is causing HCl emission production and their possible proposition to the polychlorinated dibenzo-dioxines as well as furans (PCDD/F) production. On the other hand chlorine contained in the plants causes then a corrosive effect of thee elements as well as their compounds.

Sulphur (S^r_t) comes to vapor phase as SO_2 or SO_3. At the case of biomass combustion equipments sulphur emissions are not a problem in the meaning of their limiting value. A decisive factor is corrosive action of sulphur.

Tab. 3 Final values of the individual combustion components

Sample no. (1)	Combustion components									
	volume concentration of volume amount of wet burnt gas elements					volume amount of burnt gas elements				
	CO_2	SO_2	H_2O	N_2	O_2	v_{CO2}	v_{SO2}	v_{H2O}	v_{N2}	v_{O2}
	% vol.					$m^3N.kg^{-1}$				
1	8.92	0.01	10.84	69.61	9.80	0.76	0.00	0.93	5.95	0.84
2	7.53	0.00	12.90	69.03	9.72	0.75	0.00	1.29	6.93	0.98
3	8.61	0.01	11.33	69.45	9.78	0.77	0.01	1.01	6.21	0.87
4	7.04	0.01	9.56	70.78	11.78	0.78	0.00	1.06	7.84	1.31
5	6.98	0.01	9.47	70.91	11.80	0.80	0.00	1.08	8.12	1.35
6	6.78	0.01	9.74	70.85	11.79	0.78	0.00	1.12	8.17	1.36
7	5.45	0.03	9.53	72.20	11.94	0.77	0.01	1.35	10.20	1.69
8	6.54	0.01	9.96	70.86	11.79	0.79	0.00	1.20	8.52	1.42
9	6.47	0.01	9.82	71.05	11.82	0.80	0.00	1.22	8.82	1.47
10	6.19	0.01	10.05	71.11	11.81	0.80	0.00	1.29	9.12	1.52
11	6.42	0.01	10.08	70.87	11.79	0.76	0.00	1.20	8.43	1.40
12	5.85	0.02	9.79	71.62	11.88	0.80	0.00	1.33	9.77	1.62
13	6.24	0.01	10.30	70.83	11.78	0.79	0.00	1.31	9.00	1.50

The choice and design of combustion equipment are influenced by the fuel stoichiometry and other fuel parameters, such as heating power, water content, and energy density. Analyses of selected samples confirm a wide range of nitrogen, sulphur, and chlorine concentrations in the wastes. Oxygen is a problematic part of the fuel, because of hydrogen and partly carbon binding, creating hydroxides, water, and other oxides. Oxides are mainly connected with nitrogen (in a form of amines and proteins contained in fuels) and chlorine. There is an interaction of chlorine oxides with conversion equipment, especially with combusting equipment [5, 6].

Humidity affects the combustion process and volume of waste gases produced per energy unit. Generally could be stated that the amount of wooden pellets should not exceed 30 %. In the case of straw, 20 % humidity is acceptable, however, the smaller is the combusting equipment, the drier fuel has to be used. Problems arise during a long-term storage of wet biofuels as well as self-ignition of wooden pellets with humidity over 27 %. This feature is connected with the loss of dry matter, energy value, and risk of fungi. If the average humidity of straw exceeds 17 %, there is a high risk of local achievement of organic powder, endotoxins, and excess mycoses [2].

It is necessary to obtain ideal burning conditions during combustion process to use the agricultural waste as alternative fuels in combustion equipments. Combusting of energy plants is not effective if these conditions are not satisfied. Therefore it is necessary to burn just the fuels specified by structure, sort, and quality. It is also necessary to pay permanent attention to these aspects.

In a long time perspective of sustainable development, it is very important to make use of such energy sources as effectively as possible. Also the use of financial sources should be, of course, optimized in order to limit – if it is possible, harmful effects on human health and environment. It also works for creating surplus for all parts of the world population.

In a medium time perspective, the greenhouse gas emissions, produced by human activities, influence climatic changes. These changes should be determined by a suitable method. There still exists also the impact of short time effects e.g. upon protection of energy supply.

4 Conclusion

All of the assorted fuels from the agricultural wastes have different structural parameters. It is mostly caused by different concentrations of particle composition. Presence of water content and ash matter are resulting from the elementary analysis and negatively influence the stoichiometric calculations. According to the results, the most important factors are brimstone, nitrogen and chlorine quantity in wastes, because of their influence to the final values of emissive concentrations. Main task of current activities at the research field is to set ways to decrease air pollution. Solving of this up-to-date problem contributes to emission reduction and in this way also to air pollution reduction. Most significant emission factors are sulphur and chlorine amounts, contained in selected wastes.

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NEW TRENDS IN ENERGETIC UTILIZATION OF RAPE OIL METHYL ESTERS

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Biodiesel has become a fast growing renewable liquid biofuel within the European Community. In order to ensure customers acceptance standardization and quality assurance is the key factor to the market introduction of biodiesel as a transport and heating fuel. Rapeseed-oil-methyl-ester was the first type of biodiesel fuel produced commercially in 1988, characterized as a single-feed-stock product of then questionable quality.

The paper is aimed at determining the stoichiometry of the burned rapeseed oil methyl-esters: rape straw, rapeseed oil, methylester. In this paper, further possibilities of the power exploitation will be explored of nontraditional rapeseed oil methyl-esters in the combustion equipments for classical liquid fuels.

Every stoichiometric calculation are recalculate in accordance with all water in original fuel for standard conditions (temperature t = 0 °C and pressure p = 101,325 kPa) and on referential content of oxygen in combustion gas according to standard specifications for every sort of burned fuel.

Liquid biofuels from production of methyl-esters oil in comparison with Diesel fuel has a positive influence over environment. Liquid biofuels from production of methyl-esters oil demonstrate essentially better characteristics in emissions of CO_2 and SO_2. Reasonably it has only higher emissions of N_2. Therefore FARME produces during combustion markedly lower content of carcinogenic polycyclic aromatic hydrocarbons. FARME does not contain practically brimstone and thereby evidently helps to reduce its content as a component in blended fuels.

Key words: biofuels; heating power; stoichiometric calculation; quantity of air; quantity of oxygen

1 Introduction

Rapeseed oil crushed from 00-rapeseed varieties was the first type of vegetable oil used for transesterification and rather by chance this oil is highly suitable for production of quality Biodiesel - with a content of approximately 60 % monounsaturated oleic-fatty-acid and only approximately 6 % saturated fatty-acids it shows both good stability and winter operability. New varieties are reaching even higher levels of up to 87 % oleic-fatty-acid. This type of rape-seed (or Canola) is still by far the biggest source of feedstock for Biodiesel production, and has become even more interesting as rapeseed breeders have succeeded in improving yield levels of up to 2,9 ton oil.ha^{-1} when applying „precision farming“ (1, 2).

The Czech Republic completed a program to establish 16 biodiesel plants, making this country the leading one in number of production sites. In 1992 was started realization of the “Oleoprogram” supported by the state subsidy solving complex utilisation of rape for biodiesel, i.e. alternative fuel for Diesel engine, production. The general whole-social effects of this program are based on acquisition of new renewable source, favorable influence of new alternative fuel introduction onto environment and agricultural production re-structuralisation. In the initial years of this program were granted returnable loans of the Ministry of Agriculture of the Czech Republic (MZe CR) for creation of technical background for rape oil methylesters (FARME). Total extension of there financial means represents 721,54 mill. CZK. In this framework was supported, as said before, 16 of initial 18 subjects which finished the plant construction and their production capacity has reached 63,5 thousand tons.year^{-1} of FARME. From these results are possibilities to work-up 180 – 200thousands tons of rape from about 70 – 80thousands ha of growing area. In the table 1 is presented survey production, export and consumption of FARME in the Czech Republic within 1995 – 2006. Due to subsidy of rape non-food utilisation from the MZe CR budget, there was in 2000 first time fully utilized the processing capacities and 67,2 thousands tons of FARME was produced, of which 93 % with the state subsidy (3, 4, 5).

Table 1 Summary of production, export, import and consumption of methyl esters in the Czech Republic in 10^3 tons

Index	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006 I.-IX.
Production in CR	19,3	27,6	15,7	30,63	67,2	71,1	104,4	113,5	85,142	126,892	85,082
Export from CR	3,2	1,5	0,08	0,03	0,072	22,4	31,3	43,5	41,63	131,532	86,762
Import to CR	8,7	11,4	25,8	20,2	3,2	2,9	0,04	0,06	3,122	7,812	8,082
Total consumption in CR	24,8	37,5	41,4	50,77	70,4	51,6	73,06	70,06	46,63	3,17	6,40

Nowadays in the Czech Republic are in operation 16 production plants of rapeseed methyl esters, they are able to produce (if we consider 3 shifted operations, 330 days in year) about 150 000 tons of rapeseed methyl esters. Of which to the 14 plants of the 13 business subjects of the State agricultural intervention fund (SZIF) have a license for production of standardized rapeseed methyl esters. 70 % of production capacity is centralized in three processing plants:

- 39 000 tons SETUZA, joint-stock company, subsidiary Olomouc
- 13 000 tons SETUZA, joint-stock company, subsidiary Mydlovary
- 55 000 tons AGROPODNIK, joint-stock company, Jihlava – Dobronín
- Other are plants with capacity from 2 000 – 20 000 tons per year

The FARME share consumed in the Czech Republic in 2002 is 2,74 % on total consumption of motor diesel fuel (2,66 mill. tons). In last year it was about 2,5 %. It is real to reach in 2004 the share of standardized FARME 3 % of total consumption of motor Diesel fuel. It means with regard to motor Diesel fuel consumption in 2002 amount of about 85 000 tons of FARME with quality according (6, 7).

From the medium-time view is thus real to increase production to 120 000 tons and further to 170 000 tons of FARME. In case of rapeseed oil utilization as feedstock it represents about 450 000 tons of rapeseed. The rapeseed production in Czech Republic without agronomic problems could be about 1 mill. tons. Production costs of FARME are dependent on price of income material (rapeseed) and realization price of groats and press cakes from rapeseed. From the year 2000 was stabilized the price of rapeseed for its producers in CR. The price of rapeseed bought out by SZIF from farmers was set up in business year 2002/2003 on the rate 6 991,304 CZK per ton and for business year 2003/2004 on the rate 7 200 CZK per ton. Since 1.10.2001 is valid the rapeseed quotation for rapeseed methyl esters production. The scope of this program is to obtain from the “set-aside land” 230 000 tons of rapeseed what is a limit amount supported by the Government for processing to rapeseed methyl esters. The presumption is that from 1 ton of rapeseed is produced 0,3125 ton of rapeseed methyl esters. The rapeseed obtained from the “set-aside land” is sold by SZIF of lower price to rapeseed methyl esters producers under stipulated conditions. The formula for the rapeseed price for “set-aside land” rapeseed was constructed in such manner in order the customer price of resulted product – Biodiesel, is by 5 % - 10 % lower compared with the motor Diesel price (7, 8).

The present market is simply dominated by fossil Diesel a 100 % and this is the competitive product to be replaced. Having with Biodiesel on the one hand a product, which at its best can grow to approximately an 8 % market share anyway, but on the other hand an environmentally friendly fuel, which shows clear and substantial differential advantages, it is a job of professional marketing to screen all the market segments carefully and define those niches in which the distinctive benefits of Biodiesel are needed most, fully recognized by the customer and valued. Additionally environmentally driven regulations, e.g. limitation on certain emissions, regulations for minimum biodegradability, laws for zero-toxicity to water-life, can carve out specific market segments, in which only Biodiesel fulfils the rules and can obtain a dominant market position. In spite of these market opportunities there exist strategies of blending Biodiesel with fossil Diesel (e.g. France), where the end user is not able to recognize the product and hence also not at all its differential advantages (9).

The Directive 2003/30/EC on assurance of biofuels or other renewable fuels for transport utilization was published in May 2003 by European Parliament and Council. Despite this is only directive with less binding impact but unambiguously specifies needs which have to be achieved in share of biofuels and fuels from renewable sources in comparison with those used in transport (2, 9).

Table 2 Biofuels (FARME) production, motor Diesel fuel and gasoline sale in CR – the basic data for period of 2006 – 2010 according to their energy content

Data	Specific unit	Year outlook		
		2006	2007	2010
FARME production	103 tons	175	200	300
	103 tons	142,1	162,4	243,6
Biospirit production	103 tons	-	158	220
	103 tons	-	94,8	132
Motor Diesel fuel sale in CR	103 tons	3750	3900	4050
	103 tons	3881,3	4036,5	4191,8
Motor gasoline sale in CR	103 tons	2360	2410	2470
	103 tons	2525,2	2578,4	2642,9
Motor fuels sale in CR (motor Diesel + motor gasoline)	103 toe	6406,5	6615,2	6834,7
FARME share of motor Diesel sale in CR	% (of energ. content)	3,66	4,02	5,81
Biospirit share of motor gasoline sale in CR	% (of energ. content)	-	3,68	4,99
Biofuels share of amount of fossile fuels on market	% (of energ. content)	2,22	3,89	5,49

2 Materials and Method

Taking a longer-term perspective, biofuels can be seen as one of a number of stepping stones towards sustainability, by introducing renewable components into the fuel pool. To achieve this, flexibility should be the goal, with engines increasingly able to operate effectively with the evolving mix of prospective biofuels and fuel suppliers becoming increasingly adept at delivering fuels derived from a wider range of sources. To ensure that fuels and engines continue to operate to their optimum in the future, the same degree of attention must be paid to potential biofuel components as has been paid to refinery streams over many decades. Appropriate controls and constraints will also be necessary to ensure that consumers continue to enjoy confidence in the quality of fuels supplied by the oil industry (10).

Different possibilities are considered to utilize the rapeseed oil methyl-esters as fuel for the combustion equipments. Such problems are of significant importance in view of the continually increasing needs for the fuels, renewable sources of energy and biomass. Great emphasis must be put on meeting the stringent environmental standards of the combustion processes. The assessment starts from the chemical composition of the employed fuels, stoichiometric computations, and operational parameters of a given type of the combustion equipment.

Methylester acids of rape oil are chemically distinguishing from crude oil products, but its density, viscosity, heating power and combustion process are very near to Diesel fuel. Among flexible factors that are influencing mostly the heating work of combustion establishment, stoichiometric of fuels, massic flows and emissions factors, belongs in practice coefficient surplus products of combustion air and content of all waters in fuel. By finding of basic stoichiometric fuel properties is possible to choose most effective, to propose or to check up the work of under consideration combustion establishments. The basis of every calculation of combustion equipment heat work rests in the fuel elementary analysis. Elementary composition of fuels affects all the stoichiometric computations, computations of heat efficiency and losses of combustion equipment, and it significantly affects heat work of combustion equipment. Elementary composition of solid fuels is determined by so-called elementary analysis, which finds out mass ratio (in a percentage) of carbon, hydrogen, oxygen, sulfur, nitrogen, and all water in original fuel.

The examples of Elementary analysis are in table 3, for comparing there are 5 types of fuels. An elemental analysis was done for selected samples in order to set basic parameters of fuels. Mostly focused on: water content (weight %), ash matter (weight %), carbon (weight %), hydrogen H (weight %), nitrogen N (weight %), sulphur S (weight %) and oxygen O (weight %). The fixed elemental analysis was set by the elementary analyzer multi-EA for determination of C, N and S (producer ChromSpec), by chromatograph GC-MS for detection of combustible components (producer Perkin Elmer), and calorimeter IKA-C4000 (producer IKA Laboratory and Analytical

Table 3 Elementary analysis of choice solid and liquid fuels

		Unit	Brown coal Bílina Benekov	Rape straw	Diesel fuel	Rapeseed oil	Methylester
C	Massic part of carbon in original feed	weight %	61,43	41,38	86,50	77,70	76,90
H	Massic part of hydrogen in original feed	weight %	4,79	5,20	13,00	11,60	12,20
O	Massic part of oxygen in original feed	weight %	1,645	38,09	0,0	10,60	0,01
S	Massic share of sulphate in original feed	weight %	0,29	0,11	0,11	0,0	0,11
N	Massic part nitrogen in original feed	weight %	0,81	0,57	0,0	0,0	0,0
W	Volume of all water in original feed	weight %	9,94	9,37	0,01	0,75	0,10

Equipment) for determination of combustible heat and heating power samples. The elemental analysis of the samples were converted to values to normal conditions (temperature t = 0^{o}C and pressure p = 101.325 kPa).

Determination of massic and volumetric amount of separate emissions concentrations of combustion gas is necessary for other analytical appreciation. Stoichiometric calculations of separate emissions concentrations of combustion gas are forming the state in a given concrete combusted fuel.

Results of stoichiometric calculations are:

- Heating power
- Combustible heat
- Quantity of air
- Quantity of oxygen
- Quantity of combustion gas (moist, dry)
- Resulting formulation of separate components of combustion gas

Samples heating power is determined by calculation based on measured combustion heat and elemental analyses. Combustion heat is measured by calorimeters (accordingly to ČSN ISO 1928 Solid mineral fuels - Determination of gross calorific value by the bomb calorimetric method, and calculation of net calorific value, ČNI, 1999). Every stoichiometric calculation are recalculate in accordance with all water in original fuel for standard conditions (temperature t = 0 ^{o}C and pressure p = 101,325 kPa) and on referential content of oxygen in combustion gas according to standard specifications for every sort of burned fuel.

3 Result and Conclusions

Final stoichiometric analyses values (tab. 4) indicates very good thermal – emission parameters of tested samples of liquid materials sourced from methylesther rape seed oil with the exception of rape seed oil itself. Tested sample of rape seed oil has brought up high ash content in a fuel already during a determining of a particle analyses. Lower hating power of rape seed oil, caused by ash content, was proven in stoichiometric analyses (tab. 3).

In order to other possible thermal usage of rape seed oil is necessary to adjust a combustion equipment to higher fuel input and also reset other operation parameters of device. The other possibility of rape seed oil is to form a mixture with a fuel with higher value of heating power. In following part of work is done an analysis of flue gases thermal – emission concentrations and thermal – technical efficiency of laboratory tested samples.

The choice and design of combustion equipment are influenced by the fuel stoichiometry and other fuel parameters, such as heating power, water content, and energy density. Analyses of selected samples confirm a wide range of nitrogen, sulphur, and chlorine concentrations in the wastes. Oxygen is a problematic part of the fuel, because of hydrogen and partly carbon binding, creating hydroxides, water, and other oxides. Oxides are mainly connected with nitrogen (in a form of amines and proteins contained in fuels) and chlorine. There is an interaction of chlorine oxides with conversion equipment, especially with combusting equipment (11, 12).

FARME in comparison with Diesel fuel has a positive influence over environment. FARME demonstrate essentially better characteristics in emissions of CO_2 and SO_2. Reasonably it has only higher emissions of N_2. Therefore FARME produces during combustion markedly lower content of carcinogenic polycyclic aromatic hydrocarbons. FARME does not contain practically brimstone and thereby evidently helps to reduce its content as a component in blended fuels.

Table 4 Resulting values of stoichiometric calculations of fuels

Stoichiometric calculations of representative fuels							
		Unit	Brown coal Bílina Benekov	Rape straw	Diesel fuel	Rapeseed oil	Methylester
Q_n	Heating power fuels according to ČSN 44 1352	$MJ.kg^{-1}$	24,69	15,34	42,49	34,94	37,03
Q_v	Combustible heat	$MJ.kg^{-1}$	25,98	16,705	45,33	37,50	39,70
Cubical combustion process							
O_{min}	Theoretical quantity of oxygen for ideal combustion process	$m^3N.kg^{-1}$	1,298	0,794	2,335	2,019	2,112
L_{min}	Theoretical air quantity for ideal combustion process	$m^3N.kg^{-1}$	6,182	3,783	11,120	9,612	10,056
L_{skut}	Real air quantity for ideal combustion process	$m^3N.kg^{-1}$	11,127	7,982	13,344	11,534	12,067
n	Overflow of the air		1,80	2,11	1,20	1,20	1,20
v^v_{sp}	Cubical quantity of moist combustion gas	$m^3N.kg^{-1}$	12,077	8,974	14,593	12,717	13,222
v^s_{sp}	Cubical quantity of dry combustion gas	$m^3N.kg^{-1}$	10,976	7,961	12,614	10,957	11,382
v^s_{spmin}	Theoretical cubical quantity of dry combustion gas	$m^3N.kg^{-1}$	5,972	3,725	10,284	8,943	9,276
v_{CO2}	Cubical quantity CO_2	$m^3N.kg^{-1}$	1,142	0,770	1,608	1,444	1,430
v_{SO2}	Cubical quantity SO_2	$m^3N.kg^{-1}$	0,002	0,001	0,001	0,000	0,001
v_{H2O}	Cubical quantity H_2O	$m^3N.kg^{-1}$	1,101	1,014	1,979	1,760	1,840
v_{N2}	Cubical quantity N_2	$m^3N.kg^{-1}$	8,691	6,235	10,415	9,003	9,419
v_{O2}	Cubical quantity O_2	$m^3N.kg^{-1}$	1,039	0,882	0,467	0,404	0,422
v_{Ar}	Cubical quantity Ar	$m^3N.kg^{-1}$	0,102	0,073	0,123	0,106	0,111
Representation of separate components of combustion gas in % ob.							
CO_{2max}	Theoretic cubical concentration of oxide carbonic in dry combustion gas	%	19,07	20,60	15,60	16,11	15,37
SO_{2max}	Theoretic cubical concentration of oxide sulphurous in dry combustion gas	%	0,03	0,02	0,01	0,00	0,01
CO_2	Carbon dioxide	%	9,46	8,58	11,02	11,36	10,81
SO_2	Sulfur dioxide	%	0,02	0,01	0,01	0,00	0,01
H_2O	Water	%	9,12	11,30	13,56	13,84	13,91
N_2	Nitrogen	%	71,96	69,47	71,37	70,79	71,23
O_2	Oxygen	%	8,60	9,83	3,20	3,17	3,19

Taking a longer-term perspective, biofuels can be seen as one of a number of stepping stones towards sustainability, by introducing renewable components into the fuel pool. To achieve this, flexibility should be the goal, with engines increasingly able to operate effectively with the evolving mix of prospective biofuels and fuel suppliers becoming increasingly adept at delivering fuels derived from a wider range of sources. To ensure that fuels and engines continue to operate to their optimum in the future, the same degree of attention must be paid to potential biofuel components as has been paid to refinery streams over many decades. Appropriate controls and constraints will also be necessary to ensure that consumers continue to enjoy confidence in the quality of fuels supplied by the oil industry.

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DEVELOPMENT OF FOREIGN LANGUAGE AND COMMUNICATION COMPETENCES AT THE LATVIA UNIVERSITY OF AGRICULTURE

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After the accession of Latvia to the European Union, the processes of integration and globalization have become very fast. In order to get a good job and make professional career the graduates from the university should be equipped with a definite set of competences. Besides the professional skills, the foreign language and communication skills play a very important role. They are very important to ensure the professional career of a person and to be competitive in the open market conditions as in many instances students leaving the University enter jobs that require them to work in close co-operation with other people. At the Faculty of Engineering English is taught to the students only for one or two years depending on what program they have chosen. The amount of the English sessions is not enough to master the language and be able to communicate successfully.

Keywords: communication, competence, learning, English, culture

1 Learning of foreign languages at the Faculty of Engineering

Long experience working at the Latvia University of Agriculture has shown that the level of the students in knowledge of foreign languages differs greatly. Every group of students is of mixed ability. Even in an apparently homogeneous group we can find that students' abilities, interests and talents vary a great deal. It is very clearly expressed at the Faculty of Engineering as the students come to study at this faculty from different parts of the country. We have noticed that the students who have finished schools in big cities have more developed foreign language skills that the students who come from the countryside. One of the reasons for this difference could be the possibility for the young people in big cities to participate in several extra curriculum activities or international projects, or simply more opportunities to communicate with people from other countries who speak English.

At the Faculty of Engineering the students have only two or one and a half sessions per week. It is not enough to learn new skills, train and master the existing ones. The traditional process of teaching and learning cannot ensure the development of the necessary skills in this sphere as it does not supply the students with these skills sufficiently. The extension of the study programme or the time of studies also cannot ensure the necessary educational results. So the study process should be organized in the way that the students get motivated and interested in the knowledge the acquisition of which is organized by the teacher. One of such ways at the Latvia University of Agriculture is an extra curriculum activity the English Club that serves as a means of communication between people of different countries. It offers a possibility for the attendants to get to know different cultures and their traditions. The purpose of the English Club is to motivate students to learn English through widening of their knowledge and experience level, satisfy the cognitive interests of students, develop their mental activity, and provide the opportunities to use their knowledge and skills in communication.

2 The process of communication

Communication requires a need to learn new unknown words and offers a possibility to use these words not isolated but in the context of the foreign language and system. Communication can be considered as a personal process that involves the transfer of information and also involves some behavioural input. Communication is something people do. It does not exist without people taking some form of action. It has all to do with relationships between people. It can be very complex or very simple, very formal or informal – it all depends on the message to be passed and on the relationship between the sender and the receiver (Ludlow R., Panton F., 1992).

It is therefore supposed to result in the exchange of information and shared understanding between people. A measure for effective communication of interpersonal communication is that information is passed and correctly received, and relationships are established.

In order to be successful in communication we need to know ourselves and be able to understand other people. It is one of the prerequisites for effective communication – to pass information, receive information and establish relationships.

Interpersonal competencies are not less significant. Professional skills alone cannot ensure promotion in work. The future specialists should be ready to understand their peers and react accordingly in compliance with the given situation. They should also have be able to form "external relationships that help firms strengthen and extend their traditional competencies while responding to the demands of globalization, mass customization, enhanced quality and rapid technological change". (Mascarenhas B., Baveja A., Jamil M., 2005).

Besides the above-mentioned competencies the authors of the article would like to mention other competencies that bear quite a crucial importance in communication in the process of studies in higher education. They are: being autonomous, co – operation, adaptability, flexibility, organizational competencies etc. Also the following structural competencies would be of great help: cognitive, value – motivated, operational, individually creative, and functional competencies: gnosiological, projecting, normative, informational and reflective.

It is necessary to provide the possibilities for students to gain and master their communication skills in English while they are still studying at the University for them to be able to communicate effectively after graduation in their professional life.

3 Student Motivation for Learning the English Language

According to Ron Ludlow and Fergus Panton from Cranfield School of Management, people must first of all have the will to learn. If it is lacking, no matter how relevant, attractive, well defined the courses are, there will be no positive outcome (Ludlow R., Panton F., 1992).

Today we have no big problems with student motivation to learn foreign languages. They have understood that they must be competent in English in order to find a good job after graduation and work successfully in it.

We carried out an enquiry in motivation of students to learn English at the Latvia University of Agriculture, the Faculty of Engineering, with the total number of respondents being 180.

The students were asked to answer the following questions:

1. Where do you plan to use your knowledge of English after graduation?
2. Do you agree that knowing English you have wider possibilities to find a good job or study further in Latvia or abroad?
3. Why do you learn the English language?
   - for self- development;
   - to get a good grade;
   - to make a career;
   - to go abroad;
   - the teacher can motivate;
   - other reasons.
4. Do you think that the necessity to know English will increase in the future? etc.

Today most of the jobs require work with computers, documents, informative literature in foreign languages and communication with people outside Latvia. To the question No 2 the respondents answered as follows: 168 (99%) - yes, 2 (1%)- no. See Figure 1.

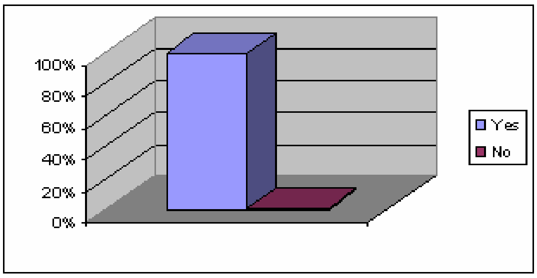

Figure 1 – opinion of students whether knowing English there are wider possibilities to get a good job in Latvia or abroad

Summarising the results of the enquiry it was stated that 50 % of the respondents learn the English language for self- development, but it is not the only motive for learning. Many students marked several versions of the answers. 24 % of the respondents learn to make a career after graduation as they consider that this knowledge will be needed in their future work. 17 % of the respondents learn English because they plan to go abroad to study or work. Only about 4 % of the respondents learn English to get a high grade that can be considered as a secondary motive. See Figure 1.

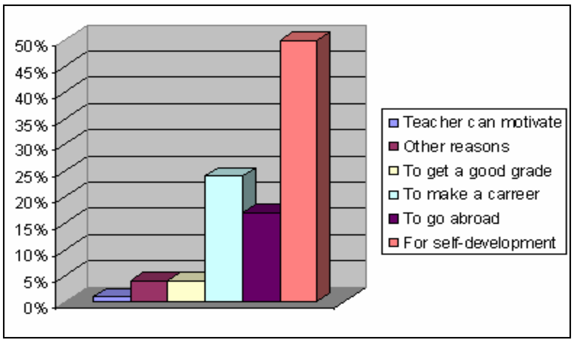

Figure 2 – English language learning motives

There is a possibility for our students to participate in exchange programs as well as to work abroad during summer holidays, sometimes also the whole year. The main advantage of these trips is not always the money earned. We consider that learning and mastering of foreign languages are more important as practical application of a language in communication and the need to speak in a foreign language abroad are the chief pre-requisites for acquiring any language.

As to question No 4 98% of the respondents answered that they think that the necessity to know English will increase in the future. This is another motive for learning as they understand that they will need to know it and hope to apply their knowledge in the future. Only 2% of the respondents gave a negative answer. See Figure 3.

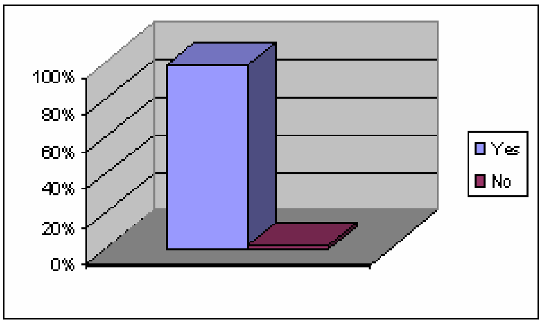

Figure 3 – opinion of students whether the necessity to know English will increase in the future

So, we can draw a conclusion that the reason why a great part of the students are motivated to learn the English language is the aim to get a good job and make a career.

If people want to learn, they must have the opportunity for it. Our students have English sessions in large groups, so there is not a possibility for every student to speak at these sessions every time.

People need also the opportunity to practice what they have learned, otherwise they will lose the knowledge and skills that they have acquired.

Due to these reasons we are trying to find other ways of learning one of them being the English Club operating at our University that is open for everybody interested in communicating in English to participate and exercise their skills.

4 Short History of the English Club

The English Club was established in October, 1990 when the author of the article returned from her first visit to England. The first meeting was organised with the people attending the English course. As they were interested to meet again and to hear more about this very beautiful country - England, it was decided to meet once a week regularly.

The Club became popular, more and more people started to attend these meetings.

In 1991, when Latvia regained its independence, the first American missionaries arrived in Jelgava. For them the English Club meetings were a good opportunity to meet Latvian people who could understand and speak English, otherwise they felt quite lonely in our country. On the other hand, it was also a good opportunity for the Latvian people to meet native English speakers and communicate with them.

Luci and Gary Stanley from California (USA) were the first to teach us about customs and traditions of Americans. Our English Club most probably is the first place in Latvia where Valentine Day was celebrated.

After six months they left and another family - John and Gail Owens from Georgia (USA) came to our town. They stayed here for about two years. They introduced the tradition of celebrating Halloween using all the typical symbols and activities of this festival, like cutting pumpkins and burning candles in them, black cats, ghosts etc.

We started to celebrate also Christmas and Easter, as they were not allowed during the soviet times being considered religious festivals.

Soon many joint - venture companies were established in Latvia. Consultants from Great Britain, Scandinavian countries, the World Bank and other places arrived to work at Jelgava sugar factory, heating company and other enterprises. All these people were invited to attend the English Club and they willingly accepted this invitation.

People from almost all European countries have been the guests of the Club during the years of its existence. We have had also visitors from Australia, many guests from the United States of America and even a black lady from Nigeria.

When we celebrated the tenth anniversary of the English Club about 80 people were present. Undoubtedly, it proves that such club is popular, important and necessary for people.

5 Culture and cross – cultural communication

Culture regulates behavior in a cross-cultural group.

Culture can be defined as a way of life developed and shared by a group of people and passed down from generation to generation. It is made up of many elements, including language, religious and political systems, customs, tools, clothing, buildings and pieces of art. Relationships with parents and friends, the way people dress, what they expect of a marriage or a job, the food they eat, the language they speak are affected by their culture. Culture cannot be learned. It changes as people come into contact with one another.

Intercultutal communication is communication between members of different cultures defined in terms of racial, ethnic or socio-ethnic differences.

Human relationships are formed in the process of exchange of information, communication and activities. During this process the social competence, experience and the system of relationships are developed (Maslo I., 1999). Communication always takes place in definite environment and experience of communication always has some impact on the participants. This impact can be emotional, physical or cognitive. Communication offers us great possibilities to acquire new knowledge, to learn more unknown facts about different things, to understand ourselves and other people better.

The English Club meetings provide a good opportunity for Latvian people not only to learn many interesting facts about different countries but also a possibility to communicate with English speaking people from foreign countries mastering the English language skills and getting to know the cultural peculiarities of other nations.

6 English Club environment

As it was mentioned before, there is definite environment where communication takes place. There have been many articles in the local newspaper about the English Club. People were interviewed, and the thing that almost everybody mentioned first was that the English Club is a place where they can feel free and they are encouraged to speak. Many of them had attended English courses before but they were not able to express themselves freely in English. At the English Club they can master their communication skills without being afraid of making mistakes as they are not given any home assignments and are not assessed by teachers.

There have been several English Clubs in Jelgava but none of them operates any more except our English Club. The main reason for it is exactly the organisation of the work at the Club. Club members can feel completely free at the meetings. They can listen if they are afraid to speak, think, express their ideas, talk, they are not asked to prepare anything before coming to the Club meetings.

Every time there is at least one foreign guest present and conversations are natural. People are talking about things they are interested in. It is very encouraging for our students if a native English speaker tells them that their English is good. It raises their self-esteem; they feel satisfied and confident in themselves and are not afraid to speak. It is possible to learn a foreign language only by doing - it is an old truth. Without speaking, even risking of making mistakes no one has ever learned to speak in a foreign language. At the Club the atmosphere is quite active and sometimes loud - almost everybody wants to speak, very often songs are sung in English. In the English Club environment is provided in which free discussion is encouraged.

It is possible to stimulate effective interactive group discussions at the Club if not only one but several foreign guests are present. These discussions are ideal means for development of communication skills.

People can present and defend arguments and make a meaningful contribution to the discussion.

People are different and we need to understand the nature of these differences and try to modify our interpersonal behaviour to cope with them. The Club is the place where we can train ourselves for this. The same as people, cultures also differ, and before visiting a foreign country it is advisable to learn about peculiarities of this country, otherwise it is easy to get into trouble.

The English Club offers integrated, favourable and flexible work for development of correct and freely flowing speech. People can listen to ideas of others, ask questions, explain, analyse, acquire new experience, change their personal views if it is necessary, demonstrate their knowledge - all these activities result in development of a personality. Besides, also behaviour manners are formed at these meetings.

7 Results of the English Club activities

Analysing the results of the English Club activities it should be mentioned that they positively influence the degree of student social integration in the learning environment and at the same time they are a great stimulus for intellectual development of a personality. These activities help to use the language not only correctly but also in compliance with a definite situation and context most efficiently for communication. For example, if somebody tells what has happened in the past, the Past tense of the verb is used, so training also grammar. Communication requires a need to learn new unknown words and offers a possibility to use these words not isolated but in the context of the foreign language and system.

The students who attend the English Club meetings have higher academic achievements, they know more information than their peers, their motivation to learn is higher and attitude towards learning is much better and also their self- esteem is higher as the knowledge of the English language has opened for them new possibilities in their lives.

Conclusions

In Latvia communication competences play a very important role in order to ensure professional career of the future specialists after graduation from a higher educational establishment.

The students have understood that the English language competences are necessary in their professional lives. It makes them highly motivated to learn the language.

The most important motives of the students to acquire the English are for self – development and to be competent in their professional career.

The purpose of the English Club is to motivate students to learn the English language through widening of their knowledge and experience level, to satisfy the cognitive interests of students, develop their mental activity, provide the opportunity to use their knowledge and skills in communication with English speaking people.

The atmosphere at the English Club encourages students to involve personally in communication without being afraid to make mistakes.

Through practical application of the English language and activisation of communication skills interpersonal communication improves and in the result the students who attend the English Club meetings regularly have also higher academic achievements.

The students who regularly attend the English Club have higher self – esteem. It helps them master their existing skills and competences. These students are also more active in the process of studies and can express their opinion freely and clearly.

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CONTENT AND LANGUAGE INTEGRATED LEARNING AT THE LATVIA UNIVERSITY OF AGRICULTURE

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In any professional sector in Latvia today there is a great demand for qualified and competent specialists. It means that the graduates from higher schools should have developed competences not only in their chosen specific fields, but also they should be able to communicate successfully with other people in the business environment. In the labour market of Latvia the requirement for high level competence of specialists in the English language and cross-cultural communication becomes more and more topical. It imposes the task for the teachers to improve the study process so that it helps the students develop their competences in different ways.

Keywords: CLIL, motivation, study process, learning, English

1 Content and language integrated learning

The study process can be improved by the introduction of the methods of content and language integrated learning (CLIL). „It is an educational approach in which languages and skills of communication are given a prominent role within a curriculum. It is often carried out by professionals who teach on courses other than languages" (Marsh D., Marsland B., Stenberg K., 2004).

At the Latvia University of Agriculture, Faculty of Engineering the teachers of special subjects in co-operation with the teachers of the English language carry out experiments by applying the CLIL methods.

CLIL does not mean learning languages but acquiring the contents of the specialty applying the competencies of foreign languages. Sometimes our students do not realize the need for these competencies as they have negative experience of foreign language acquisition from their background education. The task of the teachers in this case is to promote success in the performance of the students by appraisal of their achievements in this field. The teachers should try to notice and mention any progress of every student in the process of studies. That will stimulate the students, give them higher self – assessment and motivate them to learn more and better. "Sometimes we – the teachers manage to encourage the young people to be eager to learn and self – educate but after some time if there is no support from the teacher any more this wish diminishes. But exactly then they need our help more than ever" (Rudzitis G., Malinovska L., 1999).

CLIL is not a new concept. It has been used in many ways since the beginning of civilization. Nevertheless, the needs for introduction of CLIL today are new; they are determined by the globalization and integration processes in the world. One of these needs in the process of studies in higher schools is put up by the exchange programs of students and teachers that are organized within the European Union and all over the world. To be able to participate – to learn or to teach – in a foreign country both of them need to master their foreign language competencies.

Acquisition of the CLIL competencies help the graduates be more self – confident, they play an active role in finding a good job after graduation and promote the future specialists in making a career.

Multilingual communication within the world community today when the processes of integration and globalisation are very fast is important in economic, cultural and also political interrelations. Latvia is a small country; therefore the competences of the young specialists in foreign languages play a significant role in finding a good job and making career after the graduation from higher educational establishments. The leading scientists in foreign language teaching in Latvia are trying to find better and more successful ways how to intensify and improve the process of teaching and learning to reach higher quality of the expected results. The aim of this process is to train young people to be ready for their future professional life as well as to be able to communicate with people around them not only in their native country but also with people from different cultures. For achieving this aim it is necessary to acquire the foreign language skills and also to get acquainted with the peculiarities and differences of other cultures with which they will have to communicate.

Since Latvia has joined the European Union, the CLIL competencies have become very crucial. Latvian students have more and more opportunities to study abroad and foreign students are studying in Latvia in mobile exchange programs. The prerequisite for successful co-operation in this field is a developed competence in foreign languages. It can be considered to be one of the core CLIL competencies.

The CLIL competencies defined by Marsh D., Marsland B., Stenberg K.:

1) Language/Communication - based
2) Theoretically based
3) Methodology – based
4) Learning Environment – based
5) Materials – based
6) Interdisciplinary – based
7) Assessment – based. (Marsh D., Marsland B., Stenberg K., 2001).

Language/Communication – based competencies represent sufficient target language knowledge and pragmatic skills for the CLIL type followed so as to be a comprehensible input producer, sufficient knowledge of learner's majority language, fluency in additional language, which may be the CLIL target language, or some other, of particular relevance to target language native – speaker teachers as regards personal additional language learning experience.

The other competence that is considered to be very important by the authors of the article is the Interdisciplinary – based competence. It can help identify conceptual relations between different subjects making the learning interlinked, more interesting, relevant and easier, make conceptual and semantic relations between the different languages active in the given environment, encourage the students in developing self – assessment and self – confidence and motivate them for learning.

Much attention should be paid to such core CLIL competencies as communication and cross – cultural communication competencies. If our graduates work in joint – venture companies in Latvia or abroad, these competencies will have a very important role. If they lack these competencies they can have a lot of problems in their work and also in their everyday life. Cross – cultural communication means communication among individuals representing different identities and culture. It can cause problems, as sometimes the participants are not competent in the specifics of the other partner's culture, traditions and habits. There can cultural, political, religious and other barriers exist. Cross – cultural communication requires the competence that ensures the knowledge of the world that is very various. It depends upon the persons, groups of persons, regions, age, sex, experience, traditions, politics, race etc. By application of CLIL it is possible to have intercultural communication training that helps in widening of the experience of the students.

2 Necessity for implementation of the CLIL methods at the Faculty of Engineering

The authors of the article participated in an international scientific Leonardo da Vinci project CLIL.AXIS where five countries were involved – Finland, Latvia, Spain, Great Britain and Poland. The project continued for three years and in the result a tool kit was published in five languages and a CD was issued with the materials about the results of the project. The authors of the article visited all the mentioned countries and had a possibility to see how their colleagues were working and exchange the experience. For all of the mentioned countries introduction of the methods of CLIL in the process of studies in higher schools is very important. Participation in the project has been very helpful for the attempts to introduce CLIL also at the Latvia University of Agriculture.

At the Faculty of Engineering the teachers of the English language are co-operating with the teachers of the Autotransport speciality trying to implement inter-subject links and applying the methods of CLIL. It is essential that students have adequate educational background entering the University. Unfortunately, today there is a lack of English teachers at schools. Sometimes students have had different teachers every year while learning at school, but in some extreme cases no teachers at all. The result can be seen when the students start their studies at the University. We have groups with very different levels of competence in English.

Those students whose knowledge in foreign languages is good need to master it through practical application. It does not mean that the students with low competence in English cannot acquire the chosen speciality successfully. But at the same time they must also manage to learn the English language (the reasons are described further in the text).

Our task is to ensure the possibility for all students to acquire adequate knowledge in their specialities as well as in the English language in the process of studies while they are at the University.

The graduates from the Faculty of Engineering, Autotransport speciality can continue their studies at the Graduate course or start working in production. In both cases the foreign language competences are important. The usually work places of our graduates are automobile and their spare part or accessories sales companies, Road Traffic Safety Directorate, Ministry of Traffic and its departments, freight and passenger transportation enterprises, automobile technical services and organizations related to road management.

3 Labour market requirements for the English language competences

During the period when Latvia was a part of the Soviet Union the sources of literature related to autotransport speciality were in Russian. Everybody had to know the language as it was a natural necessity at that time. At present almost at every possible work place for our graduates literature is available only in foreign languages, the most common being English.

For instance, working in trade of automobile spare parts and servicing to order automobile spare parts various catalogues are used. Independent of what form is used- paper, microfiche, computerized or electronic- they are in foreign languages. If the producer is not Germany or France the English language is used. This requires deep knowledge of technical terms otherwise it is not possible to order qualitative spare parts. Also the work in automobile service stations requires the knowledge of the English language. The design of automobiles, diagnostics and repair of them become more and more sophisticated year by year. Many new repair technologies, materials and accessories are introduced. It means that even a locksmith needs to understand English. Technical literature describes the technology of repair of different automobile units and it is available at the service stations. If the locksmith knows the language he can quickly and easily find and learn the appropriate repair technology of the new automobile unit. Considering that the description of the repair technology is supplemented by a graphical figure it is possible to get a partly notion only by studying these graphs that is practiced sometimes due to the lack of knowledge in foreign languages. But this kind of practice can lead to ignorance of the correct technology. If the technology is too complicated locksmiths ask mechanics or other managing staff to help them acquire the new technology. In order to make the work in automobile service and trade companies easier and more fruitful workers should be competent in the corresponding technical terms.

Competence of the English language is one of the main requirements stated by employers in search for new employees. It does not always mean that this competence is essential to occupy the corresponding position. Often employers wish to have qualified staff. In any case, if the employer has a choice between candidates with different levels of knowledge in foreign languages the one with a higher level will be advantageous.

There are many advertisements in mass media every day that companies are searching for qualified employees having computer skills, more experience in the speciality and knowledge in foreign languages. Of course, people without such knowledge or having it on a low level also apply for the job. Independent of whether this knowledge will be necessary at once or later in the work these candidates are refused.

Engineers in Latvia even if their professional level is high have difficulties to find a job if their knowledge of English is not good enough. This is the reason why we decided to carry out the research in the demands of the labour market, motivation of students to learn English and possibilities to link learning of the special subjects and the English language.

4 Application of the methods of CLIL in the process of training future specialists in autotransport

As it was mentioned before the literature for autotransport engineers during the Soviet period in Latvia was available only in Russian. There was not a necessity and the students were not motivated to study any literature in foreign languages as the only automobiles used in Latvia were produced in the former Soviet Union. The only exception was some *Ikarus* buses produced in Hungary and *Tatra* trucks. The necessary literature and information on repair of these automobiles were also easily available in Russian.

The situation extremely changed after Latvia regained its independence and separated from the USSR. A large number of foreign- made automobiles appeared in Latvia. The Latvian automobile fleet that was already old became still older as compared to the average age. At present practically all car production companies are represented in Latvia. Automobile users have a great demand for qualitative service and spare parts. At the same time the design of power vehicles becomes more sophisticated.

As all the available literature on power vehicles produced in the West is only in English we must use the English language already at the University training students in special subjects.

We organised experimental sessions applying elements of CLIL. As it was mentioned before, working in automobile servicing the leading specialists need to elaborate new technologies or translate them for carrying out a definite procedure. The course “Technical Service of Automobiles” delivered to the students of Autotransport speciality includes lectures and laboratory works. As at the Faculty of Engineering literature on units of such automobiles as, for example, Ford is available, we selected this automobile as the object for studies.

The students were given the following task:

1. To develop the technological chart for replacement of the tooth belt using the hand- out literature in English (Haynes Publishing Group, 2000).

2. To replace the gear belt practically and to adjust the valve clearance.

In the books that the students received this procedure was described. In the technical literature the basic operations are not only described but also illustrated in order to understand the contents of the work better. For example, determination of the valve clearance is shown in Figure 1. Usually several figures are used to illustrate the whole technological process.

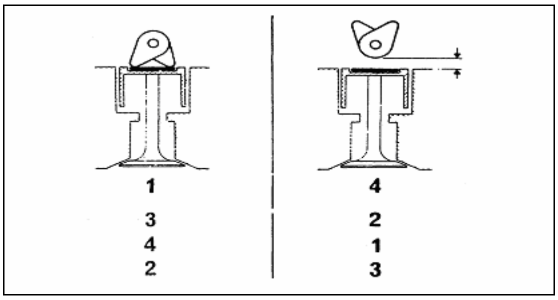

Figure 1 – checking and adjusting: 1. Turn the crankshaft so that the valves in the cylinder concerned are at "end of exhaust- commencement of inlet". 2. Check the clearance and change the pads as necessary

The task is not difficult if the student knows the special terms and general principles of the technology. In the practice at automobile services this procedure also consists of a large number of such elementary operations. If a specialist knows all of them there is a hope that he will be good in his job and able to be competitive also in the European market.

We had same difficulties in this kind of sessions as it usually happens in experiments. The first group we worked with ware part- time students. As the whole group carries out laboratory work they received only one book. Unfortunately, all students could not test their English knowledge in practice as they chose the easiest way to do the laboratory work: one of the students who was competent in English stood up and translated the technology for all the others from the book.

The experiment was continued slightly changing the hand- out material. The next group was given the same task in the following order. At the beginning the whole group had to find the necessary information in the book. After that every student got a copy of this information and a task without consulting other group mates to develop the technological chart.

In the next stage of practical application of the English language in acquisition of the subject "Technical Service of Automobiles" the students had to find the necessary information in the original automobile dealer company computer information package that consisted of five CD floppy discs. Every student carried out this task individually. After they had found the needed information every student received the technological description of the procedure. In case if it was necessary also the electronic versions (in floppy discs) of the description of this technology were handed out.

All students were successful in finding information (we prepared students to carry out these operations in the previous lectures). After the students received printed out material they were given a task to develop the needed technology based on the received materials. They were not allowed to consult among themselves, they could consult the teacher.

In order to get to know the opinion of students on usage of technical literature in English teaching special subjects another enquiry was carried out among full- time and part- time students. These students had repeatedly used technical literature in English in laboratory work. 58 respondents participated in the enquiry.

To the question "Do you consider that skills acquired in usage of the descriptions of work technologies in English in the subject "Technical Service of Automobiles" will be useful for you practically if your future work is related to technical service of automobiles?" 93, 1% of the respondents answered positively confirming that these skills will be practically useful. We also wanted to get to know whether it is easier for the students to read any text in English or technical texts. We got the following answers:

35 students or 60, 4% of the respondents consider that it is easier for them to read and understand technical texts. 4 respondents answered that an ordinary text without any special terms is easier to understand. 31% of the respondents think that they can easily read and understand any text. One respondent answers that he cannot understand English as he has learned German. The answers are illustrated graphically in Figure 2.

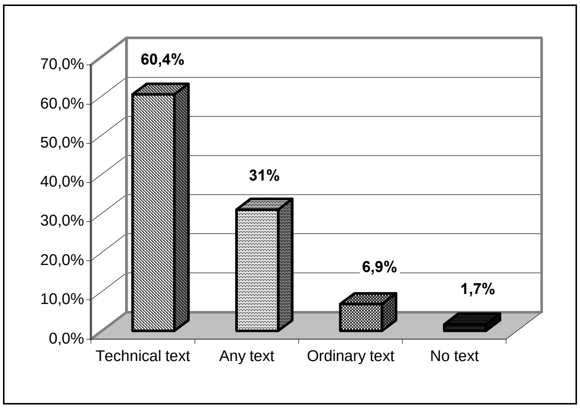

Figure 2 – opinion of students about reading and understanding of texts

94, 8% of the respondents consider that a similar usage of English texts in laboratory work should be used in the future but 5, 2% of the respondents think that this kind of work is not useful.

All respondents are of the opinion that it is necessary to use the available dealer software in learning of the definite technical service technologies for different automobile modifications.

28 respondents (48, 3%) during the laboratory work consulted neither the teacher nor the group mates. Nevertheless, 51, 7% of the respondents needed either the teacher's or group mates' help in learning and understanding the technologies.

We consider that this kind of acquiring English together with learning a special subject motivates the future specialists. In case the new engineer gets a job related to technical service of automobiles, he will be competent in the development of technological principles using the English language.

5 Problems at the Latvia University of Agriculture implementing the methods of CLIL

One of the main problems we are facing at our higher school is that the teachers of elderly age have learned foreign languages during the Soviet times when the Russian language was dominating. For many of them the second language that they learned was the German language. Therefore, many of them have acquired the English language only individually on the level of obtaining information. They are lacking fluent foreign language competencies.

The teachers at the Latvia University of Agriculture are not much interested to develop teaching programs in foreign languages, as we are having too few exchange students and if these students are from the European Union the work with them is not additionally paid for.

Another problem exists in this respect, as in Latvian legislation the Latvian language is determined to be the language that should be used in the process of studies. Therefore, new special teaching courses should be created and offered as elective courses.

As the students at our university come from different regions – cities and countryside – the level of their competencies in foreign languages and the special subjects differs greatly.

Conclusions

In the labour market of Latvia a special attention is paid to the competence of specialists in the English language.

The results of the research show that the employers prefer to have employees who know the English language.

Our work to motivate the students to learn foreign languages is based on socially significant motives, the motives related to cognitive interest in the teaching subject and the motives related to the broadening of a person's general outlook and self-development.

Summarising the results of the research we stated that students are motivated to learn the English language and they understand that they will need it in their future work.

We try to introduce methods of CLIL in teaching special subjects through practical application of the English language taught at the English sessions.

The students included in the experiment are interested in the new methods and would like them to be applied also in the future.

We consider that these methods not only help motivate students to acquire special subjects and the English but also will help them to be able to find a job after graduation and make a career.

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STRUCTURE AND SPECIFIC SURFACE OF FEED MIXTURES LOOSE FACTORS

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Effective application of core fodder used for feeding of animals demands an appropriate crushing stage. Studies of nutrient conversion at pigs performed by Danish specialists indicated its improvement at feeding by fine pollard (c. 400 μm) but, also, increase of gastrohelcomae and Salmonellae risk. From this point of view, a rougher fodder structure (50% of particles < 1mm) shows preferable results. By crushing of hard feeding mixtures (grain crops), a product of various range of fractional composition and different fineness originates. Rosin-Rammler-Sperling distribution in Bennett's adaptation (RRSB) is very efficient for description of grist obtained by this way. From the theoretical viewpoint, the following determination of specific surface is possible by means of summation of surfaces of all i-fractions for 99,8% of grain surface providing ideally spherical particles form. Thereby stated calculation inaccuracy is further increased by innocence of actual grains form coefficient bearing, in addition, to individual fractions particles sizes. On the mentioned purpose, direct determination of particles specific surface was carried out by means of the throughput method on an equipment according to the author's proposal. Obtained data were compared with the values which, e.g. at use of the same samples, resulted from the screen analysis processed by help of RRSB exponential distribution. The method verified for wheat enables to characterize surveyed sample roughness (fineness) of a polydispersive grained set by unassuming measuring of a specific surface.

Keywords**:** screen analysis, fractional composition, Rosin-Rammler-Sperling distribution, particles set specific surface, crushed grain crops

Introduction

Grain grinding originates a particles set of different sizes while the original grist specific surface always considerably increases. A newly arisen set fractional composition can be determined by the screen analysis for example. Further, from weight rates of fractions left on individual screens, it is possible to determine frequency characteristic – probability density of appearance of a particle of certain size – for the examined set. Its integral characteristic is represented by a distribution function indicating estimation of probability level on which the grinding product consists of particles of sizes less or equal than the certain given size. The mentioned statistical functions represent the most perfect characteristic of ground materials. Surface size represents another important property of loose material. It is obvious it depends on a set granulometric composition. Here, surface size represents an outer surface size limited by a particle form which is determinable by means of distribution function cognition at its comparison with a simple form particle (e.g. sphere) by a calculating way.

Materials and Methods

Particle specific surface can be defined as the rate of its surface value to its weight or, optionally, volume occupied. In the fodder branch, respect to particles sizes and loose feeding components fractional composition (e.g. grain feed), the specific surface is usually determined by the mass method. For irregular bodies, this value can be determined by help of the so called equivalent sphere diameter.

$$S_o = k_s \cdot \frac{6}{\rho . D_{ekv}} \quad /kg.m^{-2}/ \qquad (1)$$

where

k_s form coefficient – whole grain ≈1

ρ particle density (individual grains before crushing) $/kg.m^{-3}/$

D_{ekv} equivalent sphere diameter /m/

$$D_{ekv} = \sqrt[3]{\frac{6.m_Z}{\pi . \rho}} \quad /m/ \qquad (2)$$

where m_z average grain mass /kg/

In a laboratory, wheat grain densities were pyknometrically (also after triple repeating) measured and, by means of weighing of 200-300 grains from randomly selected unground material samples, the bellow stated single grain mass was detect and, concurrently the specific surface S_o was calculated:

grain crop	average density ρ [kg.m^{-3}]	specific surface S_o [m^2.kg^{-1}]	single grain mass m [10^{-3}.kg]
wheat	1,310 ± 9.5	1.19	0.0392

For a monodispersive set of characteristic **x** particles size, the specific surface is numerically equal to the single particle surface nth multiple:

$$S_O = k_s.\frac{\pi.x^2}{\frac{1}{6}\rho.\pi.x^3} = k_s.\frac{6}{\rho.x} \quad / \text{ m}^2.\text{kg}^{-1} / \qquad (3)$$

For polydispersive particles sets, their specific surface can be determined providing the distribution function cognition with assumption that the particles are of defined geometrical form.

$$S_O = \int_{x_{\min}}^{x_{\max}} \frac{6}{\rho.x} h(x).dx \quad / \text{ m}^2.\text{kg}^{-1} / \qquad (4)$$

where h(x) probabilistic density of certain size particle appearance

Form coefficient $\mathbf{k_s}$ for fine, spherical, or cubic particles equal to 1, for isometric, fine particles near, but little greater than 1.

Character of size distribution of fine-grained particles originated by grinding is well described by means of exponential RRS distribution which can be, in later Bennett's adaptation, can be expressed by the following way:

$$R = 100.\exp\left(-\frac{x}{\bar{x}}\right)^n \qquad (5)$$

where R aggregate relative residual on screens / % /

x particle size / m /

$\bar{x}$ mean statistic set particle size / m /

n material constant (in RRSB, polydispersion diagr. coeff.)

As mentioned, Formula 4 is valid with assumption that all ith fraction particles are of spherical form and fine. Character of particles surfaces of different sizes need not be the same. Rough particles bring a part of an original grain surface which can be finer than a fracture surface. Finer parts of endosperm are already of the surface created by fracturing process. A certain part of particles (e.g. pollard) consists of grain coating fragments, are not isometric and, therefore, can be of great specific surface. The finest particles can consist of starch granules, their fragments, and albuminous matrix fragments. Therefore, the form coefficient will generally be the **x** function, and the polydispersive set specific surface follows:

$$S_{POL} = \frac{6}{\rho}\int_{X\min}^{X\max} k_S(x).x^{-1}h(x).dx \quad / \text{ m}^2.\text{kg}^{-1} / \qquad (6)$$

For cereal pollard, no specifications of form coefficients were found. Orientation measurements previously carried out by the author indicated an approximate average value $\mathbf{k_s} \approx 2.4$. However, for calculation of a polydispersive particles set specific surface, it is necessary to know the course of $\mathbf{k_s}$ in dependence on particles sizes. So, count determination of polydispersive grain material specific surface is inaccurate respect to the unknown form coefficient $\mathbf{k_s}$ even through cognition of particles sizes distribution characteristic (RRSB).

Method of Analysis

Respect to the above mentioned purposes, we rose to direct experimental determination of specific surface size by means of the throughput method based on Darcy's law. The authors worked with an apparatus of their own design whose construction was derived from Lea-Nurse's one. For the measurements, the perennial wheat of Zdar II variety, density 1,310kg.m^{-3}, single grain volume 29.89mm^3, sphere diameter of equivalent volume 3.85mm, grain specific surface S_o=1.19 m^2.kg^{-1} was used.

The method description and scheme of the apparatus used for direct specific surface determination:

The measurement is based on examination of air flow pressure loss in a layer of loose grained material of known porosity. The specific surface dimension can be determined from the following formula:

$$S = \frac{1}{\rho}\sqrt{\frac{\varepsilon^3}{(1-\varepsilon)^2}.\frac{S_p}{k.\eta.L}.\frac{\Delta p}{Q}} \quad / \text{ m}^2.\text{kg}^{-1} / \qquad (7)$$

where ρ (grain) particle density before crushing / kg.m^{-3} /

ε porosity

S_p sample cross-section surface (pattern book) / m^2 /

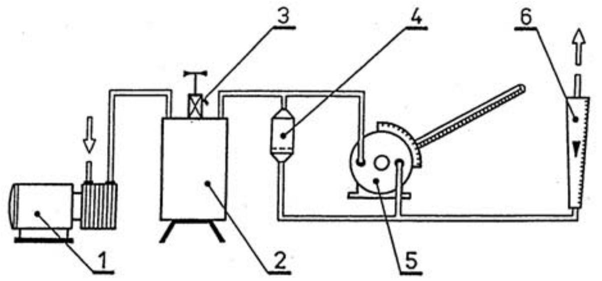
k dimensionless constant (5 ± 0,5) $k \neq k_s$

η dynamic air viscosity / Pa . s /

L measured sample layer height / m /

Δp pressure difference between measured sample upper and lower surfaces / Pa /

Q volume rate of air flow through air layer / m^3.s^{-1}/



Pic. 1 Apparatus for measuring of specific surface according to author's design

Scheme key:

1 compressor (vacuum pump output)
2 air valve
3 pressure regulation in system
4 measuring container with material sample
5 differential micromanometer
6 float flowmeter

By help of this method, it is possible to determinate so called geometric surface including the above mentioned form coefficient k_s. Grain density ρ was determined in toluene bath by the pycnometric method. Then, calculation of porosity was determined from the following formula:

$$\varepsilon = 1 - \frac{\rho'}{\rho} \qquad (8)$$

at volume weight ρ' of crushed wheat in the measuring container was calculated from sample weight *m* and measuring container chamber sizes:

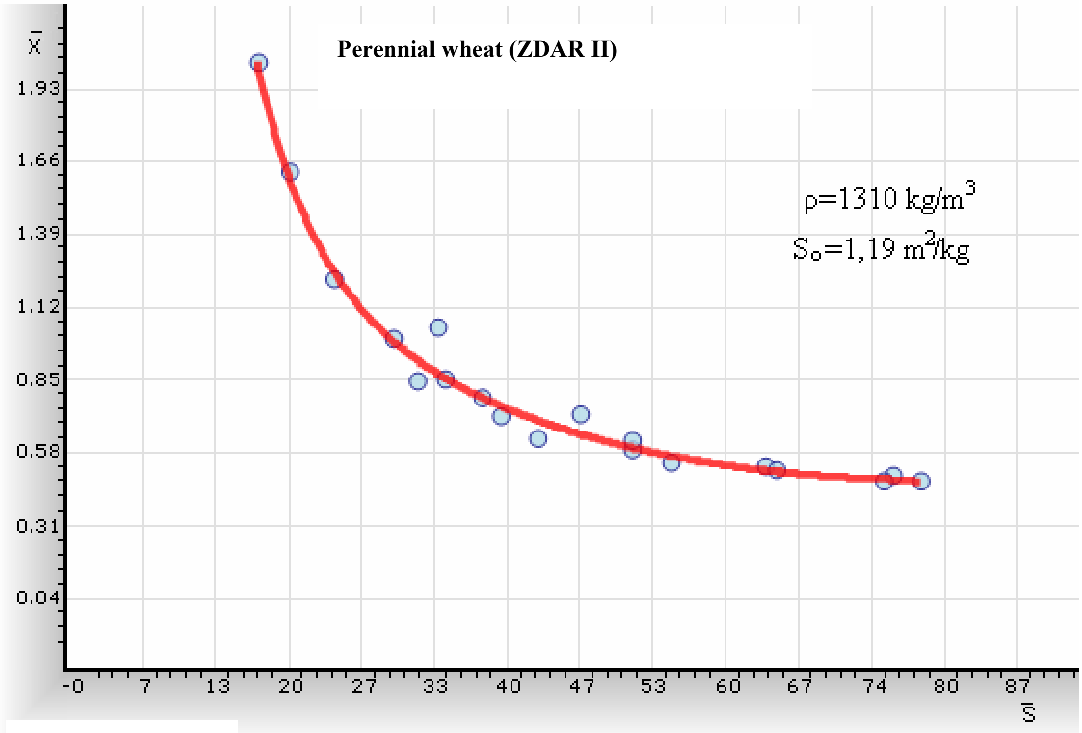
$$\rho' = \frac{m}{S_p . L} \qquad / \text{kg.m}^{-3} / \qquad (9)$$

Results and discussion

The grains were ground in the laboratory grinding mill enabling to obtain a grinding product at different kinematical and geometric conditions. In this way, a sample set of different granularity at almost identical granulometrical composition was obtained. Then, grist samples granularity structure was evaluated by help of the screen analysis at use of 17 (+1) screens. Evaluation of the screen analysis results was performed by help of the previously mentioned RRSB exponential distribution enabling to exactly determine, aside from polydispersion coefficient, also mean statistic set particle side $\bar{x}$. Procession of the screen analysis results was performed by help of the previously created software determining, after insertion of weight residues on individual screens, polydispersion coefficient, mean statistic set particle size, as well as variation coefficient. Measured values are arrange within the following table. The diagram describes dependence of mean statistic set particle size $\bar{x}$ (from screen analysis results) on experimentally determined specific surface of wheat pollard by means of the above described method.

T -1

Perennial wheat processed at defined kinematical (hammer circumferential speed) and geometric (screen surface various size) conditions of crushing machine				
Measured value of specific surface S ($m^2.kg^{-1}$) (value X)	Mean statistic set particle size $\bar{x}$ ($m.10^{-3}$) (value Y)	Constant $K_{stř}$ (mean value) ($m^3.kg^{-1}$)	Constant $K_{stř}$ ± standard deviation ($m^3.kg^{-1}$)	Polydispersion coefficient of measured set n
58.64±0.65	0.5484	32.16	31.8 - 32.5	1.1458
64.00±0.70	0.5246	33.57	33.2 - 33.9	1.5410
75.73±1.14	0.4787	36.25	35.7 - 36.8	1.1974
78.20±1.80	0.4605	36.01	35.2 - 36.8	1.2680
33.74±0.88	1.0305	34.77	33.9 - 35.7	1.0026
34.41±0.42	0.8397	28.89	28.5 - 29.2	1.1784
39.55±0.33	0.6974	27.58	27.4 - 27.8	1.1477
42.98±0.70	0.6158	26.47	26.1 - 26.7	1.1910
51.75±1.05	0.5785	29.94	29.3 - 30.5	1.2470
55.28±1.80	0.5301	29.30	28.3 - 30.3	1.2200
65.03±1.37	0.5026	32.68	32.0 - 33.4	1.2370
74.84±1.97	0.4622	34.59	33.7 - 35.5	1.2106
17.22±0.24	2.0116	34.64	34.2 - 35.1	1.1312
20.24±0.28	1.6135	32.66	32.2 - 33.1	1.0885
24.20±0.16	1.2105	29.29	29.1 - 29.5	1.5076
29.79±0.21	0.9879	29.43	29.2 - 29.6	1.1806
31.94±0.86	0.8341	26.64	25.9 - 27.4	1.1712
37.94±0.43	0.7674	29.12	28.8 - 29.4	1.1395
46.84±0.70	0.7065	33.09	32.6 - 33.6	1.1520
51.68±0.74	0.6114	31.60	31.1 - 32.0	1.0987



Legend:

Mean statistic particle size [m.10^{-3}]

Specific surface [m^2/kg]

The values contained in the table T – 1 are further used for construction of the chart $\bar{x}$ = f (S), so for representation of functional dependence of mean statistic particle size on the set specific surface determined by the weight way. Since the fact that for $\bar{x} \to 0$, will $S \to \infty$, the dependence can be represented by help of the equiaxial hyperbola equation with coordinate axes as asymptote which can be represented by the following formula:

$$\bar{S}.\bar{x} = \frac{a^2}{2} = K_{stř} \qquad / \mathrm{m}^3.\ \mathrm{kg}^{-1} / \qquad (10)$$

$K_{stř}$ = 31,43 . 10^{-3} / m^3.kg^{-1} /
[a = 0,25071]

Conclusions

Total amount of 20 perennial wheat samples with stated constants processed by blowing (grinding) was evaluated. Respect to difficult determination of ground product fragments k_s form coefficient and, also, inaccuracies at direct specific surface S /m^2.kg^{-1}/ calculation, the dependence of mean statistic set particle side $\bar{x}$ /m/ on specific surface S size was examine by experimental way. From the screen analyses values processed by help of RRSB distribution as, for example particles size distribution characteristic, the constant $K_s = 31.43 \times 10^{-3}$ / m^3.kg^{-1}/ was determined for wheat and the dependency was approximated by means of the equiaxial hyperbola by graphic way. The result for a given material enables to characterize surveyed sample roughness (fineness) of the examined set by means of mean statistic set particle side $\bar{x}$ determination by unassuming measuring of a specific surface. For the mentioned purpose, the apparatus enabling direct determination of medium-fine dispersion loose materials specific surface size was designed, constructed, and proved.

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ADAPTATION OF A FARM TO PRODUCE BEEF CATTLE

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The paper deals with the methodology for beef cattle production optimization in adapted farm. Conditions affecting the rational designing a modern technological process were set up. The procedure required working out the database containing information on inventory buildings, auxiliary buildings and other objects, tractors, machines and devices as well as fodder resources. Methodology includes the evaluation of cattle production direction, herd size and structure, designs of feeding system, preparation and giving the fodder, removal and storing the wastes.

Keywords: farm, production, beef cattle, optimization

Introduction

The fact that the Polish access to European beef markets caused a sudden increase of beef prices and two-year participation on that market strengthened in a convincing that it is constent trend, are factors encouraging to beef production development (Jakubowski 2006). After Polish accession to EU, farms gained new development perspectives. This development may refer both to modernization of current plant production profile and directing to new types of agricultural activity. Production of beef is one of such directions. Farmers who decided to select a given animal production profile might qualify for financing from a special European fund, which even reached to 60% of investments for changing their present production direction. It is a great challenge for farms that want to develop and produce high-quality beef. Accessing the EU, requirements related to beef cattle breeding have changed. EU needs made the necessity to modernize the structure of existing farms and create a proper industrial background.

Many-year studies upon the production costs give the opportunities for their minimization at optimization of production technology. The notion *optimum technology* stands for processes that guarantee cost decrease and at the same time the increase of production efficiency. The breeding process has changed from dairy-beef to beef or dairy performance. Free-stand breeding has been developed and work effectiveness has been elevated.

A lack of funds for modernizing the technology makes that beef producers cannot participate in costs of technological progress and cannot introduce the optimum production technologies. Despite of that farmers have a chance to reduce their breeding costs, including costs for forage, own concentrated fodder, outer concentrated fodder, fodder additives, feeding advice, direct service costs for buildings and machines such as: amortization, repair costs, costs for energy and breeding, including animal maintenance, insemination, costs for performance controls, certificates, membership costs, costs for prophylaxis and veterinary service, amortization of general herd, as well as indirect costs.

Presently appearing great opportunities for increasing the animal production (thus creating the possibilities to elevate the production efficiency) are accessible in existing rural resources (Głuski 1996).

The aim of study

The paper was aimed at working out the methodology for optimization of beef cattle production in adapted farm. Conditions that have significant importance at rational designing the modern technological process were set up and described. The procedure required collecting and inputting information on a farm (inventory buildings, auxiliary buildings and objects, tractors, machines and devices, fodder resources) into database, setting the cattle production direction, herd size and structure, as well as selecting tractors, machines and devices for various works in a farm.

Methodology for adapting the farm to beef cattle production

A right modernization of production direction needs fulfilling following minimum conditions for cattle breeding (Romaniuk *et al.* 2003). Evaluation of below aspects is necessary:

1. Stand dimensions.
2. Dimensions of lairs in free-stand cow-house.
3. Required dimensions of lairs in group coops with separated lairs.

4. Area of group coops without separated lairs, on a litter.
5. Area of group coops without separated lairs and without litter.
6. Area per a single animal in open system.
7. Run area.
8. Requirements referring to floors. Floors should be smooth, but not slippery and made of hard, even and stable surface. Gap floors must correspond to animals maintained on it: gap and rib width in cm): cows 4.0 and 12-14 cm, calves 2.5 and 6-8 cm, heifers up to 15 months and fatteners to 350 kg 3.0 and 8-10 cm, heifers above 15 months and fatteners above 350 kg 3.5 and 10 cm.
9. Requirements referring to technological partitions, transport lines and holes. Technological partitions are: fodder ledders, stand partitions and every short wall in cow-house. They must be adapted to a given animal category in reference to their height, distance, durability to meet their roles.
10. Passage width. In inventory buildings, a proper width of transport passages, gates, and doors is very impoetant. Animal's, people's and mobile transportation mean's dimensions should be taken into account at designing.
11. Width of gates to coops and doors to runs.
12. Environmental conditions: right microclimate affects cattle health and efficiency. Animals emit heat, carbon dioxide and water vapor into the environment. The emission intensity depends on body weight, metabolism rate and the temperature the animal remains. Main parameters of the cow-house's microclimate are: air temperature and humidity, hazardous gases concentration, lighting, ventilation and air movements.
13. Requirements referring to lighting. Daily lighting (natural) is determined by the ratio of window area to floor area.
14. Requirements referring to ventilation. Cross-section of ventilation duct should not be smaller than 0.4 m. A radius of an efficient action of ventilation duct is approximately equal to 10 mean widths of its transverse section width. Air inlet should be the same as outlet. Distribution of air inlet holes should be uniform to avoid cool air reach directly to animals. Ventilation ducts should be at least 20 cm higher over the crest. Crest lighting and vemtilation is the best in modern cow-houses without roofs. Distance of the crest from the fodder passage level should be minimum 6 m for good ventilation.
15. Manure floor. Manure can be collected, fermented, and stored in inventory buildings or on manure floors with side walls. Floors in inventory buildings and manure floors should be protected against leakage into theground and equipped in installations that remove leakage into the hermetic reservoirs for liquid manure. The floor capacity should ensure the accumulation and storage manure for at least 6 months. It should be 3.5 m^2/animal at storage height of 2 m at indoor system. That area can be proportionally smaller in relation to time animals remains on a pasture. Manure prism dimensions are $1.0 \times 1.5 \times 2.0$ m^3. Manure weight is 1[m^2] of the floor area 0.90 1.35 1.80. Access to inventory buildings and area surrounding the manure floor should be hardened. Roofing is optimum, which make impossible to flood the manure by rainfalls and it protects the manure against excessive drying out. Manure must not be stored in filed prisms, because it leads to the contamination of ground water with nitrogen and phosphorus compounds as well as over-fertilization of the ground beneath the floor.
16. Reservoirs for liquid manure. The capacity of reservoirs for liquid manure should ensure the storing manure for at least 6 months. Reservoirs must be hermetic, not permeable and equipped in hermetic cover with inlet and ventilation holes. Reservoirs for liquid manure may be equipped in floating cover. Liquid manure production should be reduced by limiting the amount of water for cleaning the inventory buildings and removal of leakage from drinking troughs. Disposal of substances from sanitary devices to liquid manure reservoir should be avoided.

Nowak (2005) claims that new or modernized farm has to meet EU regulations that are obligatory since the day Poland achieved the access to European Union. According to the law, every farmer must univocally respond to variety of questions making possible to determine the direction of building or modernization. These questions can be formulated as follows:

1. Is the information board placed in front of the inventory building? Buildings with maintained animals should be equipped with the table with the remark *"For personnel only"*.
2. Has the farm disinfection mats? Farm, from which animals or animal-origin foodstuff are introduced onto the market, should possess disinfection mats that would protect entrances to the farm against epizootic[1] hazard.
3. Is the buidling's status sufficient, roof construction well, and gates easy to close? Building should protect animals against unfavorable atmospheric conditions. Person, who maintains farm animals, is obliged to ensure them appropriate living conditions.
4. Do buildings adapted as inventory ones meet a minimum requirements referring to

maintenance, health, and safety for animals? Adapted objects like barns, stores, etc. should be assessed in a view of functional, technical, and safety correctness.

5. Does the inventory building meet corresponded evacuation requirements? Inventory building should meet following evacuation requirements:
   - Gates and doors should always open outside;
   - Distance from the most distant animal stand to the evacuation exit should not exceed: 50 m for litter or 75 m for no-litter animal maintenance;
   - Above 15 livestock density, at least two evacuation exits should be applied, and at halls divided into sections, at least a single exit from every section.
6. Is the floor clean, easy to clean, with no cracks and equipped with proper and working sewage system? Floors in inventory buildings should be smooth, have stable, hard and even surface that would make possible to keep it clean, and easy removal of wastes (in accordance to animal maintenance system). Sewage system for wastes and liquid manure should be properly protected.
7. Are walls and ceiling clean and not damaged? Walls and ceiling should be clean, with no cobwebs and fungi.
8. Has the inventory building a proper light? Light (artificial or natural) in inventory buildings should make possible to look after animals and haal control (equipped with stable or mobile light sources). In a case of light in compartments where calves are maintained, the light should be applied at least between 9 a.m. and 5 p.m. Natural light in inventory buildings is determined as a ratio of window surface to the floor surface area. Artificial light should correspond to the natural one between 9 a.m. to 5 p.m.
9. Is electric installation controlled and properly protected against animal's access? Cattle should not have access to the electric installation (swithes, wires). Electric installation in animal's compartments is made in accordance to Building Law regulations.
10. Is appropriate ventilation is ensured in the inventory building to avoid the accumulation of excessive moisture and heat? Properly working natural ventilation (gravitational) should ensure free air flow in the building. Inlets and outles of ventilation ducts should be permeable and uniformly distributed within the building in order to air flowing in winter could not directly reach the animals. Ventilation ducts must have the possibility to be regulated and closed in winter. At efficiently working ventilation, sum of the intersection area of inlets should be equal to the sum of intersection area of outlets. When the ventilation works badly, there is a stuffy air, large moisture content and ammonia odor in the building. Efficiently working ventilation protects against the decrease of animal's health, namely calve's susceptibility to respiratory tract diseases that wrong or late diagnosed become the reason of numerous disturbances and even mortality among animals. Optimum relative moisture content is 60-80%. Moisture content can be evaluated using hygrometer. In inventory buildings, air circulation, dusting, temperature, air relative moisture content and gases concentrations should remain at the level that is not hazardous for animals.
11. Do stand dimensions, the animals or animal groups are kept, take into account their age, size and type (mother-cows, beef cattle or calves)? The livestock density over normative for a given species, age, and physiological status is forbidden. Farmer should ensure the animals with the nursery and proper living conditions taking into account appropriate area norms depending on maintenance system.
12. Are compartments, stands, and equipment, the animals have direct contact with, free from sharp edges, and objects, that could make body injuries at animals? The maintenance conditions cannot make injuries at animals. Compartments should be such maintained not to make injuries at a stock. Equipment and devices inninventory compartments for animals are checked at least once a day, and found defects should be immediately removed.
13. Is the inventory building equipped with proper operation stand? A stand making possible to make some zoohygienic, or veterinary operations (hoof correction, insemination, etc.) should be localized in an inventory building.

Adaptation to above requirements would make creating solutions that meet the animal's natural needs making possible production mechanization and maximization. According to Romaniuk (2003), building can be easily built quitting the heavy and expensive monolith brick or ferro-concrete constructions and applying light and cheap cow-houses of frame structure with no utility attic. Light steel or wooden frame (made of impregnated timber) is often partially cased within protective walls (bricks or wooden) with no thermal insulation. Remaining wall surface is filled with rolled foil plain and mounted with anti-wind net. Since spring till autumn foil plains are rolled up ensuring the cows with the unlimited access to fresh air and lot of light. In winter, foils are down, which protects animals against wind and frost. Appropriate microclimate conditions are ensured by eaves-crest ventilation. If the crest is open, the cow-house interior must be designed in such a way that no stand was placed directly under it. Such solutions are successfully applied in USA. They also find more and more adherents in Western Europe, and first such cow-houses have been built in Poland as well. Under some climatic conditions, namely in north-western Poland, those cow-houses require various modifications. Floors in no-litter stands may consist of special mats that ensure cows with a comfort and farmer with litter savings. In many American farms, floor in stands are made of concentrated loam or a ground.

Verification of the methodology

Conditions in a farm

The farm is localized in Lipówka, Wyryki commune. Previously, the farm was involved in cereal, and potato production as well as various animal production directions. Several cows, ten or so swines and hens were maintained in the farm. At present, the producer possesses:

- 20.16 ha of own lands, including 5.04 ha of arable lands and 15.12 ha of meadows,
- 4.21 ha of leased gounds, including 3.2 ha of arable lands and 1.01 ha of meadows,
- 3 inventory buildings, including 1 cow-house and two auxiliary buildings.

Two-raw, free-stand cow-house of outer dimensions 45 × 90 × 10.86 m. The building was modernized. In accordance to norms, it was settled by 50 cows or heifers, one bull and 40 calves. One raw of 45 × 3.6 m dimensions was separated in the building. In total, 36 animals will be maintained in the cow-house. The second raw was divided into four parts:

1. Lairs for 15 cows (19.20x3.6 m),
2. Stand for a bull (2.8 × 3.6 m),
3. Parturition stand (4.5 × 3.6 m),
4. Lairs for 40 calves (19.2 × 3.6 m).

The farm has the following machines:

- tractor C-330M,
- tractor FARMER F-8258,
- head loader Herkules T-229,
- double-ridge plough,
- cultivator 2.8 m
- 6-field harrow,
- trailer D-45 – 3.5t,
- sprayer Krukwiak 1000l.

Beef cattle selection

Many-year breeding works led to creation of several types of cattle. In meaty herds, cows are not milked and their role is reduced to parturition and calves rearing as well as production of valuable organic fertilizer. Meaty herd may be also the solution for improvement of utilization and nursery of the field that was not effectively performed up to date. Number and weight of calves weaned from cow-mothers at the end of pasture season is a measure of production in such herds. In simplified calculations, it is accepted that three meaty cows should be kept instead of one dairy cow to achieve the profitability in cattle production. At beef cattle production, the savings may rise from reduction of investments for buildings and equipment as well as minimization of labor inputs.

It was determined that cows of Limousine breed will be the best for breeding in studied farm. It resulted from general virtues of this breed and surrounding market's needs for calves and heifers.

Selection of feeding system for beef cattle

Term *„feeding system”* is not univocal, because it may be considered from a point of view of the type of supplied fodder or the manner it is supplied. Taking into account the types of fodder supplied, two systems can be distinguished: varied and full-dose. Varied feeding consists in simultaneous supply of several fodder types, e.g. silage, root plants, hay, and concentrated fodder in winter, or green forage, dry beet-root pulp, straw and concentrated fodder in summer. Particular fodder types are supplied separately with no mixing them altogether. The larger number of fodder types, the better balancing of nutritional ratio, but at the same time, the higher labor consumption for animal feeding. Full-dose feeding consists in making a single meal in a form of forage and concentrated fodder mixture, e.g. silage-hay and concentrated fodder mixture. It is wet fodder. Also dry fodder can be prepared. It consists, for instance, of cut hay, ceral meal, concentrated fodder mixture, and dry beet-root pulp. Full-dose feeding should be very precisely balanced in reference to particular nutrients contents. Supplying the full-dose fodder is not labor-consuming, but it is necessary to have devices to its preparation and supply, therefore full-dose feeding is applied at large cow-houses.

Selection of cattle performance system

According to Piotrowska et al. (1996), reproduction performance, final result of which is giving birth to a progeny, is important for the species existence. Cows with not disturbed fertility, calve once a year. In most cases, they give one calf at a time, but twins also occur. Such case can be observed only twice per hundred calvings. Cows are characterized by low reproduction coefficient, which greatly affects the cattle population increase.

Reproduction performance of Limousine breed was selected for studied farm. Its final result is sale of calves and heifers.

Selection of machines and devices

The selection of fodder preparation and supplying technology as well as waste removal was made using the database and software worked out at the Department of Agricultural Machines and Devices, University of Agriculture in Lublin.

Forage cutter Orkan was selected to prepare green forage. Suction-and forcing breaker (H965/1 type) was selected to produce concentrated fodder. It serves for breaking the cereal grains and leguminous seeds. There is a possibility to exchange sieves of various mesh sizes, which makes possible to produce meal within the wide range of granulation.

Fodder-car Solomix (500ZK type) of 5 m^3 capacity equiped with one worm ZK and side gravitational unloading was selected to fodder supply. Its width and height is 2.15 m; unloading height 0.5 m, and power demand 45 kW. The fodder-car serves for mixing and supplying the fodder components. It makes possible to achieve fodder, any amount of which contains all added components in the same proportions.

Forage in a form of silage made of maize and hay-silage is stored in silos localized near the cow-house. Cutter TU115 (Figure 1) is applied to unload and load the silage. Its capacity is 1.7 m^3, width 1.97 m, and height 2.02 m.

Due to the shape and dimensions of lair raws in the cow-house as well as exploitation costs, versatile manure scraper was selected. Its exploitation costs are presented in Figure 2.

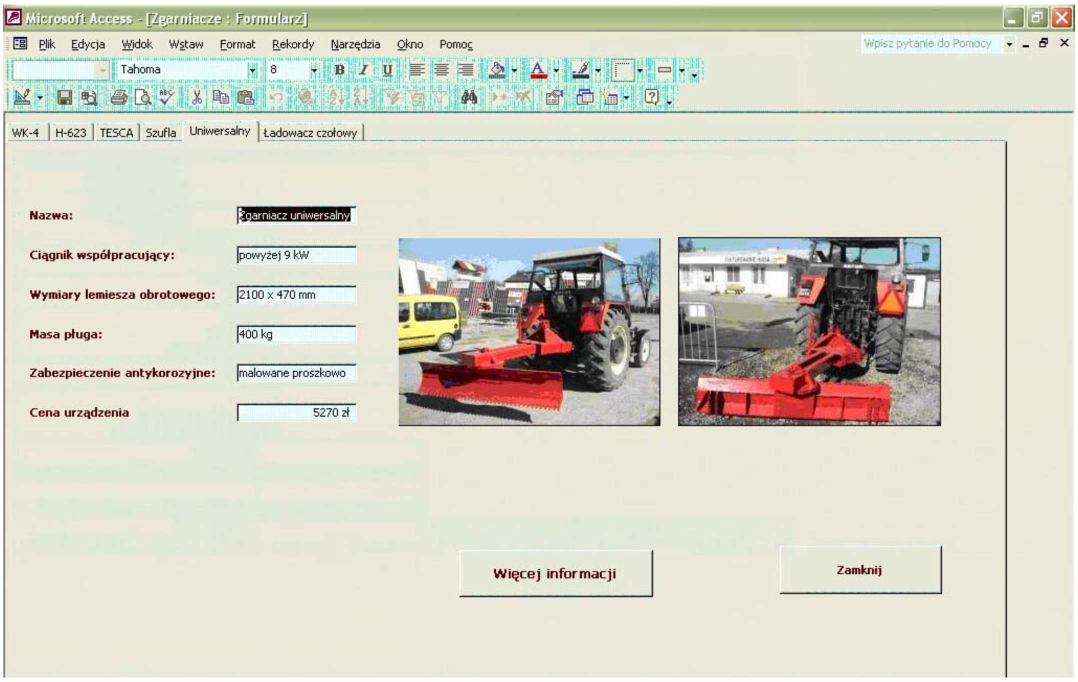

Figure 1. Window for selecting machines and devices for wastes removal – device selection

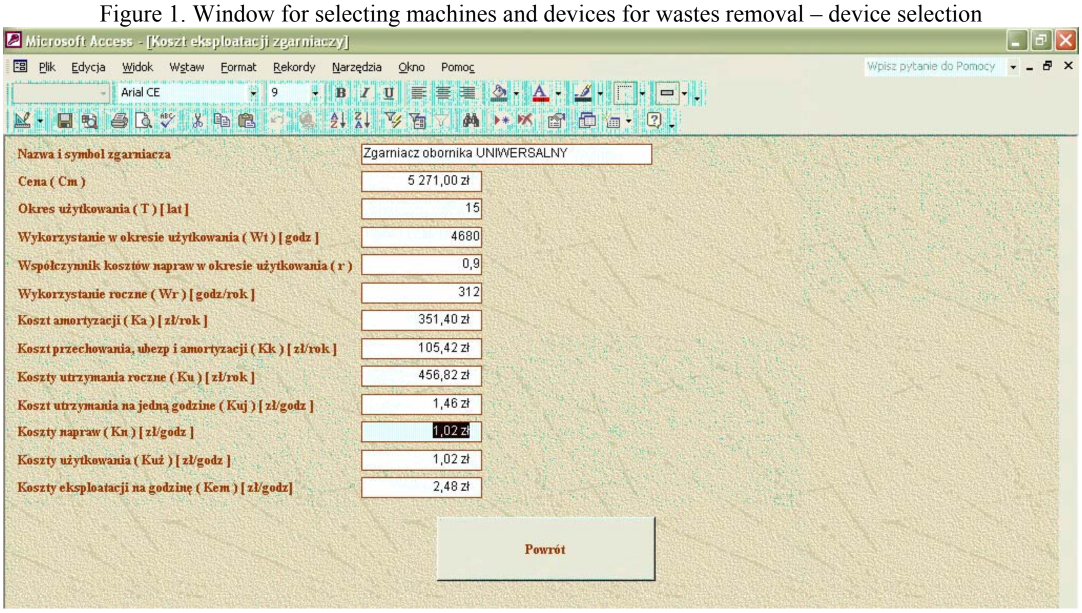

Figure 2. Window for selecting machines and devices for wastes removal – calculation of exploitation costs

Manure from the cow-house is stored on manure floor and, according to the schedule, disposed to the field during the field fertilization period. Similarly, liquid manure is stored in reservoirs and then applied to fertilize plantations.

Summary and conclusions

The paper presents the method for transporting the farm involved the plant production and mixed animal production into beef cattle production. All factors important for rational design of a modern technological process were set: herd size and structure, feeding, feed preparation and supplying systems, wastes removal and storage. Tractors, machines, and devices for works in the farm were selected as well.

The methodology was verified using the example of a farm that further tried to get support within the funding program for development of young cereal producers. Supporting the studied farm in a form of about 1 800 000 PLZ may prove the quality of worked out methodology: 500 000 PLZ for purchase cows and heifers as well as bull of Limousine breed, 1 300 000 PLZ for purchase the tractor FARMER F-8258 and head loader Herkules T-229.

Worked out method and analyses presented in the study allow for drawing the following conclusions:

1. Absolute adaptation of the production process to requirements and standards obligatory in European Union is the most important condition determining the financial supporting.
2. Tradition and preferences referring to cattle breeding on the area the farm is localized determine the selection of cattle breed, which results from the opportunities for selling the final product (heifers and calves). In other words, the profitability of beef cattle production requires supplying the markets surrounding the farm.
3. Maintenance and feeding systems along with technological procedures significantly affect the possibilities of selling the heifers and calves. Further buyers visit and check the production process in the farm.

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THE SIMULATION OF TERRAIN VARIABILITY EFFECT ON FLOW MASS SENSOR ACCURACY

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Precision agriculture is the higher level of work on the field by local different condition of soil with optimization of using product factors. The main aim of this system is modification of work operation to local conditions of field. The mass flow monitoring with help of performance parameters on the hydraulic circuit is neglected. This mode of the mass flow monitoring is very perspective according to the historical evolution of the hydraulic systems enforcement on the machines. The measurement system based on a pressure drop in hydraulic circuit for drive the sifting conveyer. Measurement apparatus accuracy depended on a slope of sifting conveyer. Conclusion of our measurement is the possibility of exact measurement of the mass flow on the rod sifting conveyor according to pressure drop on hydraulic motor in laboratory conditions. In the paper are described measurements by different slope of working plane.

Introduction

By harvest of potatoes and other root-crops as well is not solving the flow mass monitoring for yield maps creating. In this article is described one of possibilities for flow mass monitoring based on pressure type sensors (Schwenke et al. 2002). The development of agricultural machinery for root-crops growing has been advancing in accordance with the requirements on the end product high quality, on the appropriate technology choice. We aimed specially on area of agricultural machinery for harvest of root-crops (potatoes and sugar beet). In context of expansion of precision technical system is necessary for this machinery – apparatus with possibility mass flow monitoring, which in accordance with apparatus for location of place machinery in the field (with help of GPS) it contribute to the yield maps creation (Schmittmann, Kromer, 2002). These maps will be possible include to kit of precaution and machinery, which will use in precision technical system. The measurement system based on a pressure drop in hydraulic circuit for drive the sifting conveyer. Measurement apparatus accuracy depended on a slope of sifting conveyer.

Anything the research projects existing on the world, which deal with possibility mass flow monitoring; for example potato, beet and maize for silage. The mass flow monitoring with help of performance parameters on the hydraulic circuit is neglected. This mode of the mass flow monitoring is very perspective according to the historical evolution of the hydraulic systems enforcement on the machines.

Materials

According to above mentioned reasons we decided on design of the laboratory apparatus with the hydraulic system for drive (Fig. 1). The laboratory measuring stand will contain the belt conveyor and the rod conveyor, which used on the harvesting machines for potato or beet. Often the foregoing working mechanisms propelled by gear hydraulic motor (gerotor) on the machines. The rotation frequency of the hydraulic motor is approximately from 10 to 500 min^{-1}. On the laboratory apparatus will drive working mechanism by hydraulic system.

Figure 1. Overview of measuring apparatus.

All measured data were recorded onto measuring apparatus. The main aim of work is observation of slope terrain influence on to pressure sensor accuracy.

The laboratory measuring stand will contain the belt conveyor and the rod conveyor (Fig 2), which used on the harvesting machines for potato or beet. Often the foregoing working mechanisms propelled by gear hydraulic motor (gerotor) on the machines. The rotation frequency of the hydraulic motor is approximately from 10 to 500 min^{-1}. On the laboratory apparatus will drive working mechanism by hydraulic system.

The rod sifting conveyor is possible to arrange in different working slope. It was changed to 5°, 7.5°, 10° and 12° according to real terrain variability on field.

Before start of measurement, was design methodology of measurement dependence the mass flow – potato on rod sifting conveyor, on pressure of hydraulic motor intended as an driving force of sifting conveyor. During measurement mass flow on rod sifting conveyor must have been in front of this conveyor front-end belt conveyor. On the part of rod conveyor we gave fix mass of potatoes (for sugar beet is it the same case). From information about working rate of conveyor, it was 0,85 $m.s^{-1}$ and information about required mass flow, we counted quantum of crops material on 1m conveyor.

Methodology of measurement contained these points:

1. Warm up hydraulic fluid on temperature about 40°C.
2. Weigh and resolve sized of potato in length 4m on rod conveyor.
3. Set up rod sifting conveyor power by hydraulic unit.
4. Regulate frequency approximately hydraulic motor drive rod sifting conveyor.
5. Set to work rod conveyor with potato or beet.
6. Record values of pressure in front of hydraulic motor during transit without weight and during work, flow mass, temperature on measuring machinery during flow crops material trough rod sifting conveyor.
7. Repeat measurement three times.
8. After repeat change values flow rate from 2 $kg.s^{-1}$ to 13 $kg.s^{-1}$.
9. Further change values frequency approximately hydraulic motor drive rod sifting conveyor from 10 min^{-1} to 150 min^{-1}.
10.

Figure 2. The conveyors configuration by measurement in laboratory conditions.

Results

According to previews measurement is it possible to say, that pressure drop is depended very strong on the mass flow of potatoes (or another material) on the conveyor which is driven by hydraulic motor. . For measurement by frequency approximately rod sifting conveyor 100 min^{-1} (Fig. 3) is linear dependent pressure drop on a mass flow. This situation is described by following relation: $y = 0{,}9148x + 0{,}4566$. The change of linear dependent on mass flow is statistically very close, coefficient of determination $R^2 = 0{,}9867$.

But for use in real fields condition is necessary to know what the terrain influence on the accuracy of measurement is. In this measurement was changed slope of sifting conveyor step by step. First measurement was by squared position (flat1). Measurement by different slope ware marked like slope1 (5°), slope2 (7.5°), slope 3 (10°) and slope 4 (12°). For measurement was used the same flow mass of potatoes (10.2 $kg.s^{-1}$). Different flow mass was used for control variants “slope4/2” and “flat2”. The value of flow mass was in this case 6.1 $kg.s^{-1}$. In the picture 2 are displayed means of measurement in different variants of working slope.

Measured data was compared by statistical analysis (ANOVA). The results of this operation are displayed in table 1. There are statistically significant differences between variants of measurement. By measurement on the horizontal position of conveyor wasn’t difference between measurement by different flow mass of potatoes. Between small a high slope was significant difference like between middle slope. The curves of measured values are displayed in picture 4. You can see the differences between pressure drop on actuator by the same flow mass of potatoes on the conveyor.

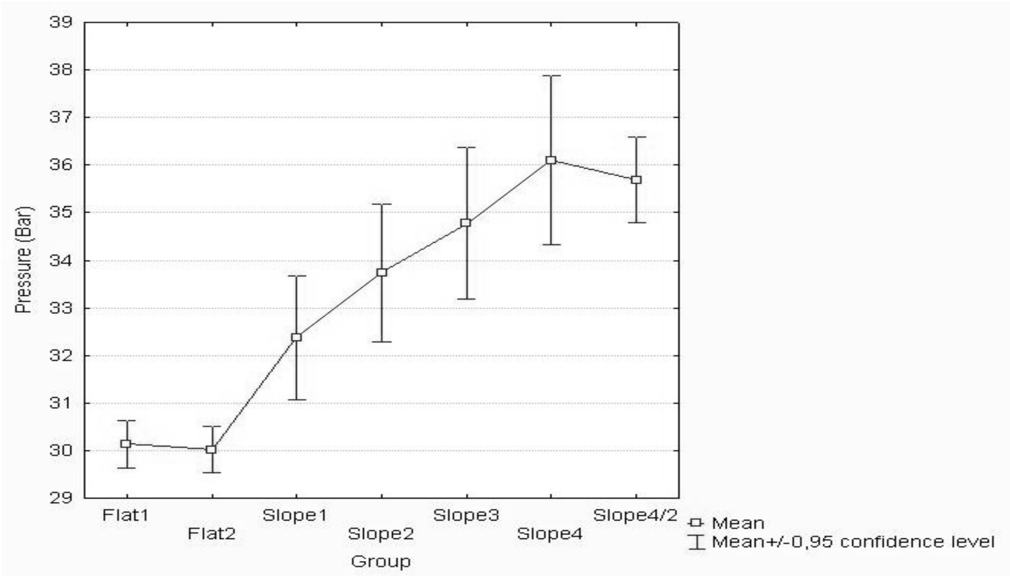

Figure 2 Means of measured values.

Table 1. Results of Fishers HSD test.

Version	Pressure (Bar)	1	2	3	4
Flat2	30,01570		****		
Flat1	30,13710		****		
Slope1	32,37063			****	
Slope2	33,74287			****	****
Slope3	34,77847	****			****
Slope4/2	35,68654	****			
Slope4	36,10030	****			

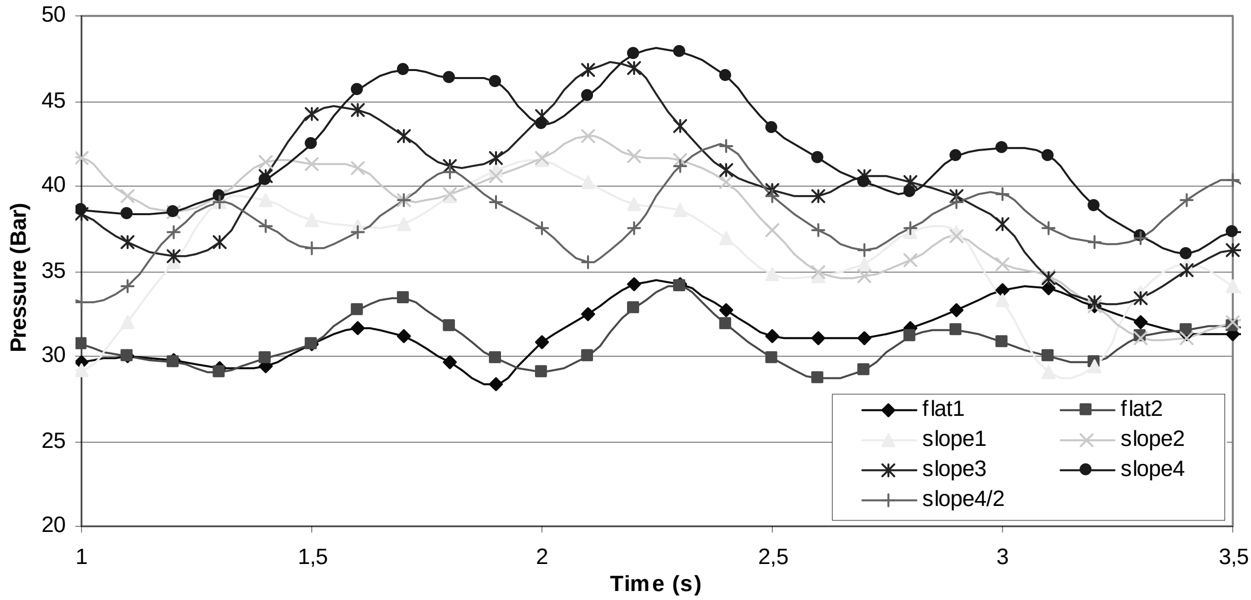

Figure 3. Parameters of pressure by different working slope.

The slope of conveyor has influence on the accuracy of measurement. For measurement in field conditions is necessary use the slope indicator for correction of measured values. Different flow mass doesn't have influence on accuracy of measurement.

Conclusions

Conclusion of our measurement is the possibility of exact measurement of the mass flow on the rod sifting conveyor according to pressure drop on hydraulic motor in laboratory conditions. In the paper are described measurements by different slope of working plane. The pressure drop on actuator has very strong linear dependence on flow mass of material on the conveyor. For measurement in the real fields condition is necessary use the slope indicator for correction of measured signal and with cooperation of GPS we can create yield maps of harvesting crops.

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CROP RESIDUE MANAGEMENT BY DIFFERENT SOIL TILLAGE

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Conservation tillage technologies where ploughing by a moldboard plough is replaced by tillers and shallow soil loosening in increasingly used as a soil treatment. It is typical for shallow soil tillage that all plant residues are left on the soil surface, or in the treated (tilled) upper soil layer. The plant residues can play very important role by next plant cultivation. In the experimental section was described the aim of research which is possible to summarize briefly as follows – the evaluation of soil physical properties on tillers work quality, evaluation of sweep tillers and disc tillers work quality by stubble ploughing. In the methodology part of the thesis are the measurements techniques explained. The results of this work are important because conservation (minimal) soil tillage technologies play an important role in plant production around the world. Especially conservation tillage systems with their modification are increasingly being introduced under an economic pressure on the field of the Czech Republic.

Introduction

Ways of farming change notably the structure soils and condition for crops growing too. Structure is changed above all external pressure mechanization agents, way fertilization, weather conditions and last but not least has significant influence also different way soil tillage systems, how confirmed in his washing Lhotsky (2000) and Powers and Skidmore (1984). In the conservation systems soil tillage is main imposition these systems limitation destruction soil textures concretion and soil conservation before effects erosion. Main reasons exploitation minimum soil tillage is in light of wardships soil textures limitation crossing after soil, above all shortly after its bulkage, soil conservation before water and windy erosion, facilitation and speeding soil tillage, limitation aeration on drying soils with high - powered mineralization organic masses and movement restriction with soil at unfit dampness. Minimum soil tillage includes above all summary proceedings progresses cultivation (Hůla et al., 1997), that are based on jointing or reduction of the number of single operation, progress with dull processing soil, when is dull depth or intensity processing or when are soil processed only in zone treatment or only in a certain layer soil profile

In the experimental section was described the aim of research which is possible to summarize briefly as follows – the evaluation of soil physical properties on tillers work quality, evaluation of sweep tillers and disc tillers work quality by stubble ploughing. The field plots were chosen at different part of central Bohemia. The first field was in VÚRV Ruzyně and on this field were evaluated soil physical properties and their influence on work quality by stubble ploughing. On the second field (in Bratřínov village) was at first evaluated straw distribution quality after harvest winter wheat and winter rap by conventional and axial combine harvesters and at second the effect of the plant residues irregular on-surface placement after harvest on residues placement in soil profile after treatment by shovel tiller. The third measurement was on field in Nechanice village. There were evaluated difference between sweep and disc tillers work quality with accent on plant residues distribution and size of clods after shallow ploughing.

Materials

On the VURV field ware sixty check points located and sighted by GPS system on a field with a acreage of 16 ha. Soil properties and characterization of plant cover were measured at these points. The aim of measurement was to evaluate local heterogeneity of soil properties and the influence of the heterogeneity on plant cover. The part of the measurement was to obtain quality of soil workability indices after single tillage operations. There was evaluated bulk density, clods hardness and size of clods and their influence on work quality by soil tillage. On the second field was evaluated straw distribution quality after harvest by combine harvester and crop residue management after shallow tillage by sweep tiller.

Quality scatter straw and chaff was investigate with the help of iron - plate boxes intermediate to the picking growth before crossing combine harvester. Subsequently was withdrawal from of all boxes captured exhibits so, that every box was divided on two halves. Achieved record was numerical assessed by the help of Christiansens coefficient.

$$C_u = 100 \cdot \left[1 - \left(\sum_{1=1}^{n} \left| i_{si} - i_m \right| / n \cdot i_m \right) \right] \quad [\%] \qquad (1)$$

where: i_{si} – weight of sample [g],
i_m – arithmetical average of i_{si} [g],
n – number of measurement.

This coefficient percentage share values departure of each metering from the total number of arithmetical average for all measurement. For evaluation influence uniformity placement postharvest the rest on quality stubble ploughed under, was on lots immediately after harvest and withdrawal designs chaff straw effected stubble ploughed under. Appraised uniformity and quantity the plant rest. For evaluation is necessary first determine quantity the plant rest on the top of soil after harvest, when this value presents 100 %, and subsequently after fulfillment work stages, when will get to changes in quantities postharvest the rest on the top and in processed layer of soil. For sweep a disc tillers comparison was chosen field in Nechanice after winter wheat harvest.

Results

The formation of large and hardly processed clods from compacted soils by primary tillage is important cause of higher energy consumption during soil processing and furthermore the soils worst quality. The intensity of slice breaking more notably declined during the compacted soil tillage; nevertheless the tillage energy consumption presents a part of compacting influence on soil workability only. Presented results show the great difference in soil workability commensurate with soil compaction caused by machines' overpasses mainly under higher soil moisture conditions.

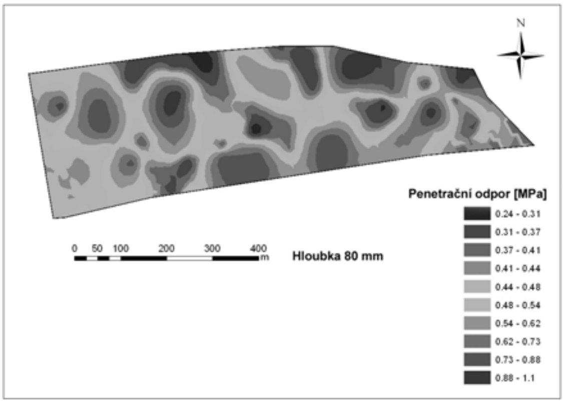

Figure 1 Penetrometric resistance in depth 80 mm.

The map (Fig. 1) shows the heterogeneity of soil penetration resistance within the drilling depth after the tillage and winter wheat seeding. The maps show localities with a specific soil penetration resistance. It has proved that localities with statistically important differences in values of soil penetration resistance have occurred on the field.

The measurement on the selected field pointed out the large differences in quality of tillage caused by a local heterogeneity of topsoil part physical properties of a soil profile. As the main reason of the differences is possible to consider a different grade of soil compaction caused by overpasses of tractors, harvest machines and transport means on a field. The important condition for establishing of new high productive plant cover of field crops is to reduce the soil compaction during former working operations to a lowest possible measure. There is dependence between penetrometric resistance, soil bulk density and size of clods.

Evaluation of straw distribution quality was observed by winter wheat harvest by axial and tangential combine harvester. In both cases were by higher throughput worse regularity of straw distribution (fig. 3).

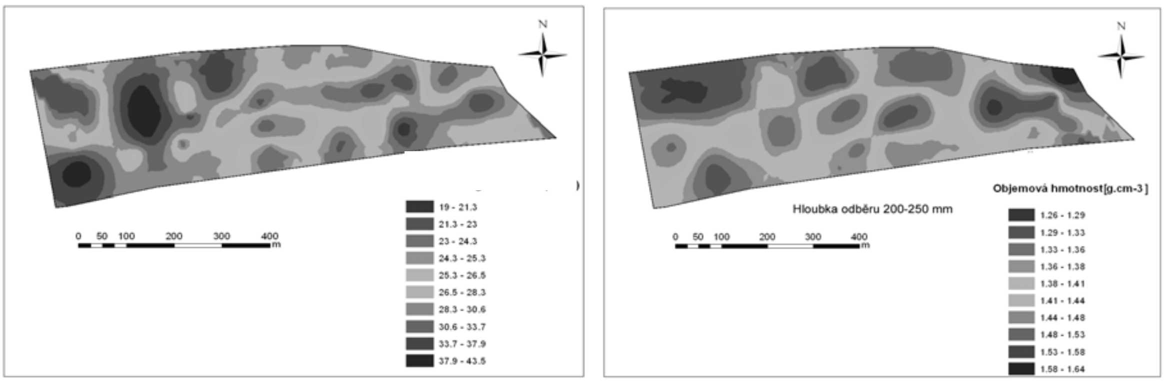

Figure 2. Median weighted average of clods (left), soil bulk density (g.cm^{-3}) (right).

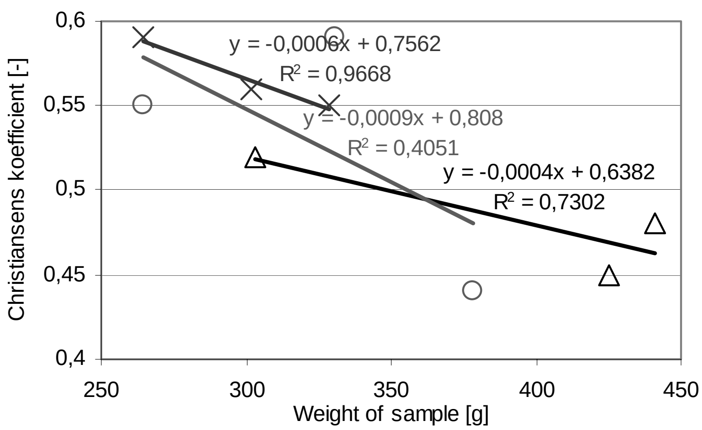

Figure 3. Christiansen coefficient for straw distribution by harvest (x-CASE, Δ-CASE without modification, o –John Deere)

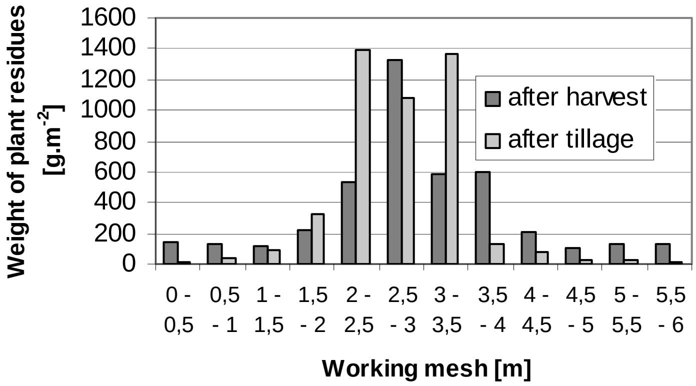

Figure 4. Distribution of plant residues after stubble ploughing (bed spreading)

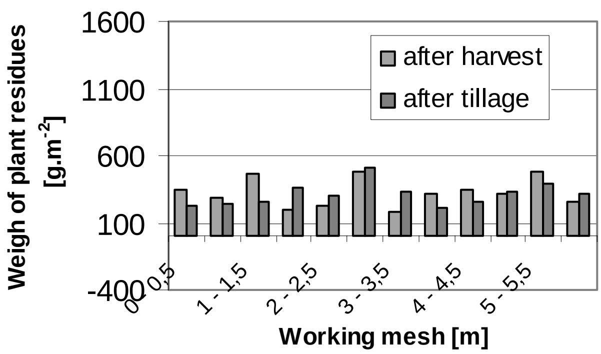

Figure 5. Distribution of plant residues after stubble ploughing (good spreading)

In the picture 4 and 5 you can see effect of the plant residues irregular on-surface placement after harvest on residues placement in soil profile after treatment by shovel tiller. The plant remains mixed into soil after tillage were placed as irregularly as they were before tillage. The plant remains left on the soil surface were placed more evenly, but the separation of small and big particles took place. The long and big particles stayed on the field surface and majority of small ones were mixed into soil. The irregularity of small plant remains in treated soil profile and so their great concentration at the particular place could affect next plant germination and growth.

On the last field were evaluated differences between sweep and disc tillers work quality with accent on plant residues distribution and size of clods after shallow ploughing. On the field have been created 6 variants soil tillage (1R – sweep 1x, 2R – sweep 2x, 1R2D – sweep and then disc, 1D – 1x disc, 2D – 2x disc, 1D2R – disc then sweep), depth processing was adjusted on 70 mm. Like variant 0 was at evaluation marked materiality of plant residues on the surface before stubble ploughing.

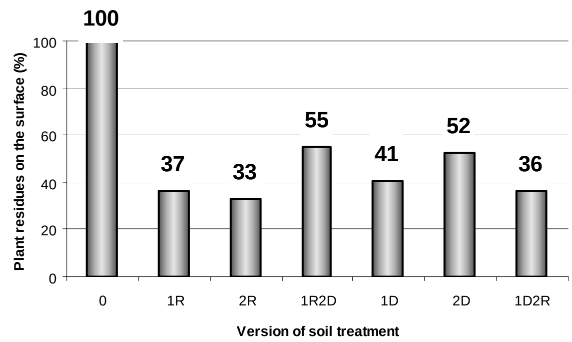

Figure 6. Rate of plant residues on the surface by different variant of soil tillage

The sweep tiller left more plant residues on the soil surface than disc tiller (Fig. 6). By the second treatment by disc tiller increase the number of plant residues on the surface. There aren't statistically significant differences between versions of soil treatment.

Conclusions

The field trial proved the important decrease in soil tillage quality. The decrease is a reason of former soil compaction caused by machines' overpasses. Carried out measurement on a field with 16 (ha) acreage enabled to evaluate the differences in soil tillage caused by heterogeneity of topsoil part physical properties of soil horizon. The main reason of irregularities of soil properties was the different grade of topsoil compaction caused by machines' overpasses on a field. The map of clods' hardness and map of soil penetration resistance on seeding bed's depth was created. Results are contributions to an evaluation of heterogeneity of soil technological properties on fields and influences that have an impact on tillage quality and plant cover establishment.

There was recognized different physical properties and it was evaluated dependence (correlation) between concerning grain size distribution, bulk density of soil, penetration resistance and work quality of tillers by stubble ploughing.

The plant remains mixed into soil after tillage were placed as irregularly as they were before tillage. The plant remains left on the soil surface were placed more evenly, but the separation of small and big particles took place. The long and big particles stayed on the field surface and majority of small ones were mixed into soil. The irregularity of small plant remains in treated soil profile and so their great concentration at the particular place could affect next plant germination and growth.

By evaluation of differences between sweep and disc tillers work quality with accent on plant residues distribution was recognized that sweep tiller left more plant residues on the soil surface than disc tiller.

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THE PREDICTION OF PRODUCTS WITH INTERMITTENT DEMAND

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Modern society has consume character pointing to maximization of satisfying its material needs. Logistics is the key factor in economy of each company is one of main expense in companies and help to keep continuous flow of many economical transactions.
The effective control of logistics has been recently assigned as the key point of possibility, how to increase profitability and company's competition ability.
The source of competition advantage is seen in the company's ability to be different in eyes of their costumer, and to work with lower expenses.

One of aims of each company is to have optimal amount of their inventories and hereby achieve higher level of customer service, shortening of delivery times and decreasing of stock hold expanses. Along the volume of inventory planning is absolutely necessary to predict future demand as accurate as possible. In this lecture I am comparing two methods used for prediction of intermittent or erratic demand.

Examples of products with intermittent demand are mostly spare parts in automotive and air industries, unique production lines and machinery or supply of special pharmaceutics products.

Inventories with intermittent demands are quiet widespread in practice. Data for such items consist of time series of non-negative integer values where some values are zero.

Croston's Method is the most widely used approach for intermittent demand forecasting, and involves separate simple exponential smoothing forecasts on the size of a demand and the time period between demands. Other authors have suggested a few modifications to Croston's Method that can provide improved forecast accuracy.

New simulating Method designed by Smart&Willeman (2001) called boot-strapping is very hopeful and its first application had positive economical effects. The method is quite easy and focuses on estimation of allocation demand probability during the delivery time guaranteed by the producer. Process is made from time series of historical inermittent demand.

Key words: Intermittent, erratic demand, Croston's Method, Exponencial smoothing, Boot-strapping

1. Introduction

Modern society has increased their requirements pointing to the maximization of satisfying its material needs. The effective control of logistic has been recently assigned as the key point of possibility, how to meet customer needs, how to increase profitability and company´s competition ability. Logistic is also the key factor in the economy of each company, it is one of the main expense for companies (inventory carrying costs are commonly 25%-35% of inventory value), and helps to keep continuous flow of many economical transactions.

In recent years, probably no logistic function within companies has grown as rapidly as forecasting, in large part due to the emphasis on supply chain management. Accurate forecasts are critical for managing and planning within a total supply chain environment, with its emphasis on customer service, efficiency, timing and decreased inventories.

2. Importance of accurate forecasting

In today`s global business environment, strategic planning and design tend to focus on supply chain management, which encompasses all of the facilities, functions, and activities involved in producing a product of service from suppliers to customer. Without accurate forecasts, large stocks of costly inventory must be kept at each stage of the supply chain to compensate for the uncertainties of customer demand.

A forecast is a prediction of what will occur in the future. A forecast of product demand is the basis for most important planning decisions. Planning decisions regarding scheduling, inventory, production, facility layout and design, workforce, distribution, purchasing, and so on, are functions of customer demand.

Forecasting is an uncertain process. It is not possible to predict consistently what the future will be. In the current international business environment, consumers have more product choices and more information on which to base choices. They also demand and receive greater product diversity, made possible by rapid technological advances. This makes forecasting products and demand more difficult. Consumers and markets have never been stationary targets, but they are moving more rapidly now than they ever have before.

3. Scope

This paper aims to introduce exponential smoothing and bootstrapping, methods used for the forecasting of intermittent demand.

Intermittent demand is most commonly found in the service parts businesses of the aerospace, automotive, high tech/electronics, utilities, and industrial machinery industries. It is also found in capital goods companies producing expensive, big-ticket items and, to some extent, in retailing.

Invetories with intermittent demands are quite widespread in practice. Data for such items typically contain a large percentage of zero values, often 30 percent or more, with non-zero values mixed in randomly.

4. Method description

4.1. Exponential smoothing

Exponential smoothing is one of the most popular and frequently used forecasting technique, and it is an averaging method that weights the most recent data more strongly.

The exponential smoothing forecast is computed using the formula:

$$Ft+1 = \alpha Dt + (1-\alpha)Ft$$

Ft+1 the forecast for the next period
Dt actual demand in the present period
α a weighting factor referred to as the smoothing constant, is between 0-1 and reflects the weight given to the most recent demand data
Ft the previously determined forecast for the present constant

4.2. Bootsrapping

New simulation method created by Smart and Willeman (2001) called bootstrapping is hopeful and its first implementation note great economical effects. It is statistical method that forecasts average demand per period and customer service level inventory requirements by using samples of historical demand data to create thousands of realistic scenarios that show the evolution of cumulative demand over a lead time.

5. Tested products

I have tested spare parts for trucks in company Avia. Avia's portfolio contains over 10 000 spare parts, approximately half of them are imported and second half made by the company. I have made ABC analysis, to split the products to three categories according to its share on the profit.

Table 1. Example of time series of category A:

Item	Model	Description	Total Sale	Sale 01	Sale 02	Sale 03	Sale 04	Sale 05	Sale 06	Sale 07	Sale 08	Sale 09	Sale 10	Sale 11	Sale 12	ABC
Z489400502	AD100	Ventilátor /LHD/	41	6	6	3	2	0	0	2	4	2	7	4	5	A
Z489783300	AD100	Vložka Filtr	87	23	2	3	0	2	3	9	0	0	20	13	12	A
Z489789800	AD100	Vložka filt.olej	97	25	10	3	0	0	5	17	0	30	0	5	2	A

Table 2. Example of time series of category B:

Item	Model	Description	Total Sale	Sale 01	Sale 02	Sale 03	Sale 04	Sale 05	Sale 06	Sale 07	Sale 08	Sale 09	Sale 10	Sale 11	Sale 12	ABC
Z483000508	AD100	Svítilna přední	121	12	5	30	0	8	15	4	11	16	7	2	11	B
Z481510041	AD100	Svazek rámu	3	0	1	1	0	1	0	0	0	0	0	0	0	B
Z481510056	A2130	Svazek rámu	3	0	0	0	0	0	1	0	0	0	0	1	1	B

Table 3.Example of time series of category C:

Item	Model	Description	Total Sale	Sale 01	Sale 02	Sale 03	Sale 04	Sale 05	Sale 06	Sale 07	Sale 08	Sale 09	Sale 10	Sale 11	Sale 12	ABC
Z992914699	A2130	Zátka s magnetem	5	0	0	2	0	0	0	0	0	0	3	0	0	C
Z992930070	A2130	Pojist. kroužek 70	4	0	0	0	4	0	0	0	0	0	0	0	0	C
Z992931035	AD100	Pojist. kroužek 35	66	0	0	0	0	50	0	0	0	16	0	0	0	C

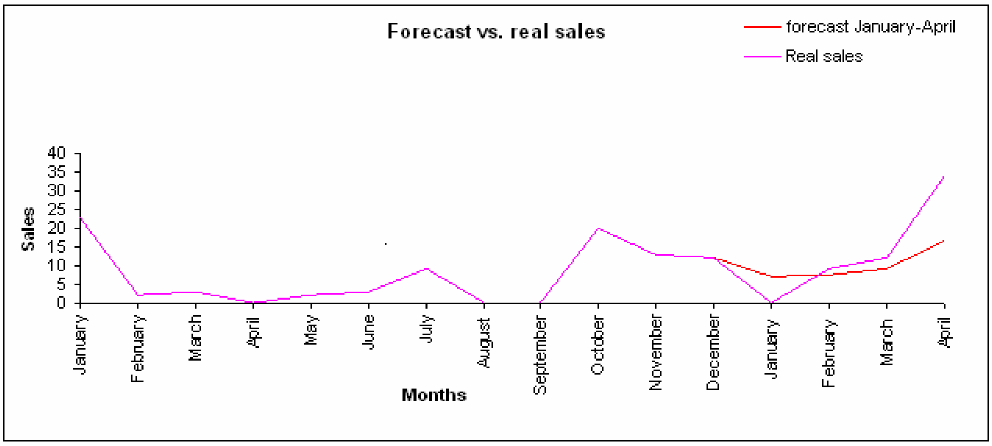
6. Conclusion

6.1. Exponential smoothing

Conventional statistical forecasting methods can produce credible forecasts of the average demand per period when demand is intermittent, but they cannot produce accurate estimates of the entire distribution of all possible lead time demand values.

Table 4. Example of forecasted values by exponential smoothing

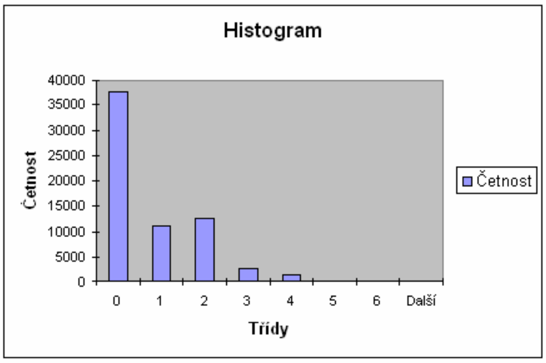
Month	Real sales	Forecast
January	0	7
February	9	8
March	12	9
April	34	16
Average	14	10



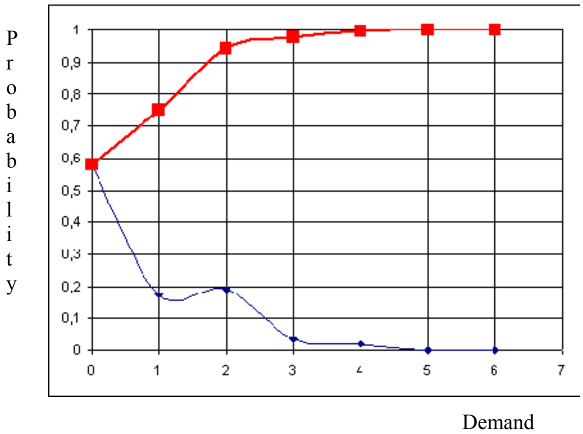
Graf 1. Forecast vs. real sales

6.2. Bootstrapping

Forecasting method, based on bootstrapping provides forecasts of intermittent product demand over a fixed lead time. Is it a statistical method that forecasts both average demand per period and customer service level inventory requirements.



Graf 2. Result of simulation



Graf 3. Distribution function

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THE ANALYSIS OF RELATIONSHIP BETWEEN THE ELECTRICAL CONDUCTIVITY VALUES AND THE VALUED SOIL-ECOLOGICAL UNITS VALUES

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This article describes the results of the correlation analysis between the soil electrical conductivity and BPEJ (valued soil-ecological units). The measurements were made in 2006 on the School Agribusiness Land Farm in Lány established by Czech University of Life Sciences in Prague. The soil electrical conductivity (EC) was measured by contact method by means of a sensor with six electrodes. The measured soil EC data were compared with data obtained from BPEJ maps. The aim was to verify, if any relationship exists between the soil EC and BPEJ. The achieved results show that the same dependency exists between the values of the main soil unit of the BPEJ code and soil EC. The achieved results could be used in the precise agriculture system to improve the decision process.

Key words: soil EC, soil classification, soli variabilty

Introduction

Within the precise agriculture system, various factors could be used to express the variability on the land, e.g. crop yield (Franzen, 2007; Lotz, 2007), data from N-sensor (Melchiori et al., 2007), tillage soil resistance (Van Bergeijk et al., 2001, Kheiralla et al., 2004). The parameter, which could be used in the precise agriculture system to manage the machines and to form the application maps are BPEJ values. The valued soil-ecological unit is a five-digit number code that expresses the main soil and climatic conditions, influencing the production soil ability. The first digit expresses the relevant climatic region. The second and third digit defines the specific main soil unit. The main soil unit is a special purpose grouping of the soil forms, with the similar ecological properties, characterised by a morfogenetical soil type, subtype, soil building substrate, granularity, and in case of certain main soil units by a considerable descent, soil profile depth, skeleton grade and grade of hydromorfism. The fourth digit gives the combination of the descent and land exposition considering the cardinal points. The fifth digit gives the combination of the soil profile depth and its skeleton grade. The detailed characteristics of individual codes are given by the Regulation of the Agriculture Ministry No. 327/1998 Col., in the last edition (Regulation No. 546/2002 Col.).

Measurement of the soil EC may be useful for mapping of the soil differences on the lands. Despite the amount of various sensors used in the system of the precise agriculture, the soil EC measurement presents a simple and cheap instrument for determining of the soil variability on the land. In case of certain soils, the soil EC values changes are in relation with the soil properties as the portion of organic mass, sand and clayey particles. FARAHAI, 2007 stated during its experiments that a high content of the sand particles and low content of clayey particles was on the places with the lower soil EC, to the contrary, the higher content of clayey particles and organic mass was on the places with the higher soil EC value. These soil properties could have a big influence on the yield crop.

In case of classical farming way, when the input are applied on the whole land in the same amount (e.g. fertiliser), the achieved yields are not same within the land. This variability may cause many effects. One of the important factors influencing this variability is the soil variability, because it impacts on such factors, as the ability to keep and distribute the water, also the nutrients near the plants root system. The soil EC is also significantly influenced by the actual soil humidity, but as states FARAHAI, 2007 „Soil water has a strong effect on the values of soil EC, but research shows that even though values of soil EC may change as soil water changes, the patterns of a soil EC map stay unchanged. Thus, a single soil EC map for a field is probably sufficient for many years to characterize the soil variability patterns." DOERGE at al., 2007 states, that main factors influencing values of soil EC are pore continuity, water content, salinity level, cation exchange capacity and soil depth.

Materials and methods

In 2006, the soil EC measurements were made on the selected land “NS KONOPAS A 6001_3” of the School Agribusiness Land farm in Lány. The contact method was used for soil EC measurement be means of a by tractor carried measuring frame with six electrodes – see Fig. 1. Measuring instrument was developed by the Department of Machinery Application, Technical Faculty of the Czech University of Life Sciences in Prague. This equipment records the soil EC values into a measuring central, incl. the position data, in the 5 seconds intervals. The position data were obtained by using the GPS unit. The data chains are stored into the .txt format. The BPEJ data were bought in the digital form by the Výzkumný ústav meliorací a ochrany půdy, v.v.i. The ArcView 9.1 software with Geostatistic and Spatial analyst add-in was used for processing.


Figure 1 Soil conductivity measuring

Results and discussion

Two data sets were used for analysis, namely soil EC and BPEJ values. Several modifications were performed on the initial data set prior to statistical processing and evaluation. Before the proper elaboration, the voltage and electrical current data, measured by the measuring central, were re-calculated to the soil EC values. Non-complete records were deleted from the basic file, same as the records containing zeros and extreme values. In such way modified file was then processed by the procedure described in THYLÉN, 1997, KUMHÁLA et al., 2001. As both authors mention identically, the most fails occur in the moment of driving the machine into a new row, as well during the driving out of the row. Thus, values that did not describe precisely the factor measured were removed from the initial data set, e.g. errors possibly occurring when recessing the conductivity measuring equipment. These values were eliminated by trimming the marginal points recorded. Values larger then double of the average were also excluded from the initial data set. The time series was smoothened during subsequent modification. A simple running average method was applied to smoothen the time series of all measurements.
The following formula was used:

$$\hat{Y}_t = \tfrac{1}{3}(Y_{t-1} + Y_t + Y_{t+1}) \quad [\mathrm{mS.m^{-1}}] \qquad (1)$$

where: Y – original values soil EC [$mS.m^{-1}$] at time t.

Average for value in the following instant of time is calculated after obtaining the average in given time point. Fig. 2 illustrates an extract from the time series of conductivity values. Original and transformed values were included in the graph. Figure suggests that distribution of values is not of a random nature, but rather follows a continuous curve. Statistical properties of transformed values for soil EC are provided in Table 1. The extent of values expressed by maximum and minimum of values and also the variation coefficient values document the variability of individual data files. The low skew values document that the data have a normal distribution. Modified data and main value unit from BPEJ code data were processed using ArcView software.

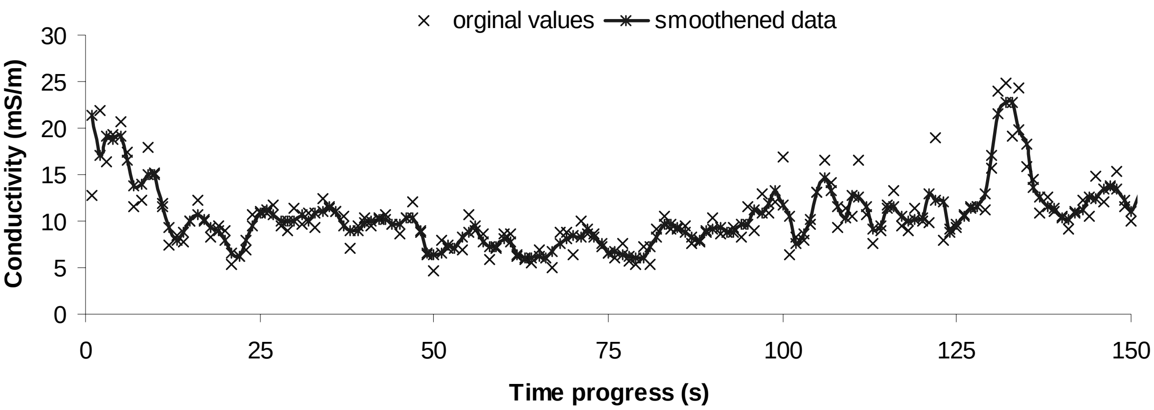

Figure 2 Time progress measured and adjusted soil conductivity values

Table 1 Statistical properties of transformed data

Variable/Property	Soil Electrical Conductivity ($mS*m^{-1}$)
Mean value	13.55
Median	13.12
Standard deviation	5.22
Variance of selection	27.21
Error of mean value	0.88
Acuteness	-0.67
Inclination	0.43
Minimum	5.81
Maximum	27.79
Quantity	3509.00

As already mentioned in the foreword, the BPEJ system consists of five digits, classifying the soil from various points of view. From this code, a part was used that corresponds to the characteristic of main soil units, and which could have the values in the range from 1 to 78. Characteristic of individual code values is mentioned in the Annex 2 of the Regulation No. 327/1998 Col. But, because no main soil units appear in the given area in the whole numeric range, it was made a re-classification for the purpose of further evaluation of the results of original values from the dial values into the following eight categories mentioned in Table 2:

Table 2 New classification value of main soil units

Code of main soil unit by BPEJ classification	New soil units	Charakteristic of main soil units
12	1	*Haplic Luvisols, Haplic Cambisols and Luvic Cambisols, including stagnic forms, on polygenetic materials, loamy with clayey subsoil, with medium content of stones and good water-holding capacity, occasionally moist in the subsoil*
15	2	*Haplic Albeluvisols and Luvisols, including stagnic forms, on polygenetic materials with eolian admixture, loamy to clayey, with medium content of stones and good water regime*
25	3	*Haplic Cambisols, including leached forms, eubasic to mesobasic, rarely Pelic Cambisols on cretaceous and hard marls, flysch, or permocarbonian rocks, loamy, with medium content of stones and good water-holding capacity*
30	4	*Cambisols eubasic to mesobasic on mixtures of sedimentary rocks – sandstones, permocarbonian rocks, flysch, loamy, with medium content of stones and good water regime or dry*
47	5	*Haplic Stagnosols, Luvic Stagnosols, Stagnic Cambisols, on polygenetic materials, loamy, more clayey in subsoil, with medium content of stones and temporary waterlogging*
62	6	*Gleyic Phaeozems, including calcareous forms, on alluvial deposits, loess and loess loams, loamy or sandy, without stones, with temporary waterlogging by groundwater in the depth 0.5 to 1 m*
64	7	*Haplic Gleysols, Haplic Stagnosols, Fluvic Gelysols, on polygenetic materials, alluvial deposits, clayey materials and marls, cultivated, with improved water regime, loamy to clayey, with no or low content of stones*
67	8	*Haplic Gleysols on different materials often with layered structure, in wide terrain depressions and plains, loamy to clayey, dependent on water level in the vicinity of streams or rivers, flooded, with difficult drainage*

These new, above-mentioned categories were assigned to the corresponding data in the geo-database. In such way re-classified data of the main soil units were used during the further analysis. The total surface area of the analysed land was ca 59.78 ha. The following Fig. 3 shows the distribution of individual main soil units acquired from the BPEJ code with new classification of the main soil units on the trial land. The percentage representation of individual categories of the main soil units on the monitored land shows the following Fig. 4. It is evident from the given figure that the first new soil unit was represented from 18.19 %, the second new soil unit from 21.73 %, the fifth new soil unit was represented from 18.34 % and the fourth new soil unit was represented from 7.87 %. The biggest part 30.88 % had the third new soil unit. On the contrary, the sixth, seventh and eighth new soil units with the shares of 1.57 %, 0.93 % and 0.55 % amounted only 3.05 % from the total land surface area. The 3509 soil EC values were measured within the monitored land with the surface area of 59.78 ha, which represents ca 58 samples from every hectare. The Table 3 gives the number of soil EC values within every interval. As is obvious from the table, the biggest amount of the soil EC values occurs in the interval 6.55 to 9.31 mS $*m^{-1}$. The point layer of the soil EC values and the polygon layer of the corresponding values of the main soil values of the BPEJ code were spatial connected by the ArcViev software. In such manner was created a table, where the fields from one attribute table with the attribute data from the second table were linked-up on the basis of mutually identical geo-references of both data layers. The soil EC values were divided into eight categories according to the corresponding values of the main soil units. The Table 4 presents the number of soil EC values, recorded for every category of the main soil unit. As it is evident from the table, the number of measured soil EC values corresponds approximately to the share of the individual main soil units on the total surface area.

The soil EC map is on the Fig. 5 showing the spatial distribution of the measured values. This map was created by the Kriging interpolating method, which uses the weighted area, when the weights of individual values give the variograms parameters. There are obvious, from visual comparison of the main soil units distribution map and soil conductivity map, some identical zones. The data, arisen by interconnection of corresponding geo-referenced soil EC and BPEJ values were further analysed by means of Pearson correlating coefficient. The average soil EC values were calculated for individual main soil units. The R^2 coefficient reached the value of 0.9585. The following Fig. 6 shows the correlation relation between the main BPEJ soil units and soil EC values.

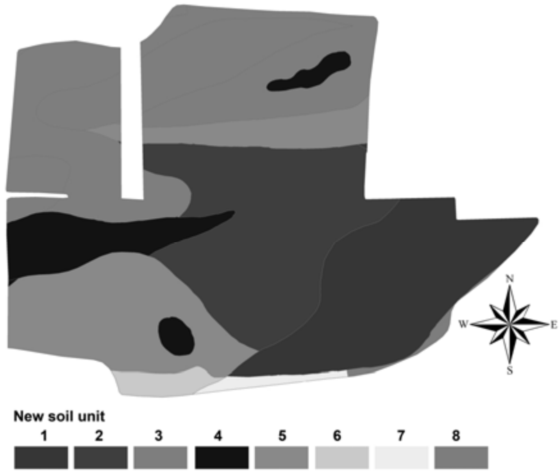

Figure 3 The map of distribution of individual main soil units obtained from the BPEJ code values

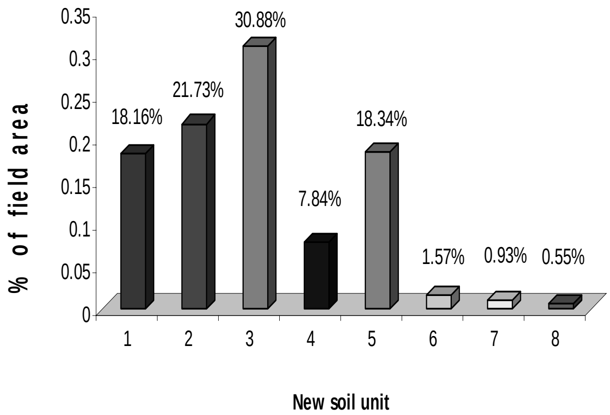

Figure 4 Percentage diagram of individual soil units on the monitored land surface area

Table 3 Quantities of soil EC values in individual classes of rates

interval of soil EC	The number of values measured in each interval of soil EC
1.367115 - 6.551991	221
6.551992 - 9.317615	731
9.317616 – 12.127282	614
12.127283 – 15.024916	604
15.024917 – 18.049726	582
18.049727 – 21.712967	488
21.712968 – 27.346794	261
27.346795 – 38.952838	8

Table 4 Quantity of measured values according to the individual intervals

soil unit	number of measured point
1	778
2	602
3	1281
4	202
5	595
6	28
7	16
8	7

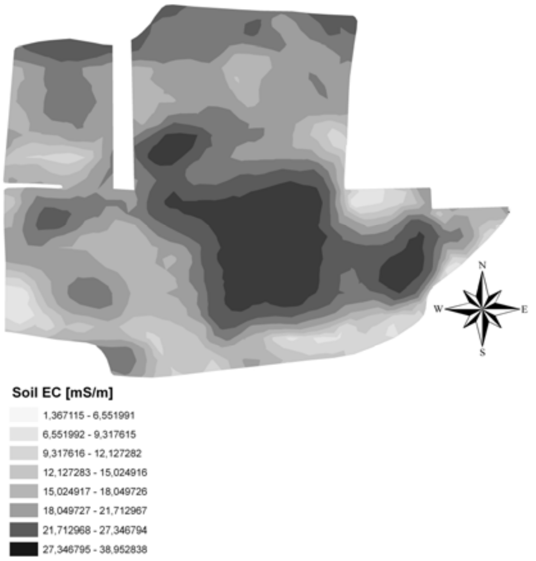

Figure 5 Map of soil EC

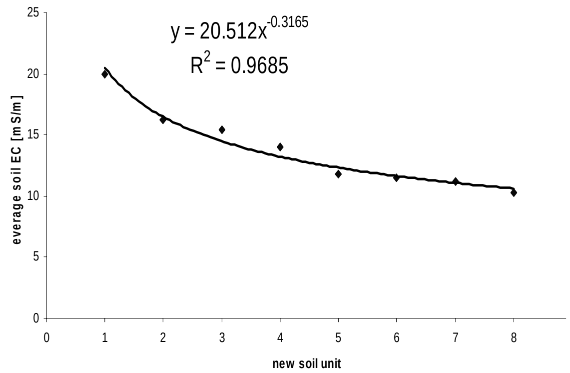

Figure 6 Diagram of correlation of the average soil EC values with the main BPEJ soil units

The correlation grade between the soil EC values and main soil unit of the code shows a strong dependency. The soil EC values describe well the land soil variability, which is obvious from the correlation coefficient level.

Conclusions

The soil EC measurement shows the actual land variability, and this monitoring is cheap and quick. As shows the analysis results, the BPEJ data are usable in the precise agriculture system for the decision process support. The BPEJ values have many positives, because they characterise the lands according to their reproduction capabilities. By their use, e.g. by production zones determining, it is necessary to keep in mind the fact that the agricultural lands could be devastated on some tracts, either by their assemblage, either by the wind and water erosion or by other influences. It is therefore necessary to interpret the possible differences also in the context of land historical evaluation knowledge. As an important way, how it is possible to obtain the information concerning the surface area variability of the soil conditions in the frame of the whole land could be considered the land electrical conductivity measurement. Many authors, as e.g. (Jaynes, 1995, Kitchen et all., 1998, Sudduth et all., 1994) refer to the concrete possibilities of use of the soil EC data to determine the production zones and to manage the lands productivity. The soil EC maps cannot determine, which input quantity should be applied on various land parts, but they may display and identify the soil differences on the land, which is important both for the sampling places determining to soil samples analysis, and for production zones determining.

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THE ANALYSIS OF EFFICIENCY OF THERMAL WEEDER AT KILLING WEEDS

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The thermal weeder becomes a non-replecable helper at killing weeds in ecological agriculture. In the field tests we investigated influence of parameters changing of thermal weeder burner on control of four dominant weeds variety in four growth stage in seeded onion. The gas consumption, which is dominant indicator influenced on efficiently utilization of thermal weeder, depend on killing weeds growth stadium if Optimum result can be done. Good effect (80% killed weeds) was obtained at beginning of growth stadium of weeds (2-4 germinate leaf) at gas consumption 30 kg.ha^{-1}. However on reaching the same effect in high growth stadium of weeds (more then 10 germinate leaf) we exceeded value of gas consumption of 60 kg.ha^{-1}. Also indicator gas consumption has it limits at growing cultivated crops. In the test, when exceeded value of 70 kg.ha^{-1} come up to the non-returnable changes also in seeded onion, which has effect on it slow growth and decreased harvest.

Key words: ecological agriculture, flame weeder, weeds

Introduction

The thermal weed control is method using high and low temperature on killing weeds. At thermal weed control we use fact, that in consequence of overheating of weeds are made non-reversible changes which cause their killing. The optimum tool effect depend on amount of transferred energy, which cause increase temperature of weed tissue. Non-reversable changes on weeds are made already in increasing their temperature on 45^0 C even without mechanical damaging of weeds (Soukup, 1996).

The thermal weed control by using flame is today most used physical methods with high range of using in agriculture (Ascard, 1988). It is used mainly in growing row cultivated crops such as corn, onion, carrot etc.

The thermal weeder can kill the weeds without damaging of soil or without intervention into the root system of crops. The thermal weeder possibly can be used mainly in dry areas where preemergent used herbicides doesn`t work good enough. Main advantage is fact, that seeds of non-emerged weeds are not ploughing onto surface and there are not conditions for their another start (Mattsson, Nylander, Ascard, 1989).

At working speed 3,5 km.h^{-1} and consumption of gas 50 kg.ha^{-1} is effect in distance 20 cm cca. 30% at 10 cm already 65%. The effect of weeder depends on working speed. At small change of working speed from 1,5 km.h^{-1} to 3km.h^{-1} are made changes on effect of killing weds up to 70% (Lacko-Bartošová a kol. 1995).

Material and methods

The field tests of influence of speed of tractor and rate of flame on efficiency of killing weeds we made on farm Dolina s.r.o. To obtain experimental verify of influence of tractor speed we choose following methodical progress: experimental field tests make on selected parcel 19 x 76 m with record about soil condition, after ploughing and tillaging ensure fertilizing of soil according to seeded crop and soil condition, into the soil seed the onion by machine with 0,35 m space between the row, parcel divided into 24 plots (12 – treatments, 4 – repeats) with plot size 1x10 m, single test plots mark with the number of treatment and repeat and secure their position according to Zimmerman method of field tests, during growing make four treatments by flame weeder Reinert DA-211 (fig. 1) with parameters in tab. 1, efficiency of treatment monitor by counting weeds before treatment and three days after treatment using steel frame 0,3 x 1m, influence of treatments on harvest monitor by collecting 8 m inner row of onion, record growth stage of weeds **D,** height of burner to the horizont $\mathbf{h_H}$, angle of burner to the horiyont φ, speed of tractor $\mathbf{v_p}$, number of weeds befor and after the treatment, pressure of gas $\mathbf{p_H}$, gas consumption $\mathbf{M_p}$, veather condition and results of harvest.

Figure 1 Flame weeder Reinert 250SB

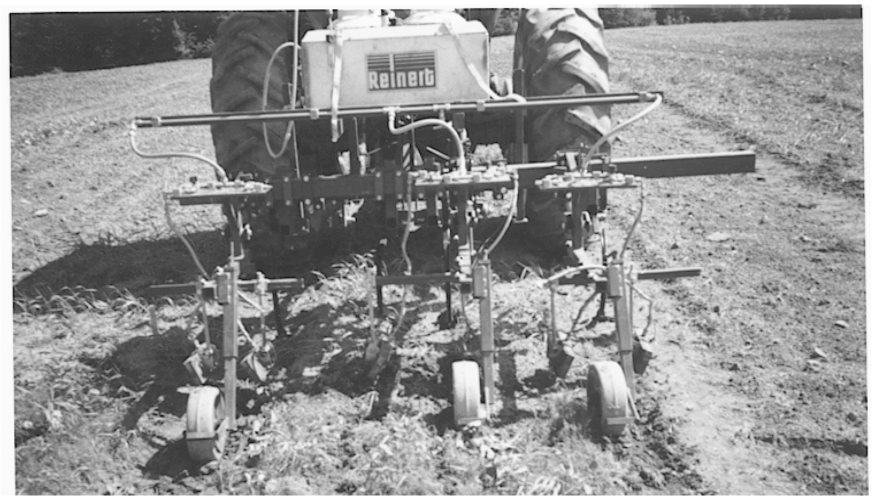


Table 1 Parameters of treatments

Treatment	Speed of tractor $km.h^{-1}$	Pressure of gas MPa	Constants
O1	2	0,15	$\varphi = 45^0$ $h_H = 0{,}1m$
O2	2	0,2	
O3	2	0,25	
O4	3	0,15	
O5	3	0,2	
O6	3	0,25	
O7	4	0,15	
O8	4	0,2	
O9	4	0,25	
O10	5	0,15	
O11	5	0,2	
O12	5	0,25	

Results and discussion

At checking influence of tractor speed and intensity of flame on efficiency thermal weed control we proceed according to introduced methodic. The term of seeding, growing, field test is shown in tab. 2.

The main parameters influenced efficiency of weed control in our tests was growing stage of weeds D and change of gas consumption M_p. The growing stage was recorded at predominate weed species (Avena Fatua, Chenopodium album, Raphanus raphanistrum and Plantago major).

Measurement of gas consumption we made by measuring weight in single work condition in 30 min intervals. Setting of gas pressure we made by control valve and manometer with Bourgon tube (range 0-5 Mpa, accuracy 1,5%). After we measure one clock gas consumption then we calculate average hectare gas consumption with regard on tractor speed, width of flame weeder and gas pressure. The hectare gas consumption we used such as comparative parameter on establishing of efficiency of weed control depended on change of tractor speed and change of gas pressure (tab. 3).

Table 2 Field records

Day of seeding	8. máj 2004
Field test	$P_H = 6{,}4$ $P_2O_5 = 1982\ (H^+)$ $Ca = 3359\ (M)$ $OM = 4{,}9$ $Mg = 419\ (m^+)$ $K_2O = 740\ (H^+)$
Fertilization	N = 12% P = 18% K = 12% + Mg = 3% 500 kg / ha
Day of growing	19-20. máj 2004

Table 3 Parameters of treatment

Treatment	Speed of tractor, km.h^{-1}	Pressure of gas, MPa	Consumption of gas, kg.h^{-1}	Time of treatment, h	Consumption of gas, kg.ha^{-1}
O1	2	0,15	7,24	5	36,2
O2	2	0,2	9,7	5	48,5
O3	2	0,25	12,1	5	60,5
O4	3	0,15	7,24	3,33	24,1
O5	3	0,2	9,7	3,33	32,3
O6	3	0,25	12,1	3,33	40,3
O7	4	0,15	7,24	2,25	16,3
O8	4	0,2	9,7	2,25	21,8
O9	4	0,25	12,1	2,25	27,2
O10	5	0,15	7,24	2	14,5
O11	5	0,2	9,7	2	19,4
O12	5	0,25	12,1	2	24,2

The results of single treatments was measured by common linear modeling procedure (GLM) in system SAS (statistical evaluate system).

On figure 2 is shown graphical evaluate of influence of change gas consumption on killing Avena fatua in different weed size. The effect of weed control of Avena fatua was between 48 – 91%. The change of gas consumption has 19 – 24 % effect ($P<0,05$) on weed control. Influence of weeds growth stage on change effectiveness of weed control was between 7 – 15 %.

On figure 3 is shown graphical illustration of influence of gas consumption on effectiveness weed control of Chenopodium album in different weeds growth stages.The weed control was between 35 – 94%. The change of gas consumption has 22-30% influence on control Chenopodium album ($p<0,05$). Influence of change weed growth stage on effectiveness of control Chenopodium album was between 29-34 %.

Figure 2 Influence of change parameters of gas consumption on regulation of Avena fatua

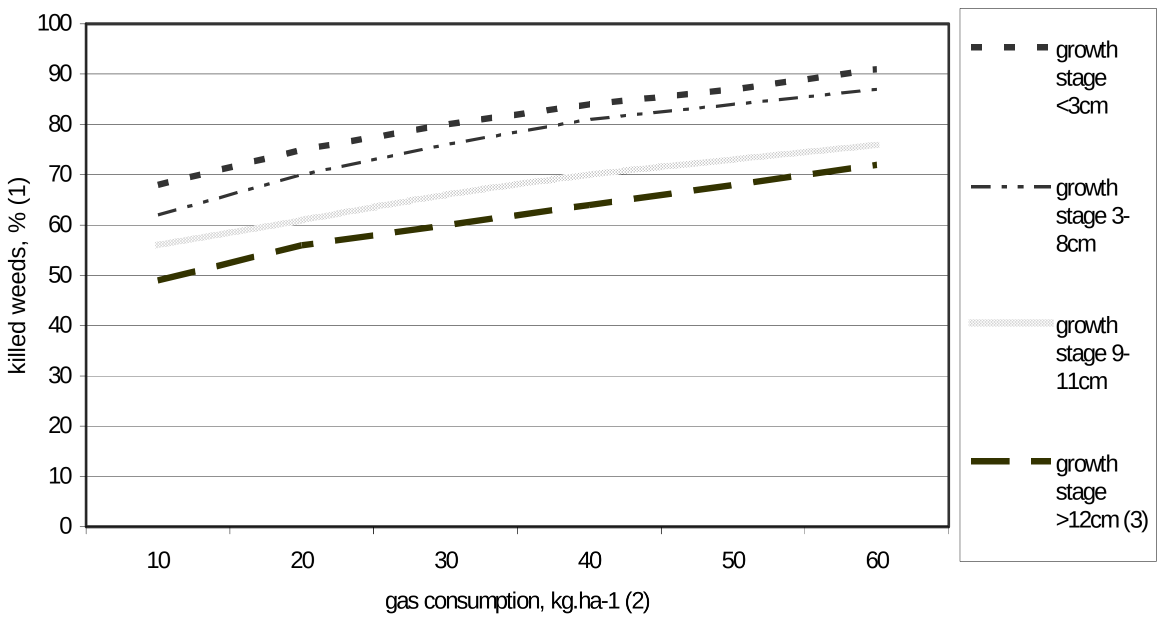


Figure 3 Influence parameters of gas consumption on regulation of Chenopodium album

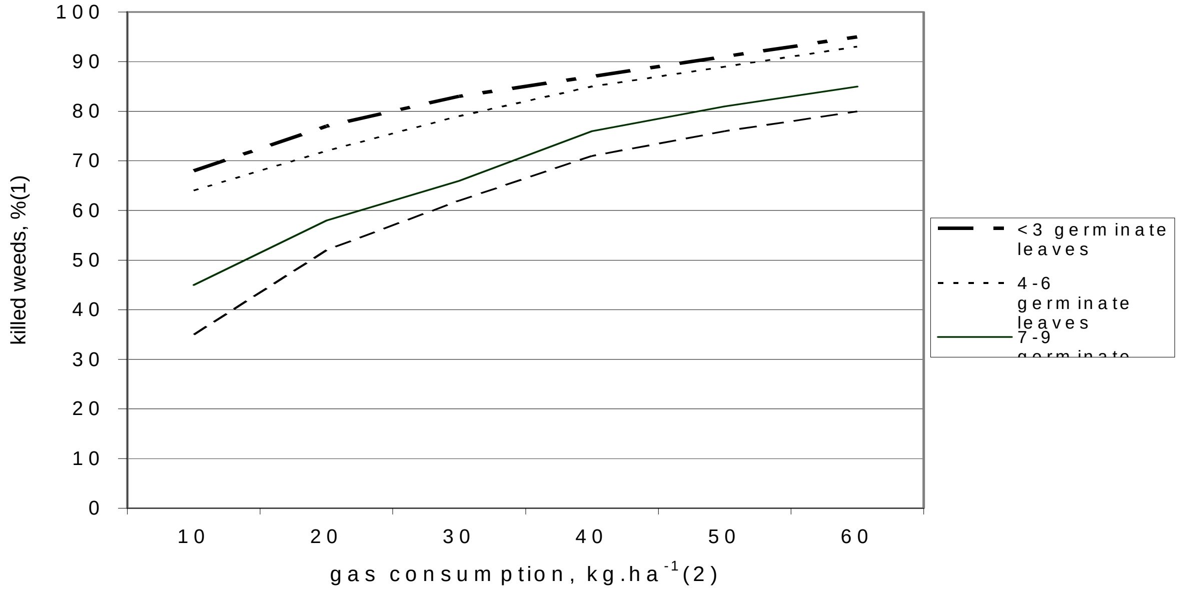
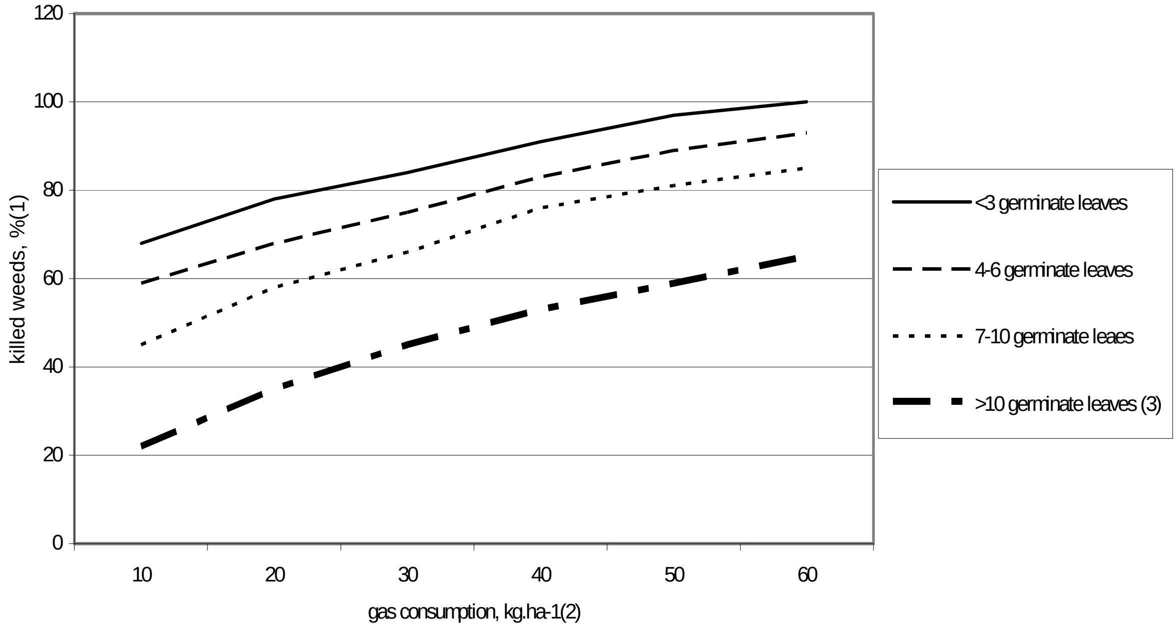


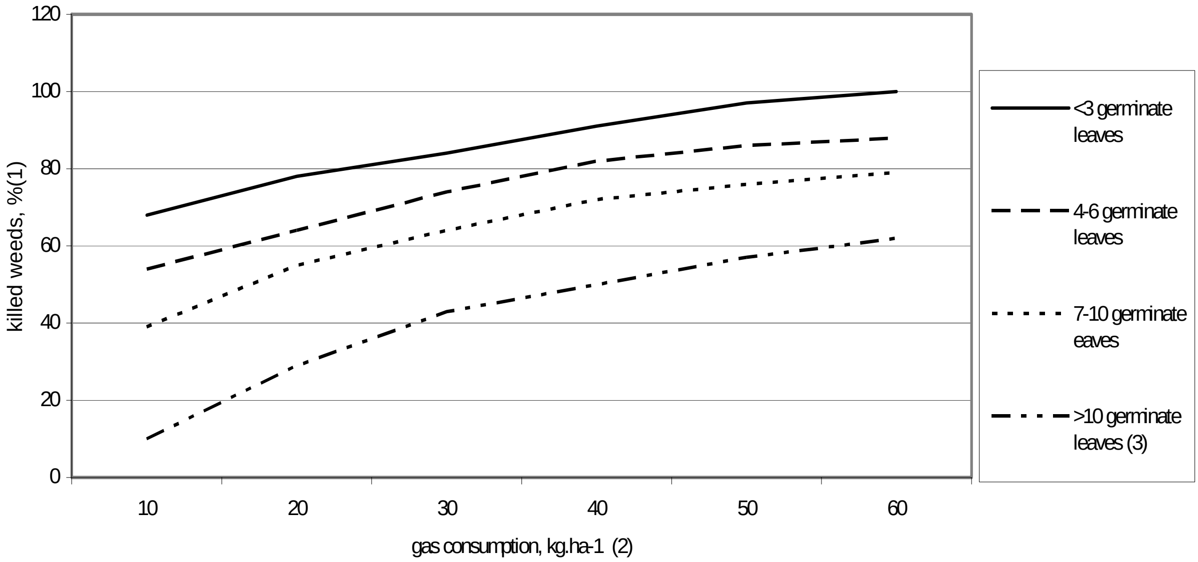
Figure 4 Influence parameters of gas consumption on regulation of Raphanus raphanistrum



On figure 4 is shown graphical demonstration of influence of gas consumption on control of Raphanus raphanistrum. In our trials we achieve this weed control in range of 22-98%. Influence of change gas consumption on control effect of Raphanus raphanistrum was 31-58% ($P<0,05$). Influence of change growth stage on control effect of the weed was in range of 35-40% ($P<0,05$).

On figure 5 is shown graphical demonstration of influence of gas consumption on control of Plantago major. In our trials we achieve this weed control in range of 5-97%. Influence of change gas consumption on control effect of Plantago major was 27-55% ($P<0,05$). Influence of change growth stage on control effect of the weed was in range of 35-42% ($P<0,05$).

Figure 5 Influence parameters of gas consumption on regulation of Plantago major



Conclusion

Thermal weed control with flaming is, without doubt, a very labour-saving and profitable aid when growing crops without herbicides. Thermal weed control will be more expensive than chemical control in set onions mainly since the labour cost for hand-weeding will increase. However, the extra cost in organic farming can be paid for by the higher product price.

The main factor which influenced the weed control effectiveness in the trials was the change of gas consumption. The demanded level of gas consumption to get optimum weed reduction, is connected with the stage of development of the weeds. When the weeds are getting older, a higher level of gas consumption is needed to control their population.

The flaming is not a once-over operation, nor does it completely eliminate weeds starting grow again from their root systems. The basic principe of flaming technique is controlling weeds on start of season by preemergence flaming, which must have an effect of at least 90%, and treat them again when they are smaller than 5 cm. Some weeds require three or four flamings per year. In this case protection of crops should be used to obtain reasonable yield.

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PSYCHOLOGICAL STRUCTURE OF DESIGN ACTIVITY PROCESS

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In the researches directed on revealing of features of understanding of constructions, technical objects, in particular, conditions of engineering tasks, the drawing, the sketch can be the important criterion of understanding which is carried out by the subject based on the information received from the technical project. The understanding of a condition of a solved task compounds an organic basis of formation of a project of the future design.

Key words: understanding, task decision, project, engineer, design.

Introduction

Process of the new task decision connected with the search, creativity, always has the real picture, falling under the full repeated reproduction influence; if it is solved precisely same or very similar task the subject behaviour can be in a significant part of his previous behaviour copy (at the decision of the first task), but it will not be precisely same solving the new task, so the subject searches for the new means for its decision. The picture of the new decision will have specificity though both in the first and in the second cases there are many common, similar, which create the conditions for studying creative cogitative activity. This resemblance shows in understanding of a task condition, construction of a decision project, in the conscious statement of strategy of the task decision - in these three basic co-ordinates of the decision round which creativity concentrates actually and which giving the project understanding in the result, subjective confidence of conformity of the project are the basic psychological regulators of the decision concrete process, or as we have agreed it to name a decision stream. Regulation of the decision stream, control of this stream are not carried out only is conscious; the most part of work occurs in the sphere which is not realized by the subject. However, the main solving moments for success are always realized, estimated, corresponded with a task condition and technical possibilities of the project realisation. Nevertheless, we have found expedient specially to consider regulating role of a guess.

If it is a question of regulation of the decision process, it is necessary to tell that except of understanding, project, guess and other very important regulators exist also. For example, one of main regulators is the complex state of readiness for the decision, desire to solve a task, it is preliminary, but a necessary regulator, it is the decision beginning "switch". In addition, it is necessary to remember a regulating role of knowledge, abilities, skills, but as a rule, we include them in realisation of understanding, project construction, and strategy. Some other qualities of the person of the subject solving a design ("construction") task, playing regulating role in controls of a decision stream, we consider at studying of personal qualities of an engineer.

So, we will consider the basic psychological regulators of process of the decision: understanding, project, strategy and guess.

Materials and Methods

Consideration of structure of the decision process of design task shows the important role of task understanding, a problem following of elucidation of task conditions.

As a whole, the understanding problem did not remain in psychology without attention. However, this problem was studied a little, especially concerning design problems. Here we will concern questions of the general theory of understanding and understanding role in the design task decision in general.

Long time the term "understanding" was not considered in psychology (and in philosophy) as scientific and independent. There is one explanation of this; the uniform psychological (and the general) the understanding theory is absent though "preconditions for construction of such theory, in our opinion, have already been created. Therefore, G.S. Kostyuk who has made the essential contribution to studying of understanding process as a part of thought process, in his work on thinking questions he marks the following. The understanding arising in the most sensual perception is the mediated, analytically-synthetic process which includes the separation of basic elements in a certain situation "semantic marks" and unites them in a single whole. The understanding process becomes especially complex if it is necessary to understand new objects, to open sense of the text, etc. The understanding is a process of synthesising through analysis. Absence of unification of elements is one of the main causes of misunderstanding. The understanding is always carried out based on the saved up knowledge and experience. Such phenomena as "inspiration", insight are explained finishing of analytically-synthetic work. Speech is very important mean of understanding, in particular, internal; correlation between an image, a word and action depending on what material it is necessary to understand and plays the big role in the understanding process.

N.D. Levitov considers technical understanding as a component of technical activity. Under technical understanding, he means correct and fast recognition of structures and functioning of devices or cars, their application and use means. To understand mechanism structure, it is necessary to be able to imagine details, to establish their interconnection in operation, to compare to others, to carry them to this or that category. Recognition elements compound a basis of understanding of structure of the whole mechanism having found which, the subject thinks about for what it is designed, how it functions etc.

N.D. Levitov underlines the importance of ability to present the mechanism, and its details in motion, dynamics marking thus the special role of memory (recall), and imagination and ability to present a subject in three measurements the work of car in variating states. In thought process, which conducts to understanding, all given supervision, memories, imagination are used. Operations of analysis and synthesis of structure and car functions (at drawing reading, installation, designing) are played the special role.

As mark almost everybody who studied understanding, the last is defined by establishment of communication new with already known, incorporation of the new information in system of already available data.

Researches show, that it is impossible to combine understanding problem only to questions of recall, identification, comparison etc. The understanding is based on establishment of essential in a task, in signs of objects.

It can be completely accessible both the form of the shown information and the maintenance concluded in it to the subject. But he hasn't the ability to process this information before representation reception about concluded in it sense (many puzzles are constructed on it). There are other cases when the working information can be inaccessible to the subject: so the experienced worker can not understand the complex drawing of the device on which it works etc

Finally it is lawful to speak about understanding as process of the decision of a task if novelty of this task is taken to the consideration (formal either substantial). Such task will be a subtask in the course of the decision of that problem into which it enters. The understanding to all process of the task decision is to divide on two stages: understanding of a task condition (requirements of a task, its essence) and understanding of the required answer (its correctness, conformity); there are not two different understanding but connecting in one, but the procedural "crosspiece" exists between them - transition from understanding of that is given, to understanding of that it is necessary to find. This last is more and more unfurled, though it constantly corresponds with the first, it is its continuation.

The question about understanding criteria is very important. It is necessary to consider a question on completeness of understanding in connection with understanding criteria. If to speak about understanding criteria of the person of a situation (for example, understanding the pedestrian of a transport situation in the street the big city) the behaviour of the person or description of this situation will be criterion of correctness of understanding. At the decision of technical tasks, the basic criterion also is the decision and its correctness. Condition retellings by "the words», comments to them, drawings, a various kinds of explanation, breadboard models, models, etc. can be additional criteria. It is necessary to notice, that quite reliable developed complex of understanding criteria in modern psychology is not present still. Moreover, to follow the understanding process it is sometimes impossible. We mean a guess, insight when in consciousness of the subject there is only a result of the decision, result of understanding. Here we must as possible as act slowly and develop understanding process. It is reached at the decision of new creative tasks at introduction of different kinds of difficulties (in our researches we took time restrictions, changes of an initial condition of a task during decision etc.).

In the researches directed on revealing of features of understanding of constructions, technical objects, in particular, conditions of engineering tasks, the drawing, the sketch, which is carried out by the subject based on the information received from the technical project, can be the important criterion of understanding. Especially it is reliable when the initial condition is represented in the form of the drawing, the scheme with rather short, "avaricious" text. The verbal comment though here again performance of "own" drawing remains nevertheless more reliable criterion, because of specificity of this kind of activity will be good criterion of condition understanding. After all engineering activity represents figurative-graphic actions and we deal in most cases with visions of concrete devices, the verbal comment does not always play an essential role, it is more often it supplements visions.

Concerning completeness of understanding it is possible to tell, that there are some difficulties of its exact definition practically insuperable. Cogitative activity of the person, as it is known, passes conscious and infraconscious spheres in a combination, and this combination is individual and it is predetermined by the situation. Very seldom, in very simple situations, the subject can confirm with confidence, that he completely understands a task. More often this understanding hypothetic, preliminary interrogation of the subjects of an experiment practises in the course of the decision that deforms this process, or after the decision that is fraught with essence distortions, as leaving from a state of task decision, the person for a variety of causes (an emotional state, weariness etc.) does not incorrectly or quite correctly reflect an event.

Result and Discussion

We carry out the special research directed on studying of the general laws of understanding of a task condition by professional engineers.

The understanding of a condition of a solved task it is the necessary precondition of construction of a project and the subsequent decision. On the other hand, understanding process comprises promotion and the decision of hypotheses necessary for the solving subject to understand concrete conditions.

We managed to find in the course of understanding of a task condition separate characteristic stages of this process. We consider them in that sequence in what they met most often though it is necessary to make a reservation, that some stages dropped out or were interchanged by the position.

1. General acquaintance with a task condition. At this stage the subject of an experiment reads the condition of text, globally studies the drawing (if it is available). For the subject of an experiment it is important to understand, first of all, the general sense of a task to give it a preliminary estimation; after the first attempt of a cognition of a condition he solves, the problem is familiar to it or it is not (an assessment for type "solved – did not solve"). Though this stage does not play the leading part in the decision and in understanding of the finishing result, speed and orientation of condition understanding as he creates at the subject of an experiment certain installation on a task depend on its outcome. This installation cannot carry strongly pronounced character – the subjects of an experiment have only vague sense, that in a task "something is familiar to them".

2. The similar vague sense promotes often purposeful studying of separate parts of a condition. On the second stage of understanding process the subjects of an experiment carry out the first "intrinsic" classification – they divide a condition on two parts: the main and minor. Final purpose of designed object, its function, a question on the general structure concerns a condition body, as a rule. So, in our tasks the subjects of an experiment did accent on that the panel is designed for monitoring and control behind object (objects), and at the decision of the first task they noticed, that the panel should be about such type as it was specified on the applied drawing (also at the decision of the third task, and at the decision of the second – the same it was fixed verbally without the reference to the available drawing). The subjects of an experiment were offered problems: 1) control panel designing by technological process of processing of a detail in mechanical shop; 2) designing of a control panel of the air traffic controller (in the general parameters); 3) designing track plans controlling a power supply system.

3. Following three stages are so closely connected among themselves, that at their serial allocation we have experienced the big difficulties. It was necessary to execute it conditional as any of them either advanced others in a concrete case, or merged with them. So, text and drawing correlation (if in a condition there is that and another), special check of conformity – the drawing further follows the text and the text to the drawing. The drawing given, as a rule, schematically enough (as well as in our conditions), is checked under the function and structure description, given in the text. The subject of an experiment s reads in part a condition and then transfers attention to the drawing, then again he comes back to the text and so until everything about what it is spoken in the text will be completely correlated with the image,(or on the contrary if pristinely the attention is intercepted on the drawing). Here the subjects of an experiment introduce the corrective amendments of the general order bound to disharmonies between the text and the drawing (corrective amendments they do orally, they correct the drawing).

4. Correlation of the text with the drawing, completion of the missing information in the condition promote simultaneously to code conversion of a task condition on the "own" tongue: the subject of an experiment carries out the drawing how its knowledge and ability allow to do it, in the same way he says judgements which are available for it in a store and which arise at correlation of knowledge with a concrete problem. As a result he has a correlation of a condition to the knowledge at new level when all parts of a condition are studied in more details that it promotes condition breakdown any more on two parts (main and minor), and on some (for example, allocation in a

design of the main knots - structures and their functions).

5. From analytical studying the subjects of an experiment pass again to a condition as a whole, and the path from analysis to synthesis is characterised by the reformulation of a task condition in a certain key. If it was primary marked (to design control panel for a definite purpose) now this essence is considered from possibilities of the subject of an experiment. There is an original transition from type reasoning "it is necessary", "it is required", ("it is necessary for me") to reasoning "I can", "I should" etc. It is possible to assert, that at this stage the subject of an experiment weighs the possibilities once again, he has already secured the basic question in a task, he approximately knows, what stores of his knowledge as a whole. This understanding, though and it is not including understanding of the main underproblem – understanding by correlation, comparison in a concrete direction. In addition, simultaneously the engineer realises (though also he does not realise in details) as he can use the knowledge; as he actually uses them, it is other question.

6. Concrete use of the previous knowledge is expressed through comparison, establishment of analogies and contrasts (resemblance and distinctions) and transmission. Transition from abstract to concrete carries out, the subjects of an experiment aspire to finding such (from among important) fields by means of which working out it is possible to come nearer to the permission of the basic problem in a task (this stage, as well as previous, it is closely bound to process of formation of a project of the task decision).

7. As a result of doing of some intellectual (including realised graphically) actions the moment comes when the engineer can give a definitive assessment to a condition of a solved task. This possibility arises thanks to that the condition in one way or another appears approved by available knowledge. Here it is possible to define two basic types of incorporation of a condition of a solved task in a chain of knowledge and experience of the subject of an experiment: 1) the condition fills a gap among already available knowledge (we have named this path interpolation); 2) the condition supplements available knowledge continues them (we have named its extrapolation, compare with F. Bartletta's terminology).

8. Finally, the subject of an experiment has confidence that he understands the condition of the offered task. A consequence of such confidence is hypothesis promotion about a path decisions (project), the beginning of practical actions on hypothesis realisation, and more often, (if the task is especially creative) he begins to search of a path of the decision. Hence, from understanding to project formation, it is possible to consider this final stage, which is transitive defining in the course of understanding of a condition of a task. Cases when the subjects of an experiment as though have correctly understood a problem condition, but they could not start decision searches. Such phenomenon is caused, apparently, by two principal causes: absence of the conforming knowledge (this phenomenon in our experiments has been shown to a minimum) or purely external understanding – understanding of verbal formulations of the text of a condition, understanding of that what is represented in drawing – without penetration into a problem essence (for example, without representation about concrete functioning of the control panel).

It is impossible to assert, that the task understanding ends with the beginning of practical actions directed on decision searches. On the contrary, searches every time deepen the task understanding, they open its sense more deeply and more widely. Only decision, which is meeting the requirements of a task, shows, whether it is understood by the engineer correctly. But as it is a question of understanding of the condition of a task, it is possible to say, that understanding process (or in respect of structure of all decision – an understanding cycle) basically has ended, when the engineer has made the decision on a direction of searches of the answer to a question (or questions), amounting essence of a task.

How does understanding process by the subject of an experiment (engineer) of a condition of a problem carry out particularly? Above we have considered the basic stages of this process. It is possible to present the same process by means of the terminology considering participation in it of the most important mental functions: understanding process begins with process of the perception promoting concentration of attention on a condition of a task (here it is necessary to consider, that attention increase should be in a direct communication with requirements, motivation of activity of the subject); then memory, and if it is not enough its data if there is no recognizance) "is connected" to process, the subject of an experiment should show additional activity to understand a problem essence, in other words, it is necessary for him to execute special search actions.

Conlusion

In summary, we will bring the most important, in our opinion, results.

1. The correct understanding of a condition of the technical project is a necessary basis of the decision and achievement of desirable result. Under correct understanding it is necessary to mean process of an establishment of essential signs of the device described in the task, establishments of

essential communications between these signs and available in knowledge of the subject samples, standards that allows to interpret objectively the information containing in the technical project. In the course of understanding the leading part belongs to thinking, but perception, attention, memory and other mental functions are rather essential.

The final goal of understanding process is to reach effect of understanding of an initial condition of the task allowing the subject to understand that it is required to execute both what objective indicators and characteristics of the mechanisms presented in this condition.

To understand a condition of a solved problem, the certain store of special knowledge it is necessary for the engineer. Speed and completeness of understanding depend on level of this knowledge and from ability to correlate them with a concrete condition, and from individual qualities of thinking of the engineer. Thus, the understanding of a condition of a task should be distinguished from understanding of a path of the decision, strategy of the cogitative activity directed on the decision.

2. Process of understanding of a condition of a task consists of a number of the basic stages, which follow one another more often in such order:

- General acquaintance with a problem condition (text reading, global studying of the drawing), a primary assessment of a condition;
- Division of a condition of a task into the main and minor parts;
- Text and drawing correlation (entering of the general corrective amendments);
- Code conversion of the form of a condition (performance of the "own" drawing, verbal commenting of the initial drawing);
- New level of studying of parts of a condition of a task;
- Allocation of quintessence of a ask and its correlation with the knowledge;
- Establishment of analogies and distinctions, transmission of structures and functions in a new condition;
- Interpolation and extrapolation of a condition of a new task in relation to available knowledge;
- The moment of understanding of a condition and transition to construction of a project of the decision of a task.

3. The engineer having by the moment of acquaintance with a condition of a new task by certain knowledge and abilities should manage to reconstruct this knowledge so that they have compounded the new installation, allowing understanding a condition. Thus he should use as the knowledge of designs and their functional qualities in general, and the new knowledge received from a new condition.

Rearrangement of knowledge and mastering of new knowledge are carried out thanks to following intellectual actions and receptions: to code conversion of text data in visually-shaped and on the contrary, to correlation of figurative and conceptual data of a condition, condition breakdown on the main and minor parts, to allocation in a condition "known and unknown parts" to synthetic comparison of a condition with other problems, receptions of analogy and opposition transmission of separate blocks of structure and its functions.

All specified receptions lean against the basic cogitative operations: comparison, analysis and synthesis, abstraction and a concrete definition, classification.

4. Solving the tasks offered by us, engineers in some cases should study conditions of tasks in three forms: text, graphic and combined (the text with the drawing). It has appeared, that optimum for the successful decision (in this case – comprehensions) the combined conditions have appeared, the least optimum is a text. It specificity of activity of the engineers, bound to thinking concrete visions and with a support on the knowledge fixed verbally proves to be true.

5. The concrete basis of understanding of a condition of a task for the subject is compounded by his confidence that set data do not hold contradictions between structure of a design and its functions.

As shown, the understanding of a condition of a solved task compounds an organic basis of formation of a project of the future design.

Thus, the given cycle of process of the decision demands the special attention in creative works.

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CONSTRUCTION & EVALUATION OF THREE ONION TOPPERS

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Manual harvesting of onion is a very laborious and time-consuming operation. To overcome these problems and decreasing the cost of operation to reasonable level, three types of onion toppers were designed and tested in 2002-2003.A factorial experiment was conducted based on a randomized complete block design with two factors and three replications. Factors were topper prototypes (flail, rotary and roller topper) and rotational speed of mechanisms (1500, 1700 and 2000 rpm). Some parameters such as acceptable top percent and damaged bulbs percent were determined and analyzed .The results showed that flail topper was the most suitable mechanism for onion topping.

Key words: Construction, Evaluation, Onion, Topping

Introduction

Onion is the most important crop in East Azarbaijan. About 10528 ha are planted yearly [3]. Droll et al. [4] evaluated and compared three types of onion topper. First, the rotary topper was a unit with a 30" blade rotated at approximately 2000 rpm by a hydraulic motor. Second, the flail topper was a two-row unit that was PTO powered. Third, the sickle topper was a small gas engine powered unit with gathers. A reel was used to assist top movement into the cutting mechanism. They evaluated toppers on a ten-row test area and selected the rotary blade topper with 68% acceptable top lengths compared to 45% for the flail and 21% for the sickle as the most effective topper for mechanical onion top removal.

Lepori [9] during 1968-1970 built and tested a belt lift onion harvester at Texas. This machine lifted the onion bulbs by their tops with lifting belts. It's topping unit were consisted of a second set of belts running at a divergent angle to the lifting belts positioned the bulbs to be uniformly topped by a rotary knife. He reported excellent uniformity and efficiency using this machine. Then, Texas agricultural extension service [7] designed and evaluated onion and carrot harvester in Michigan and Texas fields. Topping mechanism in this machine was the same as Leporie'z topper. This topper was suitable for green leaves but not for dried tops.

Maw et al. used a 254 mm diameter tungsten carbid-tipped circular saw in topping mechanism of harvester, driven by a directly coupled 0.25 kw AC electric motor that this blade rotated at 1750 rpm. Goble [5] designed an onion harvester with rotary blades for topping. Nahir et al. [10] designed an onion harvester for small farms. A fan had been installed in front of the machine that hold faded leaves vertically and then a rotary blade cut them. Texas University and Extension center at Weslaco [1] conducted an experiment on onion mechanical harvesting and used rotary topper utilized 30″ blades rotating between 1800-2800 rpm. These toppers were operated in either large green or dried tops. In this experiment, three onion toppers were designed, developed and selected the best one.

Materials and Methods

An experiment was conducted in East Azarbaijan agriculture and natural resources research center in 2002-2003. Experiment consisted of designing and construction of three topper types and evaluation of these mechanisms in laboratory condition in order to determine the most suitable onion topper.

Design and construction

Topper prototypes were flail, rotary and roller topper (Figure 1).

1- Flail topper is comprised of a roll with 152.4mm diameter and 1000mm width that some tarpaulin belts are installed vertically on the side surface of roll every other one. Belts have 100mm length and 50mm width.

2- The rotary blade topper is comprised of four units consisting of a plate with 150mm diameter and three blades.

3- The roller topper is comprised of two rolls covered by ribbed rubber with 110mm diameter. Leaves were engaged and pulled by the counter-rotating of rolls. Total work width of toppers was 1000mm and these were driven by an electric motor.

Evaluation of onion toppers

Topper prototypes were evaluated on a 1000 m2 area for two stages (1. tops were green up to 80% and 2. tops were down up to 80%). A factorial

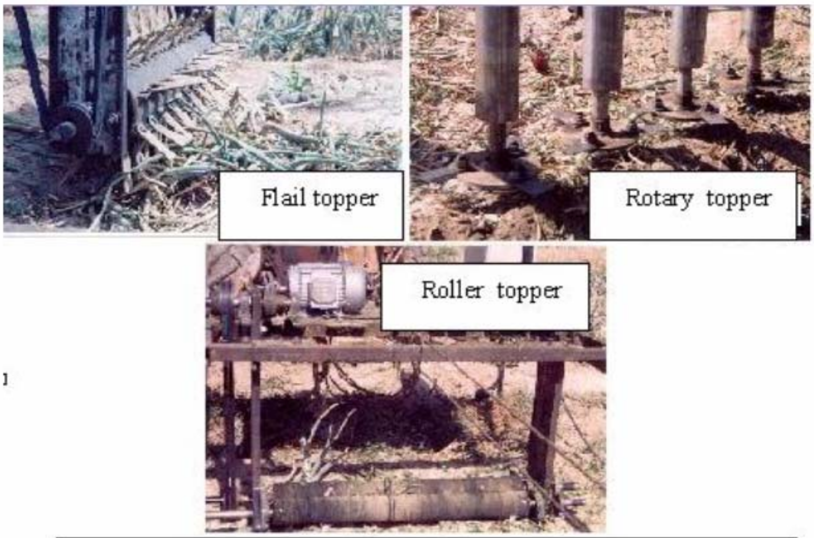


Figure 1: Schematics of onion prototypes

experiment was conducted based on a randomized complete block design with two factors and three replications. Factors were topper prototype in three levels (flail, rotary and roller topper) and rotational speed of mechanisms in three levels (1500, 1700 and 2000 rpm). Experiments were conducted on plots 6m long by 1m wide. Plots and toppers were selected for test randomizely. After adjustment on rows, toppers were operated. Parameters which included top length (mm), number of tops cut within 50mm (acceptable tops), number of damaged bulbs and number of no cut were counted, characterized and analyzed. Graphical and statistical methods were used.

Result and Discussion

Variance analysis was conducted for different stages separately. The results of analysis of variance for acceptable top percent and damaged bulb percent in both stages are shown in table 1. Results showed that the effect of topper prototype on acceptable top percent and damaged bulb percent was significant in both stages. The effect of rotational speed of topping mechanisms only on acceptable top percent in first stage was significant (Table1).

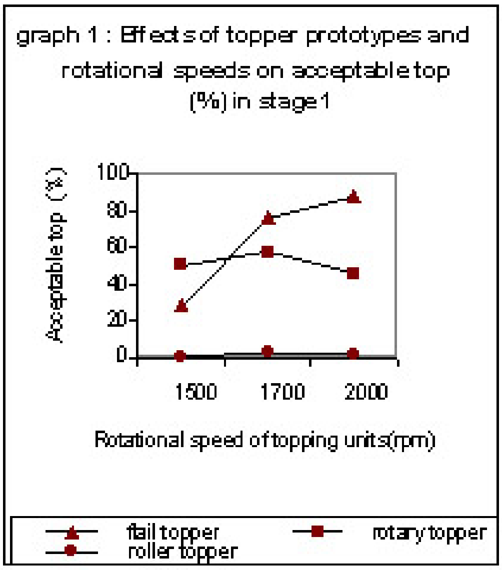
Effects of topper prototypes and rotational speed on acceptable top percent are shown in graphs 1 and 2. Analysis of graphs and means comparison indicated that the flail topper to be the most efficient. It produced maximum acceptable top 87.7% with 2000 rpm in first stage and 83.9% with 1500 rpm in second stage.

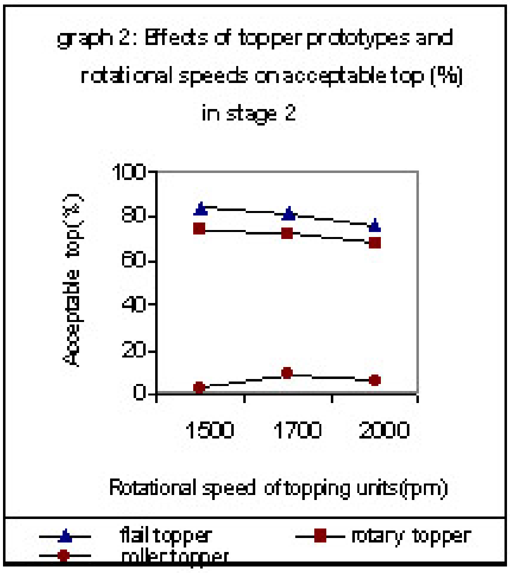
When flail topper was compared to the rotary topper alone, flail topper topped a higher percent of acceptable tops with a lower percent of damaged bulbs, but significant difference was not observed between them, statistically. The flail topper's capability to achieve maximum of acceptable top percent was attributed to the increase of air movement and lift created by the rotating belts.

Table 1. Analysis of variance for experiments in two stages

S.O.V.	df	Mean of Squares (MS)			
		Acceptable top 1 (%)	Damaged bulbs 1 (%)	Acceptable top 2 (%)	Damaged bulbs 2 (%)
Replication	2	13.713^{ns}	6.46^{ns}	15.88^{ns}	6.47^{ns}
Treatment	8	3169.23^{**}	11.83^{ns}	3532.66^{**}	22.99^{ns}
Topper prototype	2	9699.21^{**}	44.17^{*}	14026.64^{**}	60.86^{*}
Rotational speed	2	1049.68^{*}	1.04^{ns}	93.30^{ns}	19.28^{ns}
Two factor In.	4	964.02^{**}	1.05^{ns}	5.35^{ns}	5.904^{ns}
Error	16	195.4	9.28	132.67	13.129
C.V. (%)		35.44	171.32	21.62	96.21

* and ** : Significant at level 5 % and 1 % , respectively, ns: Not Significant
Acceptable top 1 and Acceptable top 2: Top cut within 50mm of the bulb in first and second stages respectively.
Damaged bulbs 1 and damaged bulbs 2: Bulb cut in first and second stages respectively.





Conclusion

1. Flail topper was the most effective and suitable topper of three prototypes evaluated for onion topping.
2. Flail topper had simple structure and was economical.

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INFLUENCE OF HARDENING PROCESS ON ADHESIVE BOND STRENGTH

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The hardening process can be simply defined as the adhesive change-over from liquid to solid with the rise of adhesive and cohesive links at the same time. The course of this process is influenced by various factors. They can be divided in the technological influences and the environment influences. All stated factors operate together and depend on one another. Their significance and effect depend on the sort of adhesive and the type of hardening reaction mainly. Three two-components epoxy adhesives have been chosen for the experimental reviewing of the hardening process influence on the adhesive bond strength. The influence of various hardening temperatures has been observed in the experiments. Further, the time factor acting on the hardening speed has been reviewed at the laboratory temperature (23 °C) and at the optimum experimentally found out hardening temperature.

Keywords: Adhesive bonding, hardening, laboratory experiments, temperature

1 Introduction

The priority of the adhesive bonding technology use in practice is its operability and absence of special equipments and aids required for creation of a bond or carrying out a repair. The adhesive bonding technology is the only bonding technology in many cases which can fulfil high requirements put on resulted bond properties. The adhesive bond is complicated combined system and its quality is influenced by a number of various factors which affect the bond during the materials and adhesives preparation, the bond creation, the hardening and also when using the bond.

The adhesive bond reach the maximum strength after a certain time period. It depends on the hardening speed of each adhesive. The course and the way of hardening differs for single adhesives. The course of hardening is influenced by the environment temperature at many types of adhesives. The essence of this paper is the environment temperature influence on the hardening process and time and consequently on the adhesive bond strength.

The hardening process can be simply defined as the adhesive change-over from liquid to solid with the rise of adhesive and cohesive links at the same time. The course of this process is influenced by various factors. They can be devided in the technological influences (the adhesive processing, the amount of adhesive, the material influence) and the environment influences (such as the temperature and the humidity). All stated factors operate together and depend on one another. Their significance and effect depend on the sort of adhesive and the type of hardening reaction mainly.

2 Materials and methods

The tested substrates have been prepared from the sheet of metal (steel 11 373) on the sizes required by the ISO Standard CSN EN 1465 (Determination of the tensile lap-shear strength of rigid-to-rigid bonded assemblies). Chemical constitution of material is stated in tab. 1. This process has included the specimen's surface pre-treatment before adhesive bonding, the adhesive bonding, the hardening in given hardening way (the hardening speed, time). The final step has been the lap-shear strength test according to the CSN EN 1465.

For own adhesive bonding process it has been chosen by chance three two-components epoxy adhesives 3-TON Epoxy adhesive 30 min, 3 – TON Clear epoxy adhesive F-05 5 min and 3-TON Quick epoxy adhesive 4 min. The adhesives are supplied in two tubes indicated by letters A, B. The tube A contains the adhesive, the tube B contains hardener. Data stated by producer on the adhesive packaging are listed in the tab. 2.

Table. 1 Chemical constitution of adhesive bonded material [mass %]

Constituent	C	Mn	Cr	Ni	Al	Cu	Nb	Ti	Fe
Steel	0.047	0.240	0.076	0.017	0.065	0.039	0.007	0.016	99.500

Table 2 - Basic data stated by the producer of tested adhesives

Adhesive - Alteco	3-TON Epoxy adhesive 30 min (A30)	3-TON Clear epoxy adhesive F-05 (A5)	3-TON Quick epoxy adhesive 4 min (A4)
Ratio of part A, B	1:1		
Temperature resistance	-20 °C till +120 °C		
Working temperature	+20 °C (minimum W.T. +10 °C)		
Manipulated strength	30 minutes	5 minutes	4 minutes
Functional strength	14 hours	8 hours	8 hours
Colour	grey	limpid	grey
Orientation price	70 Kč (56,8 g)	74 Kč (20 g)	70 Kč (64 g)

At first, pre-experiments for stating the dependence of adhesive bond strength on the adhesive layer thickness have been carried out. The aim has been to define the optimum value of adhesive layer thickness for the tested adhesive. These results have been used when testing the influence of the hardening temperature on the adhesive bond strength. The constant adhesive layer thickness has been secured by distance wires put into the bond. Fig. 1 and 2 show a necessity of securing the thickness of adhesive layer. Otherwise the adhesive layer will not be constant.

As the surface pre-treatment the blasting by synthetic brown corundum of fraction 710 – 850 μm (grain size 24) and defatting the substrates in organic solvent have been chosen.

The roughness parameters have been measured on profile meter Surftest 301, the average roughness parameters have been R_a 2.7 μm, R_t 19 μm and R_z 16.7 μm.

The influence of following temperatures has been observed: 0, 23, 60, 90 and 120 °C. In temperature 60 °C the time factor influencing the hardening speed has been reviewed too. Following times have

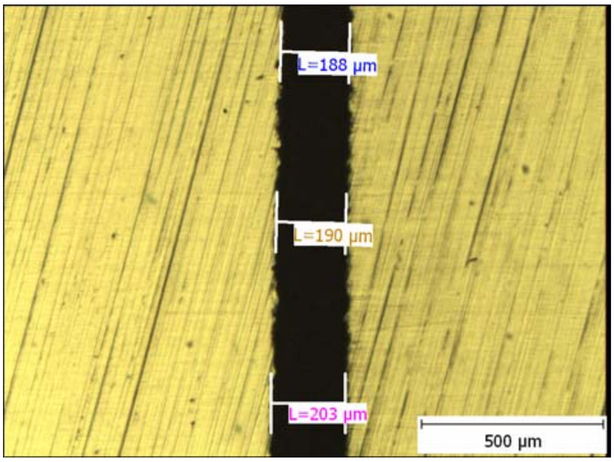

Figure 1 - Adhesive bond cut – constant adhesive layer thickness is not secured.

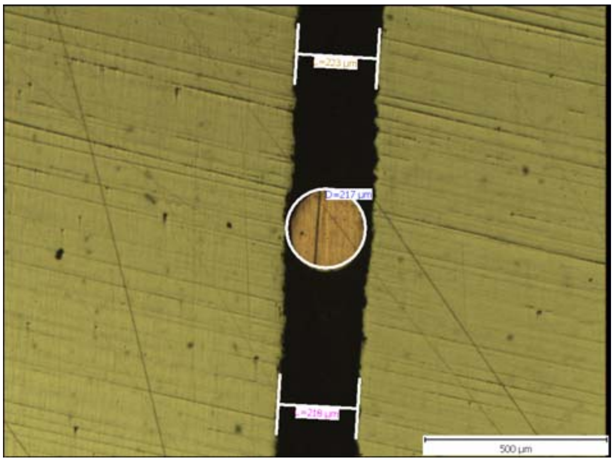

Figure 2 - Adhesive bond cut – constant adhesive layer thickness secured by distance wires

been observed: 2, 4, 8, 14, 24 and 72 hours. The hardening of adhesive bonded substrates has carried out on condition stated in advance in a dry machine KBC G 100/250 and in cooling equipment.

The hardening temperature and the hardening time have been the observed parameters. The term hardening temperature means the temperature in the dry machine or in the cooling equipment. The hardening time has been measured after putting the substrates into the dry machine from the moment of reaching the hardening condition (given hardening temperature) until removing the substrates from the dry machine. A processing time of the mixed adhesive in given ratio has been another observed parameter significantly influencing the adhesive bond strength.

3 Experiment results

The hardening level has been reviewed on a base of destructive tests of setting the lap-shear strength of rigid-to-rigid bonded assemlies. At first, the optimum adhesive layer thickness has had to be set. Four different adhesive layer thicknesses have been tested. The constant adhesive layer has been secured by distance wires of average of 0.06, 0.11, 0.16 and 0.22 mm. For each thickness, six tested substrates have been prepared. The specimens have been left in the laboratory to harden in the temperature 23 ± 2°C. Then the lap-shear strength test has been carried out. The laboratory experiment results are summarized in fig. 3.

The aim of main laboratory experiments focused on reviewing the effectivity of hardening process has been to review the environment temperature influence on the adhesive bond strength. Adhesive bonds of tested adhesives have been hardened in five different hardening temperatures (0, 23,60, 90 and 120 °C) for 24 hours. The experiments results are shown in fig. 4. Second tested batch has been hardened in the same hardening temperatures but after reaching the manipulating strength stated by the producer (fig. 5). A course of the adhesive bond strength dependence on the hardening temperature is described by a non-linear regressive function of second degree.

The results show the influence of higher hardening temperature on an increase of the adhesive bond strength. This increase is caused by defending a humidity absorption from the atmosphere into the creating bond during the own adhesive bonding process. Due the defending of humidity access it does not come to decrease mechanical properties of the adhesive.

When exceeding the temperature 90 °C it follows a drop of the adhesive bond strength which has been caused by degradation processes in the adhesive bonds in the temperatures exceeding the temperature resistance. When hardening in temperatures around 0 °C, it has not come to complete hardening and the adhesive has been of tenacious character. It has come to a rapid decrease of the adhesive bond strength at all three Alteco adhesives.

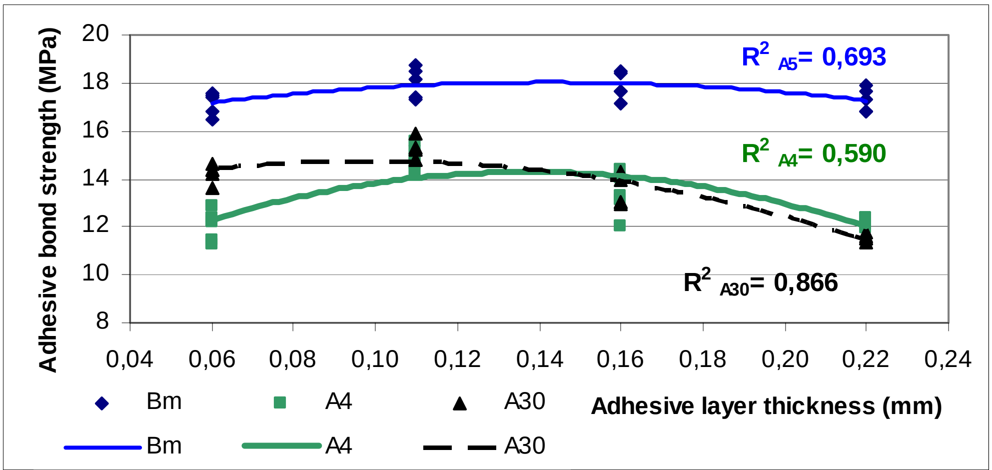

Figure 3 - Influence of layer thickness on adhesive bong strength

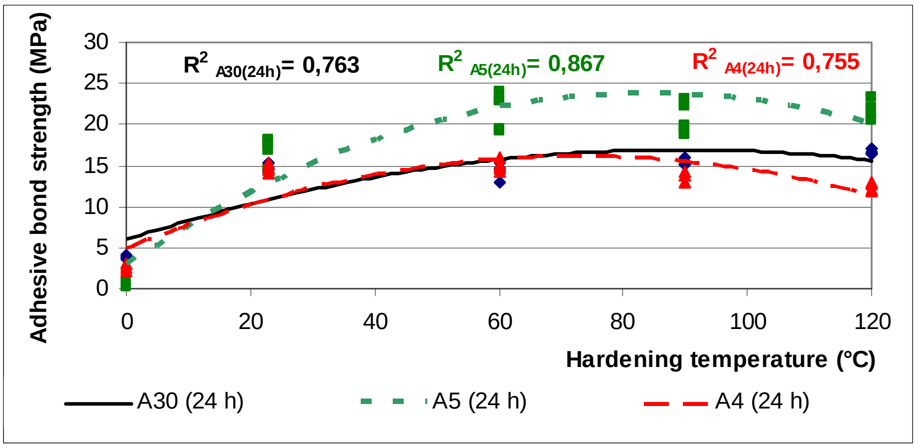

Figure 4 - Influence of hardening temperature on adhesive bond strength – 24 h

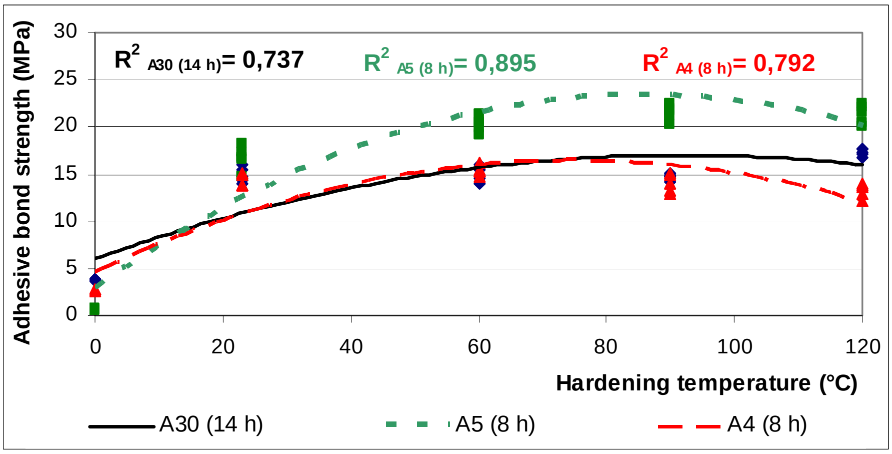

Figure 5 - Influence of hardening temperature on adhesive bond strength – after reaching functional strength

For following experiments the adhesive A5 has been chosen which reached the highest values of the adhesive bond strength from all three tested two-components epoxy adhesive. The laboratory tests results are presented in a column graph in fig. 6.

At the temperature 23 °C the hardening has been in progress mainly in first eight hours when the average lap-shear strength has reached 16.8 MPa. This fact claims the producer's data of reaching the functional strength. After eight hours the adhesive has still slowly hardened. The highest values of the strength have been measured at the longest hardened substrates. The average bonds strength after 72 hours has been 19.7 MPa.

After two hours of hardening at he 60 °C the average strength has amounted almost 17.5 MPa and after spending four hours of the hardening the values have moved up slightly under 21 MPa. The adhesive bond exposed to temperature 60 °C for four hours has reached generally higher values of the strength than the bond hardened in laboratory temperature for the time stated by the producer (8 hours). After spending four hours of hardening at temperature 60 °C the increase of the strength has stopped.

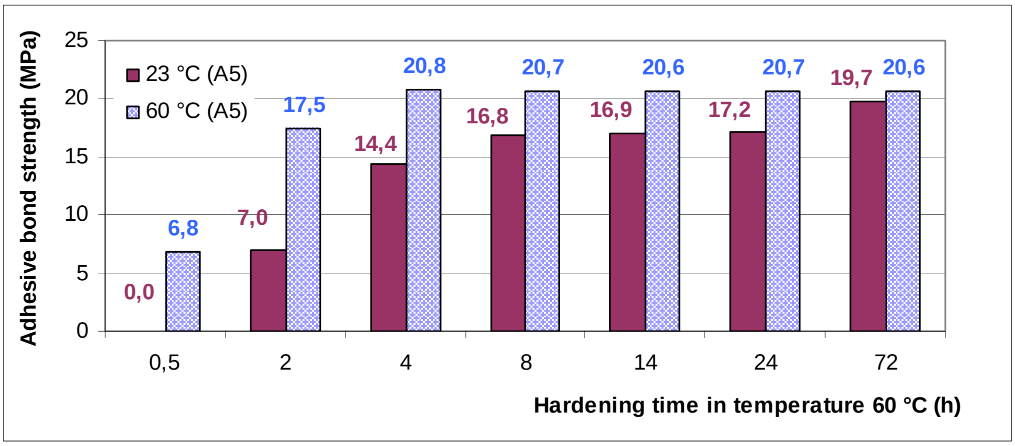

Figure 6 - Influence of hardening time in higher temperature on adhesive bond strength

4 Conclusions

The environment temperature ranks among significant factors affecting the process of creating the adhesive bond and its final properties too. The aim of laboratory experiments has been to review the environment temperature influence on the hardening time of a chosen adhesive and consequently on the adhesive bonded strength. Two-components epoxy adhesives 3-TON Epoxy adhesive 30 min (A30), 3-TON Clear epoxy adhesive F-05 (A5) and 3-TON Quick epoxy adhesive 4 min (A4) have been tested.

The hardening level has been reviewed on the base of destructive tests according to the ISO Standard CSN EN 1465 stating the Determination of tensile lap-shear strength of rigid-to-rigid bonded assemblies.

The adhesive layer thickness has been set on the base of pre-experiments. The higher hardening temperature have meant faster course of hardening.

From above-mentioned follows that the hardening time is shortened with increasing temperature. The suitable choice of the hardening temperature can significantly accelerates the adhesive bonding process. However using the higher temperature in practice requires testing the adhesive properties in advance with regard to an elimination of possible heat degradation.

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5 COMPANY LITERATURE

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EXPERIMENTAL SETTING OF ADHESIVE BONDS CORRECTING COEFFICIENTS

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The adhesive bonding technology is influenced by a number of factors which affect the adhesive bond strength. Correcting coefficients have to be considered in construction calculations too. The correcting coefficients correct the strength deviations caused by the particular factors. As I have already said, there are many factors influencing the adhesive bond strength, but I am going to devote to three basic factors – The adhesive layer thickness, surface preparation and the environment temperature which will straight affect the adhesive bond. The aim of this experiment is to determine the correcting coefficients for three above mentioned basic factors.

Keywords: Bonding technology, corrective coefficients, testing of adhesive bonds

1 Introduction

Adhesive bonding is one of many materials connecting methods. The use of adhesive bonding technology in the engineering and repairing industry brings considerable savings. Therefore the adhesive bonding technology pertains to the modern joining methods. The adhesive bonding technology is influenced by a number of factors which affect the adhesive bond strength.

Further the design engineer must suitably simulate the influences of the environment various conditions and in the bonded joint the acting stress distribution. For calculations it is very important to take corrective coefficients in consideration, which correct the strength deviations caused by individual factors. The corrective coefficients k_n should include information about bonded material, adhesive layer thickness, bonded surface preparation, bonded surface size, stress type and environment influence (temperature, moisture content etc.), which is the substantial part. The curing influence on the bonded joint strength for a certain declared time should be the integral part of the calculation.

From this enumeration it follows the necessity of the corrective coefficients k_n determination on the basis of laboratory measurements and calculations. The coefficients make the calculation of the joint real strength possible. Therefore it is important to modify the theoretical calculation and to add the corrective coefficients (1).

$$\tau_{REAL} = \frac{F}{bl_u} \cdot \sum_{i=1}^{n} k_n = \tau_{THEOR} \cdot \sum_{i=1}^{n} k_n \qquad (1)$$

where

τ_{REAL} - real strength (MPa),

τ_{THEOR} - theoretical shear strength of the bonded joint (MPa),

k_n - corrective coefficients,

F - acting force (N),

b - bonded adherend width (mm),

l_u - adherend lapping length (mm).

As I have already said, there are many factors influencing the adhesive bond strength, but I am going to devote to three basic factors – The adhesive layer thickness, surface preparation and the environment temperature which will straight affect the adhesive bond. The aim of this experiment is to determine the correcting coefficients for three above mentioned basic factors.

2 Material and methods

Experiments were carried out according to ISO Standard ČSN EN 1465. The exam essence consists in shear loading of simple overlapped bond. The shape and dimensions of tested specimens correspond to ISO CSN EN 1465. The substrates were made from duralumin AlCu4Mg substrates (Tab.1). Strips of rolled steel cut from the sheet table of 1 x 2 m were the starting semi product for the preparation of steel substrates. Three two-components epoxy adhesives are judged. The ratio of mixture was 1:1 (Tab. 2).

Table 1 Chemical constitution of adhesive bonded material [mass %]

Constituent	Mn	Cr	Ni	Al	Cu	Ti	Fe	Si	Mg	Zn
Duralumin	0.511	0.003	0.003	93.197	5.012	0.013	0.304	0.350	0.572	0.014

Table 2 Characteristics of used adhesives

Adhesive - used designation	Suitable bonded materials	Curing time	Heat temperature
Bison epoxy metal [Bm]	metals, aluminums alloys, ceramics, wood and plastics	12 h	- 60 to + 100 °C
3-TON Epoxy Adhesive Alteco 30 min [A30]		14 h	- 20 to + 120 °C
Uhu plus schnell fest 5 min [U5]		0.5 h	- 60 to + 80 °C

The surface of bonded specimens was mechanically worked. Very important factor which influences significantly the bonded joint strength is the bonded surface preparation. Therefore the suitable mechanical preparation of bonded duralumin specimens was selected. The bonded surface was mechanical treated by blasting using the synthetical corundum of grain 24 (fraction size 710 – 850 μm) and by grinding using the abrasive cloth of 40, 100, 150, 240, 320, 400 and 500 grit. The mechanical prepared surface was evaluated using the surface roughness measuring by means of the Mitutoyo SURFTEST – 301 profilograph. The optimum preparation was determined on the basis of laboratory tests. But at first the optimal thickness of the adhesive layer was determined. Following adhesive layer thicknesses were judged: 0.06 mm, 0.11 mm, 0.16 mm, 0.22 mm, 0.29 mm and 0.38 mm. Each adhesive layer thickness was secured by two distance wires of demanded diameter, which were sandwiched in the bonded joint. The optimum values of adhesive layer thickness and of the optimum surface preparation were used for the influence determination of the environment temperature.

After obtained values evaluation the tests were carried out. As the environment temperatures were chosen following temperatures: -50 °C, -25 °C, 0 °C, 23 °C, 60 °C and 90 °C. Minus temperature was reached using the refrigerator, lower temperature (-50° C) using the liquid nitrogen diluted for required temperature reaching by industrial spirit. Positive temperature values were reached using the drier KBC G-100/250 where the bonded specimens were placed. To these temperatures the tested assemblies were exposed for 24 hours.

The specimens were tested using the universal tensile-strength testing machine ZDM 5. After the bonded joint rupture the maximum force was read, the lapped surface was measured, the rupture type according to ISO 10365 was determined and the bonded joint strength τ was calculated according to CSN EN 1465.

Corrective coefficients were calculated from the relation (2) after putting measured values.

$$k_{nx} = \frac{Variable value}{fixed value} \qquad (2)$$

where

k_{nx} - corrective coefficients,

fixed value – laboratory temperature 23 °C, generally recommended adhesive layer thickness and adhesive bonded surface pre-treatment.

3 Test results

Laboratory experiments results and their reviewing are processed into following tables and graphs. The adhesive layer thickness was the first experimentally reviewed factor. The table 3 shows an arithmetical average of the strength and a calculated coefficient value was calculated according to the relation 2. The dark printed up value in the table 3 means the fixed value from the relation 2. It is the value generally presented as the optimum. The highest values of the strength which were measured in given interval are coloured by green colour.

Table 3 Adhesive layer thickness

Adhesive layer thickness [mm]	Arithmetical average of adhesive bond strength (MPa)			Coefficient of adhesive layer thickness change		
	Bm	A30	U5	Bm	A30	U5
0,06	17,14	11,43	6,28	0,95	0,94	0,69
0,11	**18,03**	**12,14**	**9,17**	**1,00**	**1,00**	**1,00**
0,16	17,87	12,54	9,82	0,99	1,03	1,07
0,22	17,16	**14,45**	**10,20**	0,95	1,19	1,11
0,29	16,39	13,33	7,69	0,91	1,10	0,84
0,38	15,89	11,53	7,07	0,88	0,95	0,77

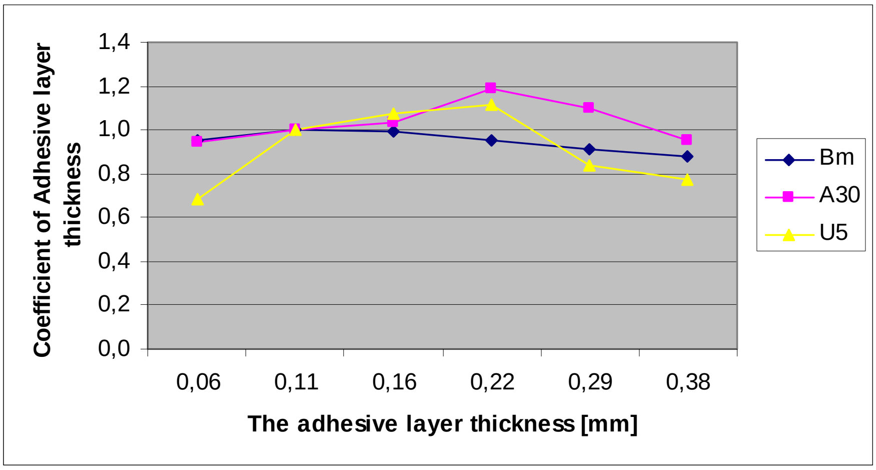

Figure 1 Corrective coefficients values – The adhesive layer thickness

A Graphical dependence of corrective coefficients values can be seen in the fig. 1. The corrective coefficients reach their maximum at he optimum values.

Green colour also means measured optimum values. The abrasive cloth of 100 grit was chosen as the etalon . It is seen from the measured values for the adhesives Bm and A30 that chosen adhesive bonded surface pre-treatment was not entirely suitable.

The surface adhesive bonded by Bison metal can be prepared by blasting on by grinding using the abrasive cloth from 150 to 500 grits with minimum difference of the corrective coefficient value and resulted adhesive bond strength.

Table 4 Adhesive bonded surface pre-treatment

Abrasive bonded surface pre-treatment	Roughness parameter (µm)	Arithmetical average of adheisive bond strength (MPa)			Coefficient of Abrasive bonded surface pre-treatment change		
	Ra	Bm	A30	U5	Bm	A30	U5
Abrasive cloth 40	5,08	13,52	12,75	4,27	0,89	0,95	0,93
Abrasive cloth 100	**2,12**	**15,19**	**13,43**	**4,57**	**1,00**	**1,00**	**1,00**
Abrasive cloth 150	1,54	18,04	12,64	4,18	1,19	0,94	0,91
Abrasive cloth 240	1,76	**18,70**	12,85	3,62	1,23	0,96	0,79
Abrasive cloth 320	1,69	18,69	11,57	3,23	1,23	0,86	0,71
Abrasive cloth 400	0,75	18,59	10,58	2,60	1,22	0,79	0,57
Abrasive cloth 500	0,54	18,45	11,11	1,86	1,21	0,83	0,41
Blasting F24	3,42	15,97	13,36	4,19	1,05	0,99	0,92

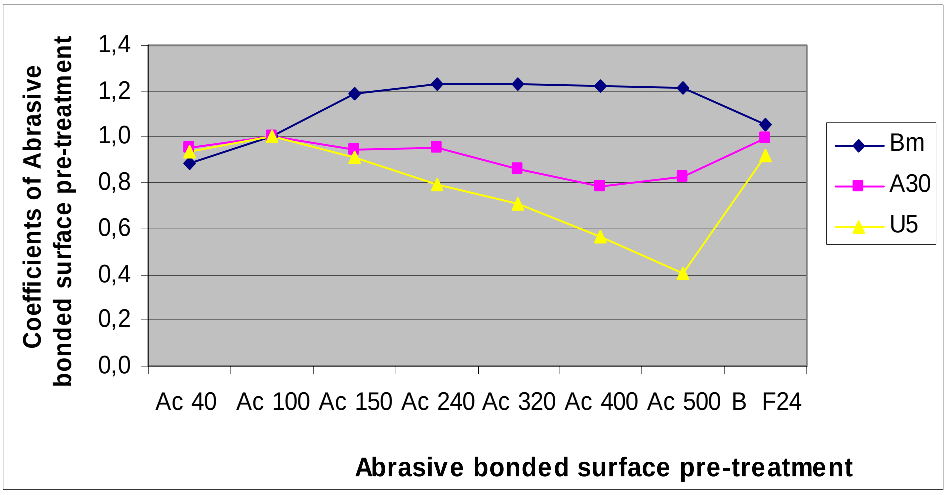

Figure 2 Corrective coefficients values – Adhesive bonded surface pre-treatment (abrasive cloth – Ac, Blasting – B)

The last focused factor – environment temperature – shows the significant influence on the adhesive bond strength. The highest adhesive bond strength were reached at the laboratory temperature 23 ± 2 °C.

Increasing or decreasing of the environment temperature have to be considered in constructional calculations – tab. 5. Almost "zero" adhesive bond strength was measured in some cases – the adhesive U5 at the temperature 90 °C.

Table 5 Environment temperature

Environmental temperature (°C)	Arithmetical average of adhesive bond strength (MPa)			Coefficients of environment temperature change		
	Bm	A30	U5	Bm	A30	U5
-50	9,24	6,31	1,45	0,49	0,47	0,32
-25	12,49	6,79	2,06	0,67	0,51	0,45
0	14,07	12,52	2,96	0,75	0,93	0,65
25	**18,70**	**13,43**	**4,57**	**1,00**	**1,00**	**1,00**
60	7,75	5,76	2,37	0,41	0,43	0,52
90	2,37	1,42	0,39	0,13	0,11	0,09

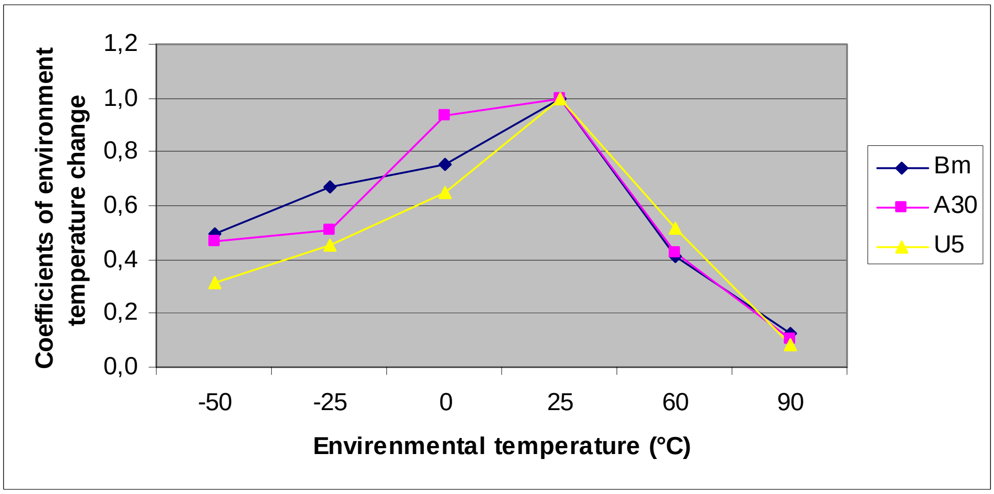

Figure 3 Corrective coefficients values - Environment temperature

Conclusion

On the basis of preliminary laboratory tests the corrective coefficients were determined which are advantageous to be taken into account. For the effective use of bonding technology in the concrete application the determination of all corrective coefficients would be suitable. These corrective coefficients should be included in the resultant stress calculation. The presented corrective coefficient values are related to measured values. The corrective coefficients modify the theoretical reached bonded joint strength according to the defined temperature.

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4 FIRM LITERATURES - *ALTECO, BISON, UHU*

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PREDICTION OF APPLE MASS LOSS BY VISION SYSTEM

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There is an increasing need for rapid and non-destructive methods to predict and evaluate the quality characteristics of fruits and vegetables. The objective of the work reported herein was to determine relationship between an optical parameter of apple surface roughness and the fruit mass loss during storage and to determine the character of the variations in apple surface roughness. The irregularities of the fruit surface change during storage because of reduction in the fruit mass as a result of drying. The mass reduction of Golden Delicious apples was determined and surface irregularities were measured by optical and mechanical methods during storage. Image processing method was developed to determine the ratio of black to the white on the images taken of the fruit surface.

The optical measurement procedure is suitable for determining the surface irregularities and the mass loss of apples. Therefore, quality can be predicted from the optical parameters. Furthermore, the purpose was to determine the characteristics of the irregularities with special respect to the frequency analysis and relationship between frequency and power spectral density function. In this case the irregularities of surface were detected by a mechanical device called Perthometer.

Introduction

Efforts have been made to develop rapid and nondestructive methods for the assessment and evaluation of quality characteristics of fruits and vegetables (Fekete A. et al., 2002). However, lately there is an increasing need for high speed and non-contact measurement methods to be used with high throughput harvesting and handling machines and for different storage facilities. Different optical test methods could meet such requirements.

During ripening and especially during storage a definite reduction is experienced in the mass of the fruit depending on fruit cultivar and storage conditions. The primary reason of this reduction occurs mainly because of the water loss. The water loss depends on several factors, but first of all on the relative humidity and the temperature of the ambient air, on the peel of the fruit, on the damage of the peel, etc. The water loss was studied by several researchers by modeling (Veraverbeke et al., 2001) and as influenced by transpiration resistances (Linke et al., 2001).

Surface roughness is of special interest for soils, roadways, pavements, machine parts and many other purposes. There are measurement methods for the evaluation of flat and cylindrical surfaces. There is relatively high roughness with pavements and relatively low with machine parts.
Therefore, surface roughness can be described by several characteristics, such as the frequency in spatial domain, the power spectral density function and especially by the “fractal concept”, with special respect to the fractal dimension, the dimension of the similarity.
The typical methods developed for the measurement of flat and cylindrical surfaces are not suitable for irregular surfaces. A special problem is the measurement of surfaces of irregular geometrical shapes. The measurement of the surface roughness of fruits and vegetables is a very sophisticated problem that should be solved by non-contact methods. Therefore, there is a need for measurement and evaluation methods to determine the surface roughness of fruits and vegetables.

Generally, the surface roughness of the fruit increases during storage. The surface roughness of the produce can be a measure of the quality, as well. Therefore, it is assumed that either a good assessment, or rather an accurate analysis of the surface irregularities could be acceptable basis for the better and early prediction of the variations in the fruit texture and fruit quality during storage under ambient conditions. Furthermore, the reduction in the quality can be predicted on the basis of such a non-contact method.

The ratio of black to white area of the surface was determined by optical method developed for the purpose. The ratio of black to white area of the fruit surface showed a close correlation with the mass loss of the apples during storage. Spectral characteristics of the roughness were studied for the apple surface during storage. The power spectral density function of the surface was calculated for fresh and stored fruits. This function was found to be suitable for determining the dominant frequency of the apple surface roughness in the spatial domain.

Materials and Methods

Experiments were performed with apples, with Golden Delicious cultivar. The apples were stored under relative warm conditions, at ambient temperature of 22 to 24º C and relative humidity of 40 to 60 %. Fresh apples were used for the measurements and the variations in the surface roughness were measured. The average mass of the apples tested was approximately 0.14 kg.

The experiments were performed for 5 weeks from the picking time. Approximately 60 apples were measured several times and the fruits were not damaged during the tests. The mass reduction was measured by electronic scale and the surface roughness of each apple was determined by conventional mechanical procedure and optical methods. The tests were performed periodically and repeated after a period of 3 to 7 days. With the optical measurements a CCD camera recorded the images of the fruit and the black and white images of the fruit surface were stored. The images taken were analyzed as black and white images.

Fig. 1. Changes of apple surface during storage

These images were converted into binary images and the ratio of the black area to the white was used to describe an optical parameter to characterize the surface roughness **(Fig. 1)**. As the result of the conversion definite edges were distinguished by filtering. The relatively dark areas were darkened to emphasize the differences. Then the evaluation of the ratio of the black and white areas was performed.

For fruit surface roughness measurement the conventional mechanical method was used. Therefore, a Perthometer was fitted with a head to which different sensors can be fitted to measure the surface roughness by
direct contact. The sensor used for the experiments was a small stick with a globe shaped end.

The globe shaped end of the sensor had to be continuously in direct contact with the surface during the scanning. A PC controlled the operation of the Perthometer type TopoSurf 3D instrument and performed the data acquisition and processing, as well. Different characteristics of the surface roughness, such as the topography and the profile were determined and average and maximum values were calculated.

The topography of a 4x4 mm area was measured on two apples and two 5.6 and 17.5 mm long profiles were recorded on each apple tested. The topography was determined from scanning lengthwise with 0.5 μm steps and crosswise with 50 μm gaps between the subsequent profiles.

The analysis of the apple surface roughness is interesting since it develops first of all because of the drying of the fruit. Therefore, the topography of the surface was analyzed to determine the frequency character of the roughness. This analysis was performed by calculating the power spectral density function of the surface when taking into account the lengthwise profile. The power spectral density function was calculated from the data obtained along the lengthwise scanning of the 4x4 mm area.

A typical topography that was measured by the Perthometer on a 4x4 mm area of the apple surface is demonstrated for fresh apple before storage and for apple after storage **(Fig. 2)**. There is a visible difference in surface roughness.

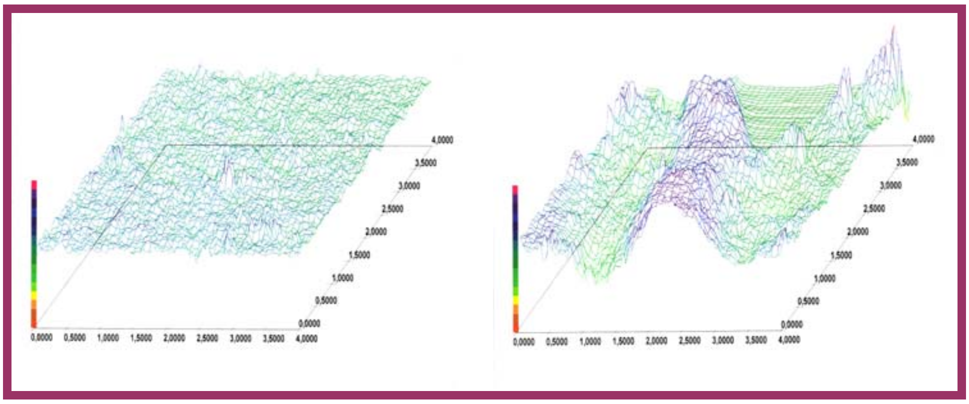

Fig. 2. Topography of the measured apple surface area before and after storage (measured by Perthometer)

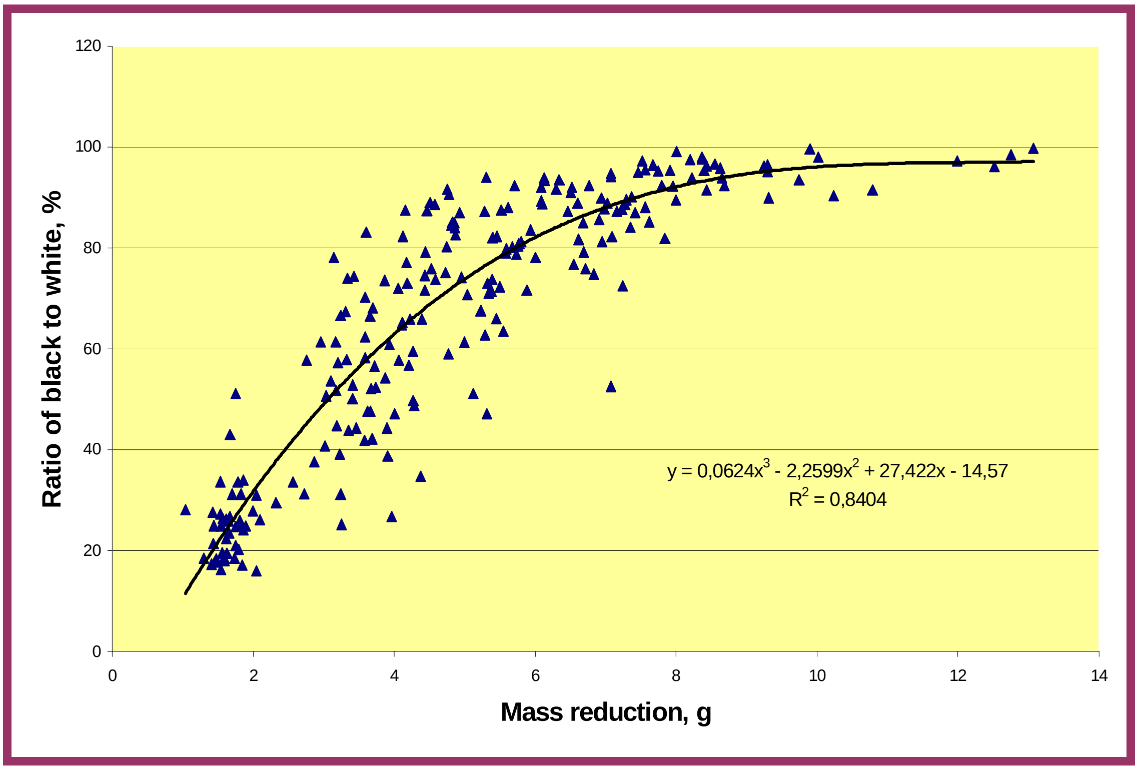

Fig. 3. Ratio of black to white area in the function of mass reduction during storage

Results and Discussion

During the experiments a definite mass reduction of approximately 10 % was found during the five week period of the experiment. The experience with the quality of the stored apples showed that the quality was acceptable for marketing and selling up to 5 % mass loss. **Fig. 3** shows the results of the optical measurements: the ratio of black to white area in the function of the mass reduction of the produce.

The apple mass reduction seems to be of a quasi-linear character up to approximately 5 % mass loss that is approximately 0.07 kg with the apples tested. The optical parameter above this limit shows only a very slight increase **(Fig. 3)**. This phenomenon is caused by the character of the black to white ratio because in that ratio above a definite level the increase of the black area is not proportional to the increase of the roughness.

The average and the peak values of the roughness measured by the Perthometer are determined in the function of the storage time **(Fig. 4)**. There is a definite steep increase in the roughness of the surface in the second half of the storage period. This phenomenon contradicts to the character of the results shown in **Fig. 3**. Since in the latter case there is only a slight increase in the optical parameter in the second half of the storage time. This contradiction can be explained by the phenomenon of the optical sensing. Since the black to white ratio is not able to sense the very rough surface. Therefore, the optically sensed roughness is smaller than the roughness sensed by the Perthometer with very rough surfaces. However, the optical method is suitable to determine the accepted limit value of the mass reduction, which is 5 %.

Furthermore, the purpose was to analyze the character of the surface roughness of the fruits during storage. Therefore, the measured surface was characterized by the power spectral density function for the spatial domain **(Fig. 5)**. This function is suitable for determining the dominant frequency of the apple surface roughness in the spatial domain. There was found a definite increase in the roughness in the range between 0.25 and 2.5 $^{1}/_{mm}$ spatial frequencies. However, there is a dominant increase in the spatial frequency above 14.0 $^{1}/_{mm}$, as well.

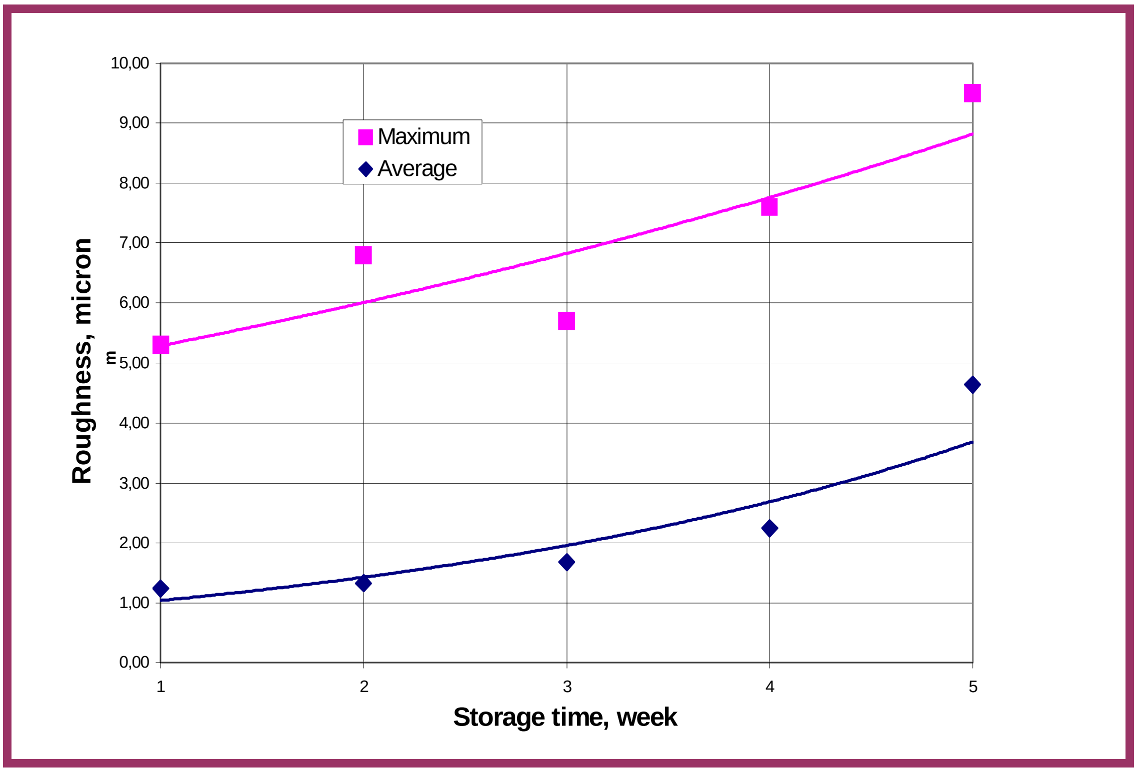

Fig. 4. Maximum and average values of surface roughness (measured by Perthometer) in the function of storage time

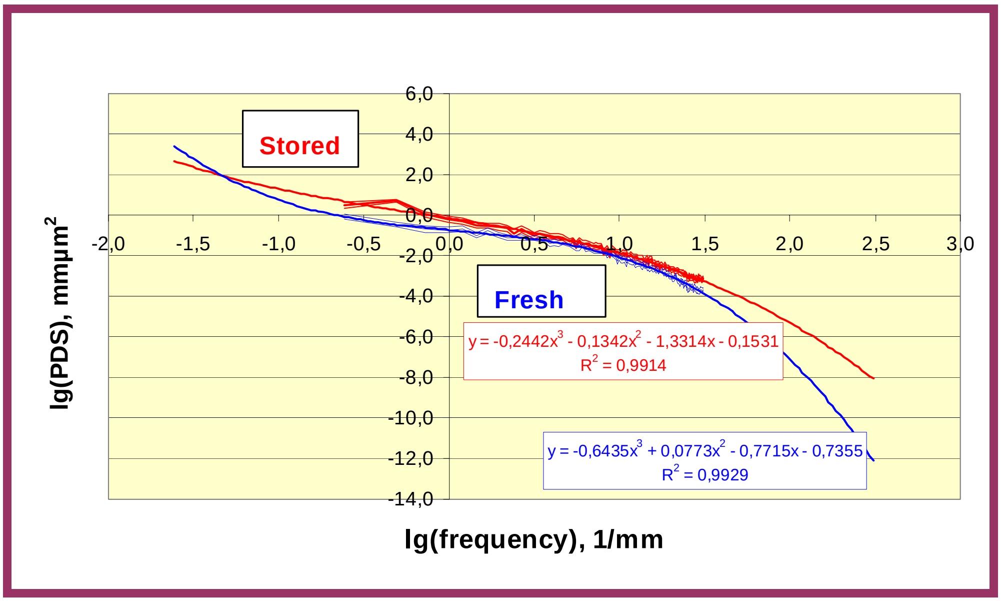

Fig. 5. Logarithm of power spectral density function versus logarithm of frequency for the spatial domain for fresh and stored apples

Conclusion

Definite reduction was found in the mass of apples stored under ambient temperature of 22 to 24º C and relative humidity of 40 to 60 %. There was a definite increase in the surface roughness of the fruits because of the mass reduction during storage period of five weeks.

The ratio of black to white area of the surface was determined by optical method developed for the purpose. The ratio of black to white area of the fruit surface was determined and it showed a close correlation with the mass loss of the apples. Therefore, this method is suitable to determine the acceptable 5 % mass reduction of the apple during storage.

Spectral characteristics of the roughness were studied for the apple surface during storage. The power spectral density function of the surface was calculated for fresh and stored fruits. This function was found to be suitable for determining the dominant frequency of the apple surface roughness in the spatial domain. The dominant frequency range for the apple surface roughness was between 0.25 and 2.5 $^1/_{mm}$ spatial frequency values. The roughness definitely increases in this range during storage.

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ALLOWABLE WHEEL LOAD OF AGRICULTURAL VEHICLES

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The trial to calculate the value of the allowable wheel load of agricultural vehicles from the wheel-soil contact area and allowable soil stress was undertaken. There are presented theoretical bases, used for developing of the function relating the allowable wheel load to the threshold value of stress, that determines internal soil strength, and to the parameters describing the tire-soil interface. For this the Boussinesqu-Fröhlich solutions as well as Sohne's assumptions, concerned of pressure distribution on the tire-soil contact area and the shape of this surface, were applied.

Keywords: soil stress, allowable wheel load, soil compaction, tire

Introduction

Pressure exerted on soil by agricultural vehicles through their elements being in contact with the soil surface (tires, caterpillars) is the most essential direct factor of influence on soil environment. In the case of overcoming threshold value of stress that determines internal soil strength cause additional compaction (Dawidowski, Morrison et al. 2001). Compaction of soil influences fundamentally on almost all proprieties of soil as well as on processes within the soil affecting in that way environmental results of agricultural production. Along with mechanization and intensification of field works more and more heavier tractors and machines to tillage, fertilization, harvest and plants protection are constructed. This and also the kneading of the furrow bottom with the wheels of tractor during plowing caused that the problem of compaction had begun becoming worldwide problem.

From among elements of the cause-effect chain load/wheel $\longrightarrow$ stress in soil profile $\longrightarrow$ soil compaction of the process of soil compaction, the first component is this which in practice can be relatively most easily measured and controlled. It seems so, that at present state of knowledge, one of ways of avoidance of excessive soil compaction is the creation of standards and recommendations limiting the admissible values of stresses in soil resulting from load exerted onto the soil by agricultural vehicles [Hakanson, Reeder 1994]. These values, after regard of the additional factors, as for example, the soil moisture, number of passes on field, year season, formulated as "the safety factor ", would determine the admissible load per axle/wheel of the vehicle.

The aim of this study was elaborating of the method that can be applied for estimation of the admissible wheel load from the internal soil strength at specified depth and from the parameters describing the tire-soil interface.

Materials

The method is based on the solution by Boussinesqu-Fröhlich (by Söhne, 1953) enabling to calculate vertical components of soil stress developed by vertical concentrated force acting on the soil surface. In the case of more forces acting it is possible to use the rule of superposition. So, when the surface is burdened with continuous load p, the value of σ_z component at the soil point M having co-ordinates (x_M, y_M, z_M) is calculated by finding the integral over the contact area A of following expression:

$$\sigma_z = \int_A \frac{\nu \cdot dP}{2\pi \cdot R^2} \cdot \cos^{\nu}\alpha \qquad (1)$$

where: ν- stress concentration factor,
dP – elementary concentrated force acting on the area element dA,
R – the radius connecting the considered soil point with the point of imposing a force on the wheel-soil contact area,
α - the angle included between the force dP and the radius R (Fig. 1).

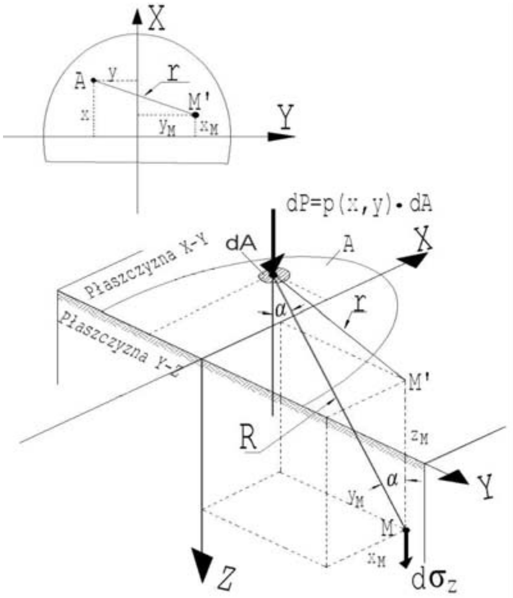

Fig. 1. The scheme of soil half-space loaded with an elementary concentrated force *dP* (Nowowiejski, 2004)

In the case of soil points lying on the *Z*-axis, i.e. along the resultant force of external load, the expression (1), after some transformations and substitutions, assumes the following shape:

$$\sigma_z = \int_{-a}^{a} \int_{-\phi(x)}^{\phi(x)} p(x,y) \cdot \frac{\nu}{2\pi} \cdot \frac{1}{\left(z_M\right)^2} \left[\frac{z_M}{\sqrt{y^2 + x^2 + z_M^2}} \right]^{\nu+2} dx\, dy \qquad (2)$$

where: $\varphi(x) = \frac{b}{a} \cdot \sqrt{-x^2 + a^2}$ - equations of the upper branch of a ellipse;

a, b – semi-axes of the ellipse representing the wheel-soil contact area.

According to Söhne (1953), it has been assumed that for different soil conditions, accordingly to the state of soil plasticity (hard to soft), the external load from wheel tyre can be distributed on the soil surface in accordance with paraboloid of 2nd, 4th or 16th degree (Fig. 2).

Then the expression describing the distribution of load on the wheel-soil contact area looks as follows:

$$p(x,y) = k \cdot p_m \cdot \left\{ 1 - \left[\left(\frac{x}{a}\right)^2 + \left(\frac{y}{b}\right)^2 \right]^{n/2} \right\} \qquad (3)$$

where: k – coefficient depending on the degree of a paraboloid (Sohne, 1953). This coefficient takes the following values 1.15; 1.5 and 2.0, for the values of paraboloid degree n = 16, 4 and 2 respectively, that is for the values of stress concentration coefficient ν = 4, 5 and 6;

$p_m = \frac{P}{A}$ - average pressure on the wheel-soil contact area;

P – wheel load;

$A = \pi \cdot a \cdot b$ – the wheel-soil contact area;

n – the degree of paraboloid.

Results

By inserting the expression (3) into the formula (2) and taking into account that

$$p_m = \frac{P}{A} = \frac{P}{\pi \cdot a \cdot b} \qquad (4)$$

the formula (2) can be write down as

$$\sigma_z = P \cdot \left(A^*\right)^{-1} \qquad (5)$$

where:

P – resultant force acting onto the wheel-soil contact area;

$A^* = f(a,b,z,\nu)[m^2]$ - reduced area of the wheel-soil contact surface calculated for the depth z and concentration factor ν.

The values of A^* can be calculated by means of the following formula (6):

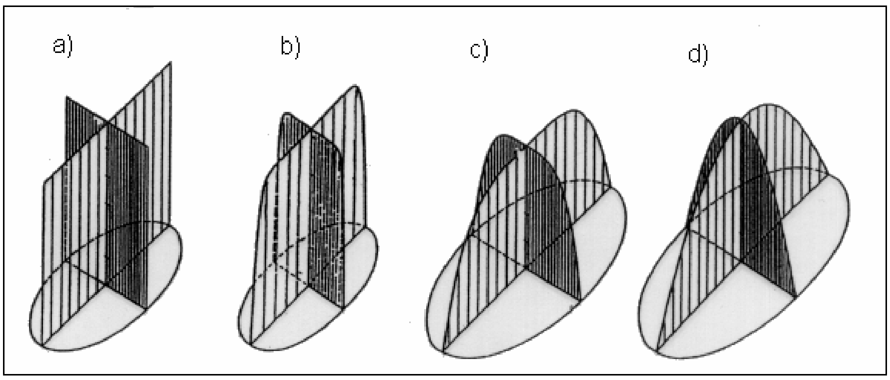

Fig. 2. The schemes of distribution of external load on the wheel-soil contact surface:
a – uniform; b – parabolic of the 16th degree; c – parabolic of the 4th degree; d – parabolic of the 2nd degree (Söhne, 1953)

$$\left(A^*\right)^{-1} = \frac{k}{\pi \cdot a \cdot b}\int_{-a}^{a}\int_{-\phi(x)}^{\phi(x)} \left\{1-\left[\left(\frac{x}{a}\right)^2+\left(\frac{y}{b}\right)^2\right]^{n/2}\right\}\cdot\frac{\nu}{2\pi}\cdot\frac{1}{\left(z_M\right)^2}\left[\frac{z_M}{\sqrt{y^2+x^2+z_M^2}}\right]^{\nu+2} dx\, dy \qquad (6)$$

According to Söhne (1953), the semi-axis of an elliptical wheel-contact surface can be described as:

$$a = 1.40 \cdot R \qquad b = 0.707 \cdot R \qquad (7)$$

where: $R = \sqrt{\frac{A}{\pi}}$ - the radius of an equivalent area of the contact surface.

The expression (5) after transformation has the form

$$P = \sigma_z \cdot A^* \qquad (8)$$

If for σ_z the threshold value of stress that determines internal soil strength σ_{dop} is taken then value of the allowable wheel load can be calculated as:

$$P_{dop} = \sigma_{dop} \cdot A^* \qquad (9)$$

The calculated values of A^* can be presented graphically on the nomogram drawn for the settled concentration factor ν, for various values of area of the contact surface A and the depth z, at which internal soil strength σ_{dop}. The nomogram can be used to determine allowable wheel load in the easy way, as is shown in example below.

Example

1. From measurement or calculations the area of the wheel-soil contact surface was obtained that:

$$A = 0.45\ m^2$$

2. Then for this value and the depth at which the threshold value of soil strength σ_{dop} was determined (in this example z = 0.4 m) the value of A^* was taken from the nomogram as follows (Fig. 3):

$$A^* = 0.324 m^2$$

3. When the threshold value of stress, that determines internal soil strength, which can be measured or calculated (Dawidowski, Morrison et al. 2001), is:

$$\sigma_{dop} = 50\ kPa$$

4. Then allowable wheel load is calculated according to the formula (8)

$$P_{allow} = 50.0\ kPa \cdot 0.324\ m^2 = 16.2\ kN \cdot$$

Discussion

5. Assumptions lying at the grounds of Boussinesqu's solutions, as well as modifications introduced by Fröhlich and Söhne, were ones simplifying the course of real processes having a place in the soil. Moreover, forces exerted onto soil surface by the wheels of agricultural tractors and machines have dynamic character, changing in time. There is also left the problem of the value of stress concentration coefficient for the specified soil

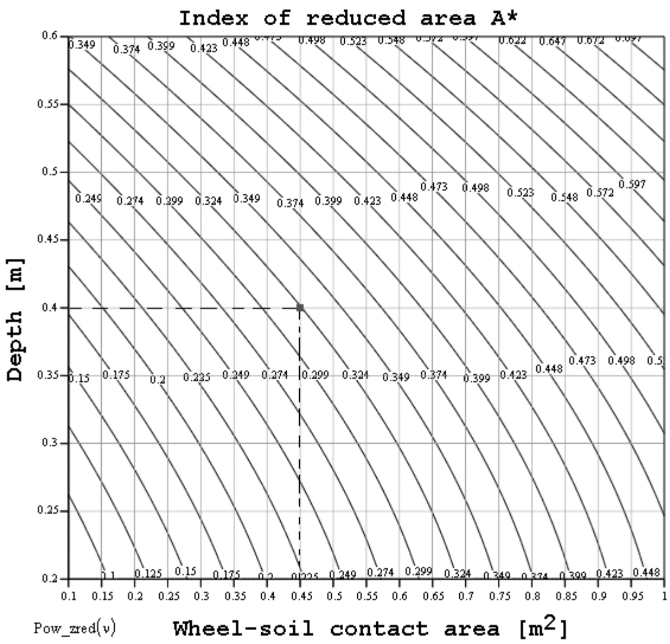

Fig. 3. The nomogram to determining the value of A^* for $\nu = 5$

and its condition. Due to that, it seems to be reasonable to take these factors into account in form of the safety coefficient correcting the calculated allowable wheel load.

Recapitulating above, it is possible to state, that determination of admissible load exerted by the wheel onto soil, based on the ground the threshold value of soil strength σ_{dop} requires the introducing of coefficients, which should take into account several factors influencing calculated value of allowable wheel load. They would be mainly:

- variability of the soil state which is not taken into account in the Boussinesqu-Fröhlich solution;
- the variability of the real distribution of pressures on the contact surface;
- difficulty in assignment to given soil of the proper value of coefficient of stress concentration accordingly to its actual state;
- not taking into consideration tangential forces and vibration in the case of the driven wheels;
- dynamics of agricultural vehicle.

At present there is no sufficient knowledge available to take all these above factors into account, in order to obtain exact values of allowable wheel load. One of ways to solve this problem would be introducing "coarse" values of such correcting coefficients, giving the larger margin of safety in the process of specifying allowable load. The results from field experiments show, that the Söhne's model gives considerable underestimation of foreseen stress values in comparison with these values measured in field conditions (Dawidowski, Jurga et al. 2001; Nowowiejski, 2004; Nowowiejski, Dawidowski et al., 2006). Then, as the first approximation, it would be possible to calculate the value of the correcting coefficient from the relation of static force acting on the wheel and the value of allowable wheel load, determined from equation (9). Such a wider safety margin would be profitable taking into account that agricultural equipment used at present practically forbids easy adaptation its parameters to actual field conditions.

Conclusions

1. The method presented in this work can be helpful in estimation of the potential hazard of soil compaction created by field traffic of agricultural vehicles since it allows the calculation of allowable wheel load from the coefficient of reduced surface A^* and the threshold value of stress, that determines internal soil strength.
2. For estimation of the real risk with soil compaction by the wheel load exerted on soil surface in field conditions, these values of load require the usage of coefficients enlarging the load following from only static burden with vehicle mass.
3. Further studies are needed to improve the accuracy of calculations by identifying and taking into account factors influencing determined value of the allowable load, exerted on the soil by the agricultural equipment.

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MATHEMATICAL DESIGN OF PROCESS OF DYNAMIC «SHAKING» OFF PEPPER SEEDS FROM CARPELS

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A mathematical model of process of the dynamic «shaking» off the pepper seeds from a carpel with the determination of the contact tension of destruction of the seeds-carpels connection has been developed.

1 Introduction

The creation of modern seed separating machines and production lines as difficult technical systems needs a deep theoretical study of the state of this question. The co-operation of the working organs of a machine and vegetables that are processed (carpels) with the purpose of high-quality separation of seeds from the carpels requires a clear design of the process which that allows to make a correct choice of the machine construction and its working organs at the stage of planning taking into account the desired results.

The machine offered by the authors for the receipt of the seeds of sweet and hot pepper is the machine of shock action [1, 11]. An object of treatment in it is the carpels, which has a shape of a semi-sphere, truncated pyramid or truncated cone with the seeds located perpendicularly to its surface. Every seed is fastened to the body of the carpels by a short neck (a stalk).

The plate of the whip strikes the carpels, that is located in the lower part of the perforated wall of a drum. The carpels is in the tensely-deformed state, and «shakes» off some part of the seeds from itself and then begins to move (to slide) on the internal surface of the drum. As the plate of the whip has a certain angle with the axis of the drum, the curve of the motion of the carpels is a spiral line with a small angle of ascent. At sliding on a cylinder surface it loses the certain amount of seeds as well. Obviously, the way passed by the carpels and the «loss of seed» are linked with the force of a blow (the speed of the whip plate). It is desirable that after the blow the carpels maks a complete turn on a circle and simultaneously moves up along the axis of the drum to interact with the next plate of the whip. Thus, on the average, the carpels perceives as many shots, as there are plates on the whip. The output of the seeds will be proportional to the force of the blow (linear rate of the plate movement) as well as to the number of shots. However, the force of the blow should be limited both cinematically and dynamically, although they are the associate factors. The kinematic limitations of the speed of the whip are determined by the length of the way of the carpels (one turn), and the dynamic ones by the possibility of destruction of the body of carpels and the seed. Thus, the contact pressure of the whip plate and that of the carpels should not exceed the limit of durability of the carpels material.

Thus, for theoretical grounding the process of segregation of the seeds of sweet and hot pepper it is necessary to create an adequate dynamic model of «shaking» off the seeds from the carpels.

2 Materials and methods

On the basis of the conducted analysis [2] the machines and equipment for vegetable plants, water-melon, melon and gourds it has been found out that while treating the pepper with the purpose of the separation of the seeds it is not obligatory to grind its body completely, but taking into account the biological features, after the separation of a small boll from the carpels (a core with the seed) it is advisable to separate the seeds by «shaking» them off [3, 4].

The theory of blow relates to the field of theoretical mechanics [5] and also mechanics of continuous environment [6, 7, 8, 9]. The character of interaction at a blow is determined by the force of the blow, time of the interaction and the material of the interactive bodies. But in the mentioned works the results obtained relate to the bodies of a regular geometrical shape, homogeneous material with the properties well studied.

The bodies of vegetable origin, such as pepper carpels, heterogeneous in their structure, of a wrong geometrical shape, considerably change these indexes depending on the variety. Therefore, the construction of the adequate mathematical models which describe the physical essence of the dynamic process of «shaking» off the seeds from the carpels will make it possible to optimize the choice of structural and technological parameters of the machine that is being developed.

3 Results and discussion

As far as the carpels moves chaotically inside the drum during the process of «shaking» off the seeds, it is next to impossible to foresee the appropriateness of the contact of the whip with the carpels. Therefore, mathematical description of the process of the separation of seeds from the carpels, it is advisable, with the purpose of adequacy to consider three models which in general will represent the reality very closely.

The first model represents the collision of a whip shoulder-blade of a working organ of the machine with a seed which is on the surface of the carpels. Let the carpels fall on a «flag» with the speed of falling V_0 (Fig. 1).

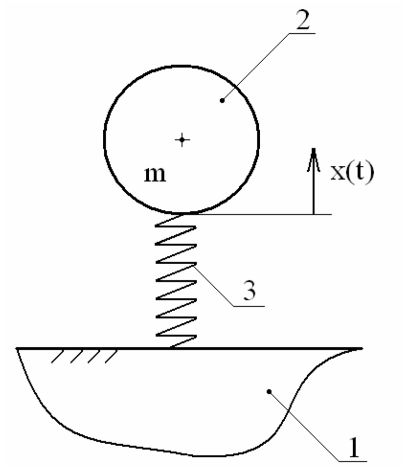

Figure 1 - Calculation chart for the first model of «shaking» off the seeds:
1 – body of carpels; 2 – seed; 3 – stalk of seed

At the moment of the carpels and flag collision the equation of motion of the seed on the neck is as follows [10]:

$$m\ddot{x} + kx = 0 \tag{1}$$

where m – is mass of a seed;
k – is coefficient characterizing energy of deformation of neck.
In its turn,

$$k = \frac{S_ш \cdot E}{l}$$

where $S_ш$ – is area of transversal cut of neck;
l – is length of neck;
E – is module of resiliency of material of neck.
At the moment of blow $t = 0$ initial velocity of motion of seed neck is V_0.
For the sake of convenience (1) it is possible to rewrite the equation as follows:

$$\ddot{x} + \omega_0^2 \cdot x = 0 \tag{2}$$

where ω_0 – is circular frequency of harmonic motion $x(t)$:

$$\omega_0^2 = \frac{k}{m}. \tag{3}$$

Initial conditions look like:

$$x(0) = 0; \quad \dot{x}(0) = V_0. \tag{4}$$

Then the solution of the equation (2) according to [10] looks like:

$$x(t) = \frac{V_0}{\omega_0} \sin \omega_0 t \tag{5}$$

$$\dot{x}(t) = V_0 \sin \omega_0 t. \tag{6}$$

Tension in a neck:

$$\sigma(t) = \frac{E \cdot x(t)}{l} = \frac{E \cdot V_0}{l \cdot \omega_0} \sin \omega_0 t. \tag{7}$$

The maximum tension is achieved at the moment t_0 from a condition:

$$\sin \omega_0 t_0 = 1 \tag{8}$$

$$\omega_0 t_0 = \frac{\pi}{2}. \tag{9}$$

With (9) we will get:

$$t_0 = \frac{\pi}{2\omega_0}. \tag{10}$$

Thus, we have:

$$_{\max}\sigma = \frac{E \cdot V_0}{l \cdot \omega_0}. \tag{11}$$

Maximum tension is compared to the limit of durability of material of neck (by the limit of fluidity σ_T).

The second model of «shaking» off the seeds from the carpels is to the effect that a whip shoulder-blade contacts directly with the carpels, and through deformation of its body the point of fastening the neck (a stalk of seed) undergoes moving $y(t)$ (fig. 2).

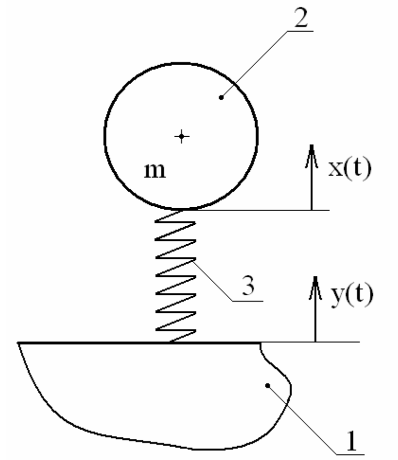

Fig. 2 - Calculation chart for the second model of «shaking» off seeds:
1 – body of carpels; 2 – seed; 3 – neck (stalk of seed)

In this case, the equations of motion of seed looks like:

$$m\ddot{x} = -k(x - y) \tag{12}$$

where m – is mass of seed;
x – is law of motion of seed;

y – is law of motion of body surface of carpels.
Let $y = y(x)$ be the set (known) function of time.
Then equation (12) can be written down as follows:

$$\ddot{x} + \omega_0^2 \cdot x = \omega_0^2 y(t) \qquad (13)$$

where $\omega_0^2 = \dfrac{k}{m}$.

As there is a blow, then:

$$y(t) = y_0 \cdot H(t) \qquad (14)$$

where $H(t)$ – is the single function of Heavyside;
y_0 – is quantity.

Initial conditions:

$$t = 0; \quad x(0) = \dot{x}(0) = 0 \qquad (15)$$

Solution of equation (13) according to [10]:

$$x(t) = y_0(1 - \cos\omega_0 t) \qquad (16)$$

$$\dot{x}(t) = y_0\omega_0(1 - \cos\omega t) \qquad (17)$$

Then the size of tension in a neck will be determined as:

$$\sigma(t) = E\frac{(y(t) - x(t))}{l} = \frac{E}{l} y_0[1 - (1 - \cos\omega_0 t)] = \frac{Ey_0}{l}\cos\omega_0 t \qquad (18)$$

Maximum tension:

$$_{\max}\sigma = \frac{E \cdot y_0}{l} \qquad (19)$$

is achieved at in a moment $|\cos\omega_0 t| = 1$ or at $t_0 = \pi$.

The third model represents the process of «shaking» off the seeds at the direct contact of the carpels and seeds with the shoulder-blade of the whip.

We will consider the dynamic system of two masses: m_1 – body mass of the carpels and m_2 – mass of a seeds (or all seeds) (fig. 3). The masses are connected by an equivalent spring (a neck). Mass m_1 has undergone the influence of shock impulse $F(t)$.

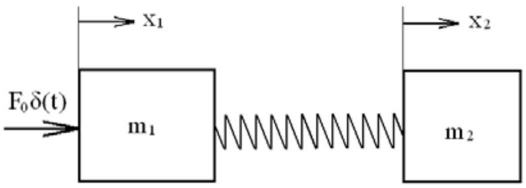

Fig. 3 - Calculation chart for the dynamic system of carpels-seed

Shock impulse $F(t) = F_0 \cdot \delta(t)$

where F_0 – is force of blow on the system;
$\delta(t)$ – it is Dirak's delta function, which looks like:

$$\delta(t) = \lim\frac{1}{t_0}[x(t) - x(t - t_0)] \qquad (20)$$

Delta function has the following properties:

$$\int_0^\infty \delta(t - a)dt = 1 \qquad (21)$$

$$\int_0^\infty f(t)\delta(t - a)dt = f(a) \qquad (22)$$

where $0 < a < \infty$.

Equation of motion of the system according to [10] looks like:

$$m_1\dot{x}_1 + k(x_1 - x_2) = F_0 \cdot \delta(t) \qquad (23)$$

$$m_2\dot{x}_2 - k(x_1 - x_2) = 0 \qquad (24)$$

We accept the initial conditions as zero ones.
Then, as it is shown in [10] the system of equations has the solution:

$$x_1(t) = \frac{F_0}{m_1 + m_2}\left(t + \frac{m_2}{\omega m_1}\sin\omega t\right) \qquad (25)$$

$$x_2(t) = \frac{F_0}{m_1 + m_2}\left(t + \frac{m_2}{\omega}\sin\omega t\right) \qquad (26)$$

where $\omega^2 = k\dfrac{m_1 m_2}{m_1 + m_2}$ (27)

$$k = \frac{S_{ш2} \cdot E}{l} \qquad (28)$$

where $S_{ш2}$ – is area of neck of a seed or seeds.
If $m_2 = n \cdot m$, them $S_{ш2} = n \cdot S_ш$, n – is a number of seeds.
The tension in necks will be as:

$$\sigma(t) = \frac{k(x_1(t) - x_2(t))}{S_{ш2}} = \frac{F_0}{S_{ш2}(m_1 + m_2)}\left(\frac{m_2}{\omega m_1} + \frac{1}{\omega}\right)\sin\omega t = \frac{F_0}{S_{ш2}\omega m_1}\sin\omega t \qquad (29)$$

At $t_0 = \pi/2t_0$ we have

$$_{\max}\sigma(t) = \frac{F_0}{S_{ш2}\omega m_1} \qquad (30)$$

As a result of impulsive action the system has speeds

$$\dot{x}_1(t) = \frac{F_0}{m_1 + m_2}\frac{m_2\omega}{\omega m_1}\cos\omega t = \frac{F_0 \cdot m_2}{(m_1 + m_2) \cdot m_1}\cos\omega t \qquad (31)$$

$$\dot{x}_2(t) = -\frac{F_0}{m_1 + m_2}\cos\omega t \qquad (32)$$

If to designate $\dfrac{F_0 \cdot m_2}{(m_1 + m_2) \cdot m_1} = V_0$, then

$$\dot{x}_1(t) = V_0\cos\omega t \qquad (33)$$

$$\dot{x}_2(t) = -V_0\frac{m_1}{m_2}\cos\omega t\,. \qquad (34)$$

4 Conclusions

Three developed basic mathematical models of the dynamic «shaking» off the seeds from the carpels of pepper make it possible to describe adequately the process of destructing the carpels-seeds connection and determine the contact tension of destruction. Exactly such amount of models is rational for the description of physical reality of the process.

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THE DIFFERENTS IN IMPACT RECORDS ON VARIETIES OF BARLEY KERNEL

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The article describes efforts at the detection of some differences in properties of barley kernels by impact analysis. Two varieties of barley (Czech – PRESTIGE and Libyan – ALRAIHAN) were compared. Impact of kernels was realized as uniformly accelerated motion (free fall) of kernels onto a force transducer from heights of approximately 21cm. The record of the impact parameters (time and force mainly) was captured and stored by the Digital Storage Oscilloscope (DSO) for subsequent processing. The shapes of the impact records of barley kernels were different and depended on the size of kernels, their humidity, a position of acting impact and damage of kernel. Investigating the acting of impact on germ and awn (brush) of barley kernel (two ends of kernel) was preferred, as so as a visualisation the different on impact shape between damaged and undamaged kernel. The repeated impact (with the same kernel onto the same place) brings very similar shapes of impact records as show the captured impact records. The different in these shapes, in the repeated impact, is caused mainly by non central orientation of kernel acting onto the force transducer (at the end of kernel falling). Obtained the shapes of impacts were statistically processed and their differences for damaged and undamaged were founded not significant for some parameters of impact.

Keywords: repeated impact, impact record, barley kernel, quartz force transducer, damage of kernel

Introduction

Quality of cereal grain has been and continues to be an increasingly popular subject of research. Very often grain quality depends on the state of endosperm, or rather on the extent is absence of its damage. Non invasive methods for the detection and visualization of damage, determination of its type and its quantification are commonly preferred. Among the modern methods for cereal grain or seed analysis, the X-ray method is very often chosen. [2]. The experiments presented here were focused on the application of impact for the characterization of single kernel properties. Kernel impact records were used to extract many different details that characterized the various properties of kernels. On the basis of differences in impact records, the author considered the applicability of using the method of impact analysis for internal damage detection [7,8] as a substitute for the X-ray method. It was assumed that the time duration and shape of impact record would depend primarily on the orientation of kernels during their fall. It was also expected that differences in the form of the impact record would reflect kernel shapes and their kinds and humidity of kernels and their internal structure and place of impact. One of the goals of the work was to test a simple device for impact record acquisition. One example of a good and simple method for recording impacts is described in reference [1].

Material and Method

The experiment was focused on the possibility and practicability of applying the impact method as a substitute for the X-ray method for in the detection of one kind of internal damage to seeds. This was the reason for so much attention being focused on the acquisition of single kernel impact records of good quality and repeated impact records too. The impact was realized by free fall motion of kernel in a pipe of suitable internal diameter. The kernels were falling from heights of 21 cm onto a force sensor (force transducer). The obtained records were compared with respect to their shape and impact duration (the time of impact). All impact records were acquired this way. Figure 1 shows a typical impact record from the screen of the oscilloscope. Four parameters (four rows under Fig.1) describe each impact record and they are computed automatically during record capture in the oscilloscope. Figure 2 explains the geometrical sense of the parameters of impact record. Each impact record is a pulse, and it is analysed from that point of view. Next, processing of these impact records is made on the basis of analysis of the pulses, characterized by mentioned four parameters of the signals which are subjected to simple comparison and statistical processing.

The experimental material used in this case was kernels of barley (the Libyan variet ALRAIHAN and the Czech cultivar PRESTIGE). Mass of all used kernels covered interval from the lighter to the heavier kernels. Each kernel was used repeatedly ten times for acquire of average values of impact record parameters. of four parameters mentioned above for characterize of each impact record were used next three parameters: force, mass and humidity of kernels. Acquired parameters were statistically processed. There were two basic groups of experimental kernels all varieties: damaged and undamaged. The damage of kernels was made artificially by the same way. The impact was realized by free fall motion of kernels in a pipe onto a force transducer from 21 cm height on the germ or the tip (awn) of kernels. More detail about used the laboratory apparatus is in [4].

The basic properties of two used varieties of barley are:

	Humid. (%)	,Nitro. (%)	,Starch (%),	Hard. (%)
PRESTIGE	9.5	14.31	59.3	22.0
ALRAIHAN	7.6	15.01	54.4	15.7

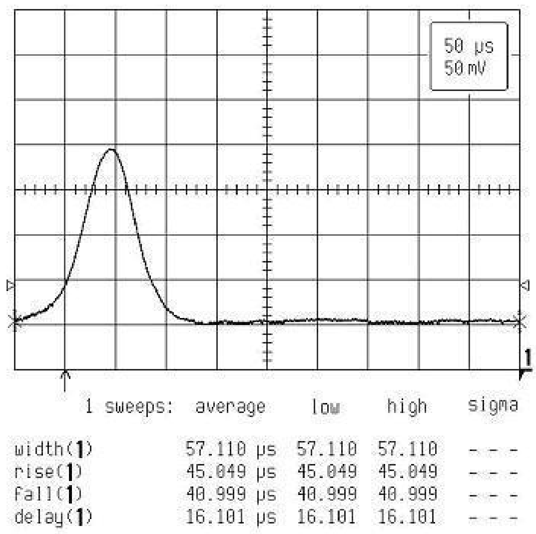

Fig. 1. A typical shape of impact record. The four parameters of the record are defined below.

Width (Pulse width) determines the duration between the **Pulse Start** (median point, i.e. the 50% magnitude transition point, on the leading edge) and the **Pulse Stop** (median point on the trailing edge) of a pulse waveform. The pulse stop is a 50% magnitude reference point.
Rise (Risetime) measures the time of a pulse waveform transition with a positive slope.
Fall (Falltime) measures the time of a pulse waveform transition with a negative slope.
Delay is the time from the trigger point to the first 50% transition crossing, i.e. the Pulse Start.
The geometrical meaning of these parameters is presented in Fig.2. The data in the upper right corner this picture (Fig.1) mean:
50 µs is the value of one division of the grid in the horizontal direction
50 mV is the value of force. One division in the vertical direction means 0.05 N (Newton). The data values are valid for all the figures in this paper and reflect the setting of the switch of the charge amplifier. (The setting of the switch depends on expected value of force).

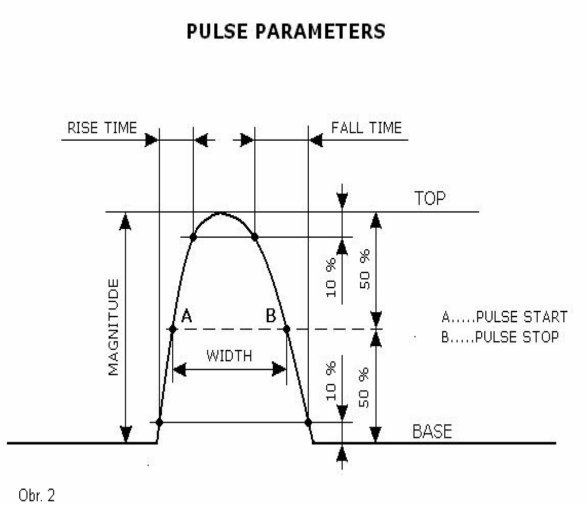

Fig. 2. A graphic presentation of the pulse parameters and their geometric sense.

Experimental apparatus

The impact of each kernel was realized by letting it fall freely from the height of 21 cm onto the force transducer which was connected to the amplifier and the DSO (Digital Storage Oscilloscope) for impact record acquisition and storage. The main components of the apparatus are detailed described in [4]. The main parts of the apparatus are mentioned below, include of their important properties

Piezoelectric sensor with high output impedance converts a mechanical quanties, such as force or acceleration, directly into an electric charge. The charge produced is proportional to the force acting on the internal (piezoelectric) quartz crystal element of the force transducer. Measurement of the mechanical quantity is thus derived from a force measurement. The threshold of this type of sensor is less than 10 mN. The sensor has very high resolution, high natural frequency, very small dimensions, and welded construction. The sensor used in the study was of type

9213sp0,1-3 (produced by KISTLER, Switzerland) and was calibrated in the range of 0-250 N. The specification measuring range of the sensor is 0 - 2500 N, with overload at 3000 N and natural frequency of 200 kHz.

The charge signal of the force transducer is transformed into a proportional output voltage in the **charge amplifier,** type 5011B. This microprocessor, controlling a single-channel charge amplifier, converts the electrical charge yielded by piezoelectric sensors into a proportional voltage signal. Transmission of data measured is not available. The amplifier has a low-pass filter in the range of 0.01-30 kHz (8 stages).

The voltage signal of the charge amplifier, type 5011B, is processed by the **Digital Storage Oscilloscope (DSO),** type LeCroy 9310A. This is a two channel DSO with 400MHz bandwidth, 100MS/s sample rate, and 50 k points acquisition memory capacity (50 k points of measured, captured and stored points. Each point represents 8 bits). Digital Storage Oscilloscopes are essential instruments for capturing, viewing, measuring, analysing and storing electronic signals. Each DSO has a few basic elements and their properties determine the primary applicability of the DSO for practice. The cardinal parameters of the DSO are: **bandwidth, sample rate and acquisition memory length** (record length).

Basic acquisition technique for DSO is **single-shot acquisition** which is a very suitable working mode for the study of signal phenomena that have a low repetition rate, or that are not repeated at all – hence *single-shot*. The time base sweeps only once, on receipt of a trigger signal, and the input data signal is captured into acquisition memory for **viewing, measurement and analysis.** All impact records in the experiment were made by this technique.

Results

The Czech and Libyan varieties of barley show a different in their mechanical properties, dimensions and shape of kernels. The husk on the cover of Libyan variety is thicker than Czech variety and Libyan barley has much longer and lighter kernels. Perhaps from these reasons the shape of impact record both national varieties of barley is different. A statistical processing of acquired data was made for the relation between **mass** of kernels and **with, rice time, fall time and force** of the impact record for each kernel. The influence of kernel humidity on the above mentioned parameters of impact record was investigated for two varieties of barley only. More information about this problem is in [5]. Each point in the next figures represents average value of the quantity of ten or twelve kernel acting singly onto the force transducer. It means that each kernel was used ten (or twelve) times. The kernels were falling onto the force transducer on a germ (B) or the tip (A) (awn or brush) of kernels. **Mass** of kernels is an independent variable. A variance measured parameters of impact record is higher for Libyan variety than Czech. A smaller different is in two parameters, **rice time** and **fall time** (for lower relative humidity of kernel). The velocity of kernel in the moment acting of kernel onto force transducer is around one ms^{-1} and it is the same value in all presented cases.

The impact force (for mass versus impact force) was bigger for damaged kernels and for both varieties of barley. This same result was found for both ends of kernel (embryo and awn). Falling the kernels onto the awn bring bigger differences in obtained values of all parameters. The with of impact records show smaller changes for damaged kernel both varieties. The with of impact records for undamaged kernels is changed more quickly than for undamaged. Next differences can be found on rice and falling time of impact records. The experiment with barley kernels, described above, was done for two value of humidity and was done at room temperature.

Discussion

Barley grain structure has a big influence on the value of presented parameters and has a big influence on their variances. The barley grain can be divided into several major components (the embryo, the endosperm, the scutellum, the aleurone, the husk). This structure is presents for the purpose understanding processes running in grain mainly [9]. Each part of grain plays its own and different roll in the grain.

- the embryo, for example, is the living or metabolically active part of the grain
- the husk covers the whole grain structure and consists of two main parts
  - the lemma on the dorsal side of the grain (which is normally extended into the awn)
  - the palea on the ventral side

the husk acts to protect the grain from infection during development and as such is relatively water resistant. In

intact grain where the husk has not been damaged during cropping or harvesting water enters the grain and the

embryo through the micropyle.

- the endosperm is the initial source of stored nutrition. The majority of the endosperm tissue is not metabolically active and consist of of large cells without nuclei packed with starch granules embedded in a matrix of storage proteins

- the scutellum is a shield-like structure that divides the embryo from the endosperm. It plays a role in both the degradation of the starchy endosperm and the nutrition of the embryo. The aleurone in barley grain consists of three layers of cells, which surround the endosperm. These cells are responsible for the production or activation of the key hydrolytic enzymes for next processing.

The big roll in a behavior of kernel plays temperature and humidity. Drying of barley requires extra care to preserve germinability for malting because heat or mechanical damage may result from some drying protocols. Aeration of stored grain with a fan can both reduce the grain temperature and dry the grain especially dehumidified air is used or low ambient humidity prevails. The relationship between moisture content and temperature and longevity in storage can be used to determine the probable storage life of barley samples. Barley should have less than 130g per kg of moisture for safe storage for one year, and less than 110g per kg for safe storage for five years.

Bad storing and handling of grain is commonly very often a source of damaged of this material. Next are defined hazards associated with storage of grain include a type of damage:

- Mechanical damage in handling
- Insect and arachnids (e.g. weevils, mites)
- Microbial infestations
- Excessive moisture
- Extremes of temperature

Conclusions

On the base of the results, obtained from this experiment, and comparison with data formerly acquired in laboratory measurement can be noted:

- the results of impact analysis showed a significant different in some parameters Libyan and Czech varieties
- the kernels falling onto the force sensor on the tip achieve smaller variance of parameters
- the force of impact record is different for damaged and undamaged kernels as so as for both ends of kernel
- the parameters of impact record for damaged and undamaged kernels are different and the parameters of damaged kernels have smaller variance their values
- the parameters impact record depend on the value of kernels humidity and mass mainly
- the with of impact records depend on humidity of kernels and partly on stage their damage.
- statistics processing of acquired data is needed for a valid results for next usefulness

Note:

The graphic form the result of impact analysis (in form of tables and figures) was not accepted in this paper because is too extensive.

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SEMICONDUCTOR GAS SENSORS AND THEIR STANDARD UNCERTAINTIES

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SnO_2 has found as important technical material in the field of semiconductor gas sensors. This material transduces different gas-surface interaction to its conductivity changes. A severe drawback of this material is their strong dependence on surrounding conditions, temperature and humidity of measured gas mainly. The properties of semiconductor gas sensors are commonly and obviously described by the semi-empirical Clifford model, which is suitable for the linearization of characteristics and for the correction of cross-sensitive. However, it often badly reproduces the disturbing influences of humidity and temperature on the sensor properties. In these cases, processing-based correction algorithms can not be applied satisfactorily. The mechanisms of change of the charge carrier concentration by adsorbed water molecules are shortly described as so as a simple model for the correction of the zero point is described. It is shown that the semiconductor sensors have commonly the wider range of their properties and are not identically. The relation between their temperature and conductivity or resistance is not linear (when the humidity is parameter). This is a reason why the results from these sensors must be analyzed carefully because any result of measurement is affected by the measurement uncertainty. The sources of these uncertainties for semiconductor sensors are described briefly.

Keywords: semiconductor gas sensor, gas concentration, humidity, uncertainty

Introduction

The semiconductors sensors are a part of chemical sensors after their definition (Ripka and Tipek 2003, part B): “A **chemical sensor** may be defined as a device, consisting of a transducer and a chemically sensitive film/membrane, that generates a signal related to the concentration of a particular species in a given sample”. “The **sensor** is the element in contact with the sensing environment. The output signal of the sensor is function of the physic variable measured. **Transducers** transform the sensor output signal into a standardized electrical signal for a suitable treatment” (Ripka and Tipek 2003, part A). Regarding the previous definition, sensors can be classified by their operational physical properties (**resistive sensors, reactance variation sensors, electromagnetic sensors, piezoelectric sensors** and etc.). For example, **resistive sensors** may be classified by the kind of physical variable measured with thermal, mechanical, optical or chemical sensors. In a group of chemical sensors the change of semiconductor resistance can be used for gas detection (oxygen detection or gases that react in the presence of oxygen as H_2, CH_3, CH_4, etc. and some applications like odour sensors (its detection). Chemical sensors are devices that provide information about the types, chemical states and concentrations of the species present within a sample. A part of chemical sensors are **electrochemical sensors** that are based on one of three categories of transduction mechanism: (amperometric and voltammetric, potentiometric or conductometric). The conductometric methods measure conductivity through the sample between electrodes. Electrochemical measurements can now be performed in the solid, liquid and even gas phases to accurately determine the concentrations of redox reactions active at concentrations as low as parts per trillion. Commonly, a accuracy and error (uncertainty) of measurement depends on many conditions, that have an various influence on finally value of result uncertainty. The type and a working mechanism of the semiconductor (solid-state) sensors brings specific situations and difficulties for determine the result uncertainty.

Semiconductor (solid-state) gas sensors and their properties

The semiconductor gas sensor is a relatively new and young measurement instrument and method. It is mainly a result of the boom of the semiconductor technology used for manufacturing electronic sensors of this type. These sensors are used for detecting and concentration measuring of many toxic gases, not only NH_3 concentration. The basic principle of these sensors is a change of their conductivity which depends mainly on interaction of the measured gas and the sensitive material (the layer on the sensing element) of the sensor. Electrical properties of semiconductor compounds depend moreover on the composition of the surrounding atmosphere.

For measuring concentration of various gases only limited group of sensitive semiconductor materials are suitable and are used the solid state gas sensors design. These materials have polycrystalline structure and are example: **In_2O_3, Ga_2O_3, TiO_2, WO_3, SnO_2, ZnO, CeO_2, CuBr, NiO, ZrO_2, $In_xO_yN_z$,** etc. In present, the **ZnO and SnO_2** are preferred to design of gas sensors and next more details about their properties will be presented. These polycrystalline semiconductor materials are very often doped by **Pt, Pd, Au, Ce, etc.** so that the sensor sensitivity is increased (the change of its conductance is increased) to the detected gas. The increasing has not constant value for various interactions sensing material of sensor and gas. Interaction of the measured gas and the sensitive material of the sensor are based on chemisorptions and its variants in used materials. Must be said the above mentioned semiconductor sensing materials have few "commonly bad properties":

- high dependence on the surrounding conditions (humidity and temperature mainly, velocity flow of air or gas, composition of gas mixture, etc)
- smaller selectivity for most of gases (it is result of basic principle the sensors of this type
- high nonlinearity between sensor output and input (between gas concentration and sensor output signal)

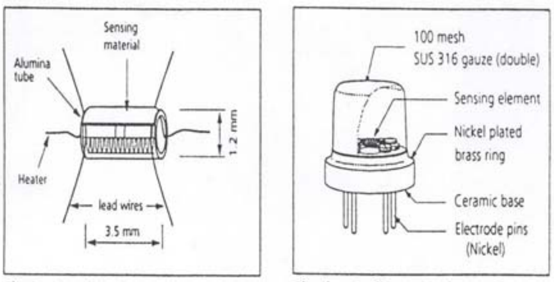

Fig. 1. The arrangement of the sensing element (left) and configuration some parts of the semiconductor sensor (SP-53).

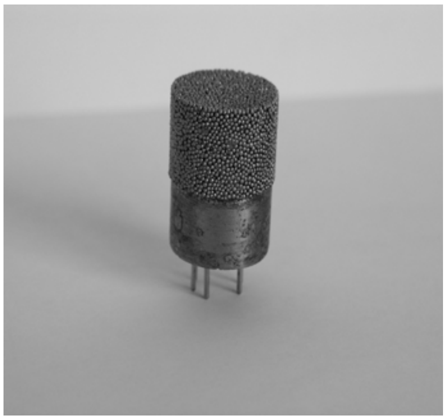

Fig. 2. The case of sensor – sintered metal housing. Diameter is 15 mm.

The sensing element of sensor has very small dimensions, as show figs 1. and 2. Because power consumption this type of sensors is smaller than 400 mW a sensor surrounding is not too heated. The applied heater voltage regulates the sensing element temperature to obtain the suitable performance of sensor. The change in the sensor resistance is generally obtained as the change of the output voltage across the load resistor (in series with the sensor resistance). Fig. 3. presents the semiconductor gas sensor in the case for continual measuring of ammonia emissions. The air with ammonia flows through this case for long time.

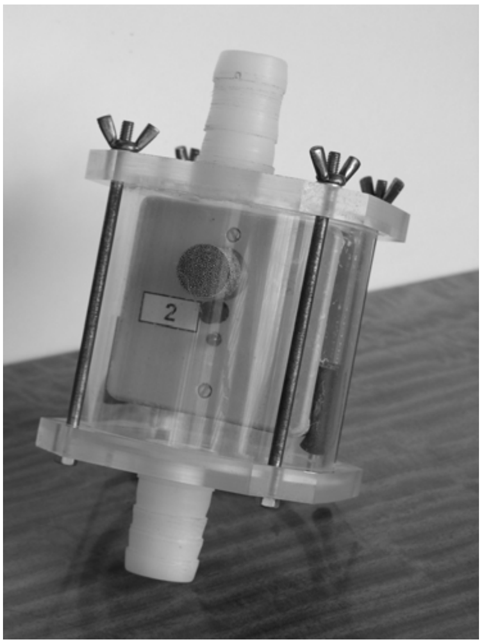

Fig. 3. The semiconductor gas sensor is in case. The complete is prepare for continual measuring of ammonia emissions. Air with ammonia flow through the case.

Nowadays many semiconductor gas sensors are based on the use of micro hotplate that creates "sensing element" of the sensor. This element is usually kept at higher temperature, higher than

200°C. It depends on kind of sensitive material, which has to be kept on temperature constant value because its temperature changes bring nonlinear changes of gas concentration measured through the conductivity changes of the sensor. This is first disadvantage. The second disadvantage is the strong dependency of sensing element on humidity of the measured gas. Both disadvantages are analyzed (Golovanov, 2002) for semiconductor material SnO_2. The same author explains very carefully the mechanism of interaction between CO gas and SnO_2 sensing layer of sensor element. This sensing material was used by (Guerrero, at al. 2002) for design of sensor for detection and measurement of C_2H_4 in humid atmospheres. The sensing element is smaller than 1 mm and is based on micro hotplate architecture. In this case, the booths mentioned disadvantage, poor selectivity and signal drift, were successful solved.

Above mentioned the strong dependence of the semiconductor gas sensors on surrounding conditions, especially temperature and humidity, is the serious problem and disadvantage of this type of gas sensor. The resistance characteristic of gas sensor with SnO_2 represents the sensor's humidity-dependent on zero point humidity (Horn, Czajor, 2002). These materials have the typical sigmoid behavior for temperature-stimulated conductance measured in mix gases, as show figure 4. The next important disadvantage of gas sensors with SnO_2 is their unselectivity. It may be reduced by the use of the sensor matrix which contains the array of sensors with different sensitivities to particular gases. Commonly, there are several advantages of semiconductor gas sensors such as simplicity, quick response, low price, automatic measurement, long life and etc. Some of their disadvantages were mentioned above.

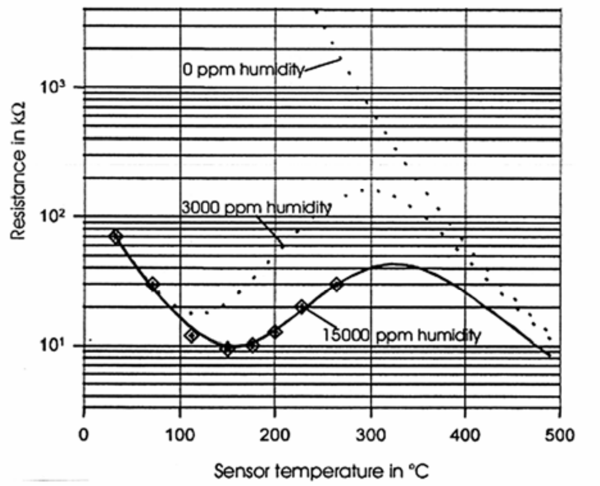

Fig. 4. Typical resistance of a semiconductor gas sensor as a function of temperature with humidity as the parameter (Horn, 2002)

From historically point of view, approximately since 1962 the development of conductometric gas sensors using thin films or porous ceramics of n-type semiconductor oxides, such as SnO_2 or ZnO started. However, the gas detection mechanism is unspecific (for mentioned materials). The electric resistance of n-type semiconductor under high oxygen partial pressure is high, because electron transfer from the semiconductor to adsorbed oxygen leads to an electron-depleted space charge region near the semiconductor surface. This type of conductometric gas sensor presents an inherent lack of selectivity, because more or less any type of reducing gas is detected by this mechanism. The properties of these type semiconductor sensors are determined by this mechanism. It is one from reasons for development of selective micro sensors, based on "molecular recognition".

The conductivity mechanism of polycrystalline semiconductor materials

Tin dioxide material, such ZnO, SnO_2 has found the very important technical application in the field of chemical sensing due to its ability to transfer different gas-surface interactions to conductivity changes. Although these materials were having been extensively studied, their detection mechanism is not yet fully established. Depending on the conditions preparation of the sensing materials, sensor design and surroundings matter, large differences of behavior concerning mainly value of conductivity and sensitivity (selectivity too) are observed.

For polycrystalline sensitive material gas sensor, oxygen is reversibly adsorbed at holes in the grid. The previously unoccupied places act as donor (Horn, 2002):

- **the charge carries** injected by the donors are again bounded by the adsorbed oxygen, thus in near-surface areas the concentration of charge carriers and hence the sensor's conductivity changes. For next explaining, the proportionality between the numbers of adsorbed particles or holes and of the charge carrier concentration can be presumed.
- **water molecules** ever present in nature are reversibly adsorbed at the sensor's surface (its sensing layer), dissociate and thus contribute to the creation of either additional charge carriers or holes underlying the some procedure.

The charge state of the chemisorbed hydroxyl group varies depending on the different atomic faces of these thin sensitive materials prepared different technological process. Involving of the differently charged OH groups in catalytic reaction with CO affects the sensor sensitivity. Morphology and grain structure include their dimensions these sensing materials play a key role in determining of main physical and chemical properties (Golovanov et al., 2002). These materials have the typical sigmoid behavior for temperature-stimulated conductance measured in air and mix gases.

The effect of the Pt and Pd additives on the gas sensing properties of SnO_2 is well-known and there are two basic mechanisms:

- **electronic**, where the gas molecule takes place not on the surface of the SnO_2, but on the surface of Pd and Pt clusters. The Pd acts by the electronic mechanism.
- **chemical,** where the SnO_2 itself acts as a chemical catalyst. The Pt acts by the chemical mechanism.

The gas sensing mechanism strongly depends on the location and chemical state of the additives (Kiss et al., 2002). A comprehension of the relation between the sensing material catalytic properties and its electrical response is indispensable to understand the whole gas sensing mechanism and needed to determine the performance of gas sensor arrays or active filters. A deep analysis of the material-gas interaction and its influence on the sensor electrical response is still lacking to completely understand additive role on gas sensing mechanism (Cabot et al., 2002). Improve the sensor selectivity depends on better knowledge of physicochemical parameters on the surface-gas reaction of interfering gases.

Uncertainty analysis

The uncertainty of a gas measurement (its determination) is made techniques described in the ISO Guide to the expression of uncertainty in Measurement. The uncertainty of each of the input quantities is determined, weighted by its sensitivity, and combined with the other uncertainty components to arrive at a combined uncertainty. Consider a process that has an output $\boldsymbol{y}$ based on $\boldsymbol{M}$ input quantities $\boldsymbol{x_i}$. The generic basic equation is:

$$y = y(x_1, x_2, \ldots, x_M),$$

If all the uncertainty components are uncorrelated (gas temperature, gas humidity, gas velocity, voltage of sensor supplier, etc) the standard uncertainties are combined by root-sum-square (RSS):

$$u_c(y) = \sqrt{\sum_{1}^{M} \left(\partial y / \partial x_1 \right)^2 u^2(x_1)}$$

where $\boldsymbol{u(x_1)}$ is the standard uncertainty for each of the inputs, and $\boldsymbol{u_c(y)}$ is the combined standard uncertainty of the measurand. The partial derivatives in the second equation represent the sensitivity of the measurand to the uncertainty of each input quantity. In case where correlated uncertainties are significant to the second equation have to be completed (under root-square) by the expression:

$$+\,2 \sum_{i=1}^{M-1} \sum_{j=1}^{M} \partial y/\partial x_1\, \partial y/\partial x_j\, u(x_i) u(x_j)\, r(x_i, x_j)$$

where $r(x_i\ ,\ x_j)$ is correlation coefficient, running from -1 to +1, and equaling zero it the two components are uncorrelated. As will be seen in the following analysis some uncertainty components in this system are correlated and this leads to a significant improvement in the uncertainty of the measurand. Very often, correlated and uncorrelated uncertainties will be treated as separate components, even they are related to the same physical quantity. For instance, there will be a correlated as well as uncorrelated temperature component. In this manner, the correlated components can be considered as having a correlation coefficient of 1, while uncorrelated components have correlation coefficients of 0.This approach simplifies the process to deciding which uncertainty sources are correlated versus uncorrelated and checking that the assumption of perfect correlation is reasonable.

Calibration of measuring devices

Calibration of measuring devices provides information about drift, linearity, stability, precision and etc. Calibration of an NH_3 measuring device is usually realized by measuring NH_3 concentration in certificated gas mixtures of NH_3 in nitrogen or NH_3 in the air. The difference between the known NH_3 concentrations and the device outputs guides the correction of the measurement by adjusting system hardware or software, or by correcting concentration data during data processing. Recalibration after using the device for a certain time is necessary, because drift of the instrument occurs.

Discussion

Common properties gas sensors with SnO_2 (and similar sensing materials) were presented on gas sensors for long time monitoring of ammonia. Many subjects have big practice opinions with type these sensors. Moreover the ammonia concentration is worldwide carefully investigated and the ammonia (NH_3) is an important substance playing a big role in the nitrogen cycle. Its properties are described in (Kamin et al., 1979). Agricultural NH_3 emission has become one of the major worldwide air pollution problems. Although studies of agricultural NH_3 have been increased in recent years, reliable field measurements of NH_3 at animal buildings are a major need. Understanding and control of NH_3 at animal buildings depend on sampling and measurement techniques, including devices, instruments and procedures. In recent years, commonly the possibilities of NH_3 concentration continual measuring are improved. (Pecen, 2004) shows very short review the method and technical means for this purpose. Semiconductor gas sensors based on metal semiconductor oxidizes are preferred for the ground and long time measuring outside a laboratory. Accurate and reliable techniques provide high quality data that are essential to research as well as abatement of NH_3 emissions.

To obtained good information about NH_3 at animal facilities or buildings, suitable measure techniques must be adopted and one or more measurement variables have to be chosen depending on measurement objectives. To obtain accurate information about atmospheric NH_3 concentrations inside and outside animal buildings, measurement of concentrations at required locations is indispensable while all the other variables are optional (they are relatively less important). To obtained NH_3 emission from animal buildings or facilities, the measurement of NH_3 concentration difference between the outgoing and incoming air is essential along with the air exchange rate.

Most NH_3 concentration measuring devices offer direct reading in volumetric concentrations. However, mass concentrations are required to calculate NH_3 emissions. It is known that the volume of gas depends on temperature and pressure and is not constant. For converting volumetric concentration to mass concentration, the volumetric concentration must be multiplied by the molecular weight and the pressure and divided by the gas constant and the temperature.

A question of semiconductor gas sensors accuracy, long term stability and reproducibility of date obtained these sensors is very often not considered. It means that the data (were obtained this way) have various accuracy. A final result of ammonia monitoring is pressed in these cases with various uncertainty. It is very important for next calculations, based on the data carried out these sensors. Very often the uncertainty of used sensor is small and the uncertainties of the measuring terms are much bigger. These situations have to be solved for each case of measure separately and the uncertainty analyses have to be done. The uncertainty must be determine when a calibration or recalibration of sensors is carry out.

Conclusions

- Semiconductor gas sensors are suitable for field measuring of ammonia concentration as well as in an animal building. They are not suitable for monitoring with low or very low ammonia concentration.
- Sensors based on semiconductor sensitive materials as ZnO, SnO_2 must be carefully watched and recalibrated regularly.
- This type of gas sensors is suitable for continual measuring of gas concentrations.
- Some sources of errors associated with sampling and measurement need a careful study.
- The uncertainty analysis of the whole chain measurement have to be done before an each kind of measure.

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DIAGNOSTICS OF SHOCK ABSORBERS WORKING CONDITIONS

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In this paper the possibility of realization on-board diagnostic of the shock absorber is discussed. System implementation is based on instantaneous values analyzing of the vertical acceleration of the sprung mass, e.g. the vehicle body and the unsprung mass, i.e. the wheel hanging and the wheel itself. It is assumed that change of the technical conditions of shock damper will be sufficiently exhibited on the measured data.

Key words: shock dumper, diagnostics, vibrations, acceleration

Introduction

The shock absorbers are parts of mechanism which build the interface between sprung and unsprung mass. Properly working shock absorbers must ensure reduction of the oscillation of the vertical force which is transmitted on the road surface. Shock absorber malfunction calls decrease of the overall tangential force, which can be transmitted on the road surface. Consequently, this state result in longer braking distance as well as decreased vehicle directional stability, accelerated and uneven wear of tyres and increased load of both vehicle and road. The vehicle shock absorbers affect significantly the active safety of vehicle operation and the passengers' and driver's comfort. The shock absorbers' efficiency in operation decreases gradually and slowly. It is impossible for the driver to sense gradually increasing shock absorber malfunction. This problem conducts to finding the way, how diagnose the shock absorbers in the real time. There is possibility of shock absorbers on-board diagnostic realisation by measuring and analyzing of the time behaviour of the sprung and unsprung mass acceleration. It is assumed that change of the technical conditions of shock damper will be sufficiently exhibited on the measured data.

Material and methods

Generally used shock absorber diagnostics

The most accurate method how to diagnose the technical condition of shock absorber is using by special stationary technical device. This diagnostic method is applied only on dismounted shock absorbers. There is measured the dumping force by defined speeds of pressing and releasing of the shock absorber. Because disassembling of the shock absorber mechanism is necessary, these tests are not usually conducted. Commonly used (less accurate) method is measuring without disassembling right on the vehicle using stationary vehicle testing station [1].

Testing stations uses these basic testing principles:

1. **Amplitude method –** measuring and evaluation of sprung and unsprung mass oscillation
2. **Adhesion method** - the static value of the vertical force between the wheel and the platform is measured and evaluated
3. **Impulse method** – measuring of sprung mass movement (oscilation) after the excited force impulse

First two methods are widely used nowadays. Driver rarely pass the vehicle through one of these tests out of regular technical check period.

Permanently shock absorber diagnostic

Design of the new permanently diagnostic method is based on several simplifications which simplify especially dynamic model of shock absorber behaviour or more precisely vehicle itself. Mathematical model of the vehicle has to conform to dynamic model. This model is usually considered for 4 wheel drive vehicles as it is shown on figure 1. It is obvious that the real dynamic model is more complicated and for mathematical explanation is very complex. Generally, it is assumed that for simple mathematical explanation are sprung and unsprung mass parts of the dynamics system with only 2 degrees of freedom (Figure 2.). This simplification is possible according to reference [1].

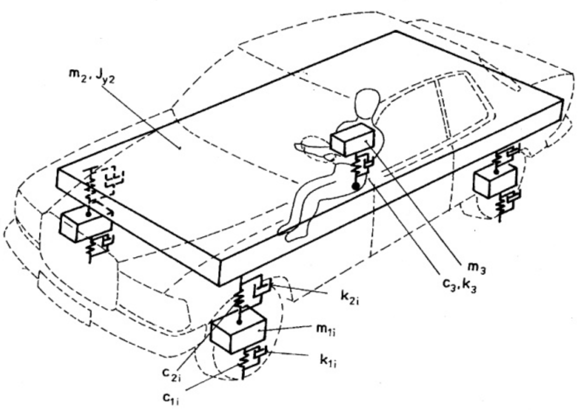

Figure 1 Dynamic model of an vehicle

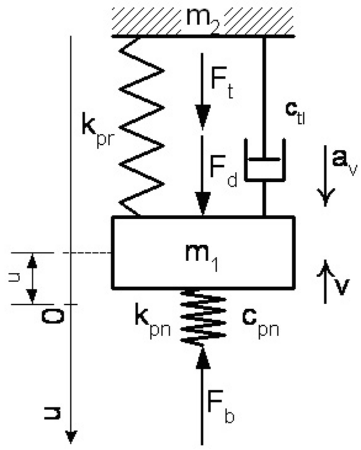

Figure 2 Dynamic model of wheel and wheel arm

It is possible to derive, that:

$$F = F_d + F_t + F_b = m_1 \cdot a_{v1} = m_2 \cdot a_{v2} \quad \textbf{(1)}$$

Where:

m_1 is oscillating unsprung mass (wheel and swinging arm) [kg]

a_{v1} is vertical acceleration vector of mass m_1 [$m.s^{-1}$] and is function of time

m_2 is sprung mass (part of overall car body's mass) [kg]

a_{v2} is vertical acceleration vector of mass m_1 [$m.s^{-1}$] and is function of time

Conversion of formula (1) leads to:

$$\frac{m_2}{m_1} = \frac{a_{v1}(t)}{a_{v2}(t)} \quad \textbf{(2)}$$

Formula (2) is directly useable as basic calculation for on-boar shock absorber diagnostic. In this case values m1, m2 are meant as the constants. It is necessary to measure the values of time dependencies *$a_{v1}(t)$, $a_{v2}(t)$*. Technical solution of measuring can be based on using accelerometers. Ratio of absolute maximum acceleration values a_{v1}, a_{v2} measured just after some force impulse is assumed as diagnostic criteria d_k (Formula 3). This ratio characterizes and quantifies the dumping of particular wheel shock absorber [2].

$$d_k = \frac{|a_{v1}(t)|}{|a_{v2}(t)|} \quad \textbf{(3)}$$

Exciting force impulse can be excited by run over reference bump by defined velocity (Figure3).

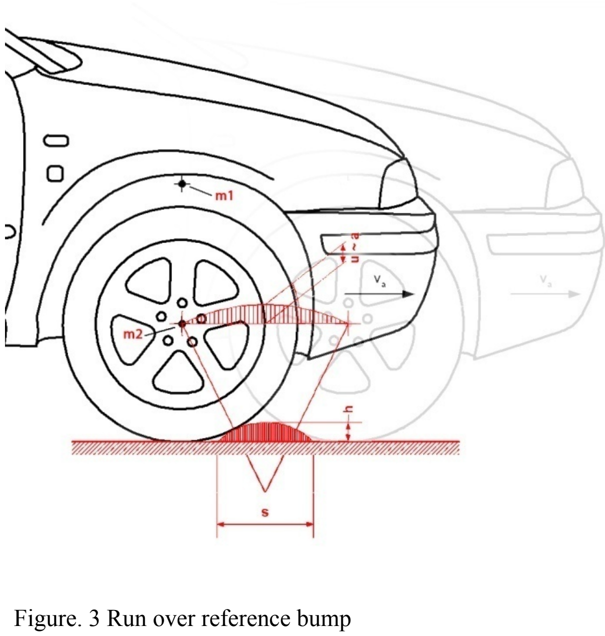

Figure. 3 Run over reference bump

Figure. 4 Speed bump

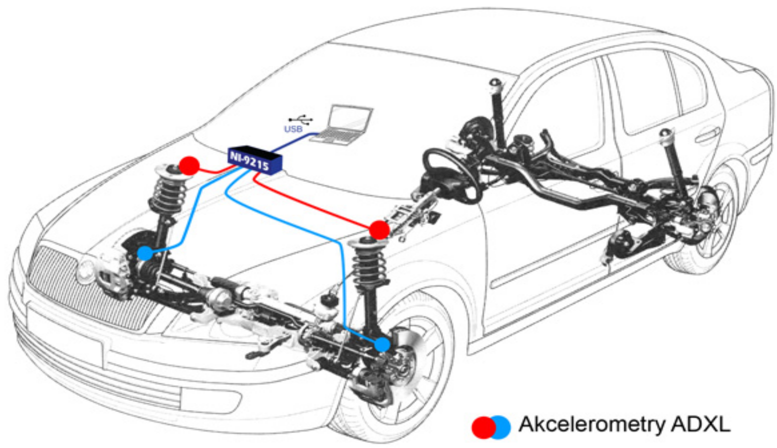

Figure 5 Measurements system diagram
(red/white = ADXL accelerometers and wiring)

On the ground of presented theory verification requirements was designed system for measuring of the acceleration of the vehicle's sprung and unsprung mass. System consists of 4 accelerometers ADXL210 and of data acquisition device NI-9215 (DAQ device). DAQ device is set and controlled by computer program which was created in LabView programming environment. The program make possible set up a range of parameters of the measurement, e.g. sampling rate, calibration values, storing options etc. Whole device is mounted in vehicle and connected via USB bus to notebook (Figure 5.).

Result and discussions

Checking of measurement device and methods has been made on testing vehicle ŠKODA OKTAVIA 2.0 TDI 103 kW. The vehicle was equipped by properly working original shock absorbers.

The time behaviour of vertical component acceleration of wheel arm acceleration is shown at Figure 6. Acceleration of sprung part of vehicle is distinctly lower which is evidently caused with absorbance of substantial amount of energy in correctly working shock absorber (Figure 7).

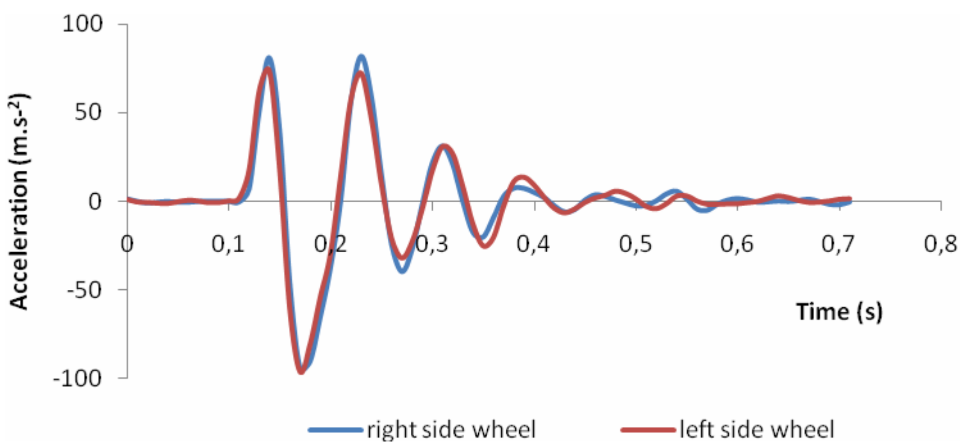

Figure 6 Time behaviour of unsprung mass acceleration by running up the speed bump (v=30km/h)

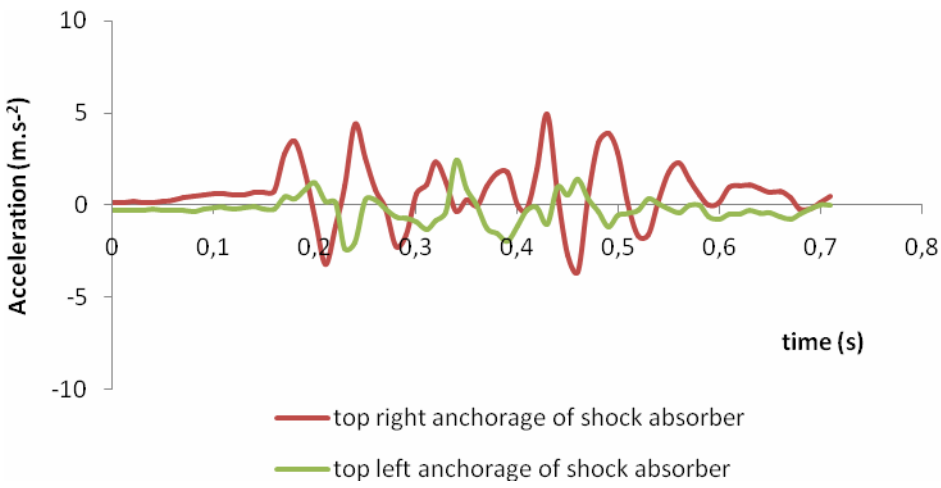

Figure 7 Time behaviour of sprung mass acceleration by running up the speed bump (v=30km/h)

It is assumed that change of the technical conditions of shock absorber will invoke change of values of acceleration both unsprung and sprung mass as well theirs ratios. This case has not been verified due incorrectly working same type shock absorber unavailability.

There are obviously usable couple of different methods for evaluation of technical condition:

1. Actual values of acceleration ratio evaluation - according to formula (3). There is necessary to measure and evaluate both sprung and unsprung mass acceleration.
2. Dampening capacity evaluation – there is necessary separate data incoming just after exciting impulse and build exponential envelope curve of oscillation analogous to stationary impulse method.
3. Trending of acceleration values evaluation during total operational time - there is not possible to determine real –time statement of shock absorbers technical state, nevertheless this method is useful.

All of designed methods involve comparing of evaluated parameters with referential parameters of equal type of mechanical system. These methods are not separately usable at this time. For example: it is not possible to accept alert notification generated by this system, in order to proceed with maintenance action. This alert notification will be the first recommendation for using other diagnostics procedures, e.g. using by standard stationary test stations.

Conclusions

There has been designed functional device for measuring and recording of vertical acceleration components of sprung and unsprung masses. Furthermore, there have been proposed suitable methods for evaluation of measured data, which could result to main aim, i.e. permanently diagnostics of shock absorbers technical condition. It is necessary to verify this developed measuring system by obtaining more data amount, which will be statistically processed. Comparing of parameters will be conducted for properly working shock absorber and for damaged shock absorber. Based on partial results will be selected right algorithm for evaluation of shock absorber technical condition. If given hypothesis will be experimentally proven, there is the chance to implement such a system directly by automotive manufacturers.

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BRAKING TRAJECTORY - SAFETY PART OF ELECTRONIC TOLL

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Road-traffic safety is a big priority not only for car companies, but especially for car users. Achieved braking trajectory, directly measured only at homologation test, is one of the main aspects of safety. Routine measuring in vehicle testing stations doesn't give this specification. Possible use of braking trajectory simulation is indicated in the paper (software MathCad 2001 Professional). A possibility to change input parameters and to follow their influence on final braking trajectory is an advantage of this model. This information is given to the driver to know his vehicle behavior during changing situations.

Keywords: electronic toll, traffic safety, braking trajectory

1 Introduction

Modern engine management systems (as well as other vehicle systems) obtain a number of data from the vehicle sensors. These data are used for on-line control of certain functions. The information capability of these data is currently utilised only partially for the purpose of on-line control. By means of further processing of these data it is possible to expand capabilities of control systems. One of the suitable areas of this enhancement is safety of vehicle operation and automotive traffic, with possible links to registration and records of inappropriate or forbidden behaviour of drivers. Another possible area is maintenance and dependability of vehicles.

In a similar way, electronic toll systems are utilised only for calculation of road toll, although the information capability of these systems is substantially higher. Because the system of electronic toll can be connected to the vehicle on-board information and control system, it seems to be useful to enhance the electronic toll system with other modules, which would enable to utilise existing primary signals in on-board systems for other applications. One of these applications could be "the safety component of electronic toll".

Especially vehicle operation economy relating to environment protection, reliability, but above all **safety** gain ground today.

Road-traffic safety is a big priority not only for car companies, but especially for car users. Achieved braking trajectory, directly measured only at homologation test, is one of the main aspects of safety. Routine measuring in vehicle testing stations doesn't give this specification.

Increasing requirements to active safety influence vehicles construction and driving characteristics. Brake system is an indivisible component creating the level of driving characteristics. In reference to still escalating transport safety requirements, maximum effectivity, reliability and durability demands are posed at vehicle brake system. Brake system functionality is regularly checked at technical controls.

From standards, to which the vehicles must conform at Vehicle Testing Stations (regulation no. 341/2002 Coll.), it is possible to deduce the ways of brake control also for other purposes than Vehicle Testing Stations, e. g. at vehicle servicing, checking after brake or their parts revisions, vehicle prototype testing and vehicle preparing to Vehicle Testing Stations:

- braking effect control by measuring of **braking distance on the road**,
- braking effect control by measuring of **braking distance in the brake test room**,
- braking effect control by measuring of **braking power on wheel circumference in the brake test room**,
- braking effect control by measuring of **braking power on wheel circumference in the plateau brake test room,**
- braking effect control by measuring of braking deceleration by **decelerometer**.

Tendency, already quite clearly proving in testing method and system research and development area, leads to dynamic control ways. Suitable indicators are measured during very short system working interval.

2 Materials and methods

Dynamic way of measuring principle consists in taking impulses of rotating cylinders on time basis. Braking power and other parameters evaluating braking system condition are calculated according to them.

First it is necessary to start cylinders to chosen circumferential speed (vehicle speeds 40, 60 and 80 km.h^{-1} were chosen). The cylinders are left to stabilize their circumferential speed and after then the programmable data collector is turned on. The cylinders are left to continue 3 to 5 seconds in stabilized surface speed and then vehicle deceleration to speed about 30 km. h^{-1} by using service, emergency or hand brake follows.

After reaching of this speed, braking pedal release and time for next stabilized cylinders speed achievement follow. This original circumferential cylinders speed achievement it is impossible to miss, because it would not be possible to determine braking power on the wheel circumference. The power depends on the deceleration part, but also on the part, where the cylinders are accelerated.

3 Results

Measuring system, described in work methodics section, was several times repeated and tested. As it was revealed during individual measurements, this measuring system is problematic in case of front axle measurement, because of its big braking power.

The problem consists in fact, that front brakes are able to block revolving wheels on rotating cylinders, but tyres are not able to transfer this power to cylinders, that are further rotating and strong abrasion of tyres occurs.

Back axle measurement is troublefree, because braking power is smaller and tyre slip on cylinders does not occur generally.

At individual measurements it was achieved similar results, which are comparable. Final measuring, chosen to the mathematic model, is introduced on following figures no. 1 and 2.

If these braking power values are put in the model, vehicle braking distance in length of 68,2 m is reached. For passenger vehicle, which the vehicle Škoda Octavia is, maximal braking distance 50,7 m is valid in standard conditions according to regulation no. 341/2002 Coll.

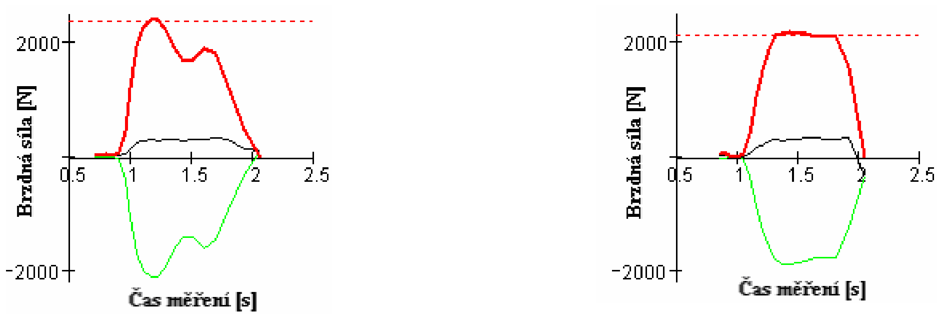

Figure. 1 - Front axle braking power (< left, right >)

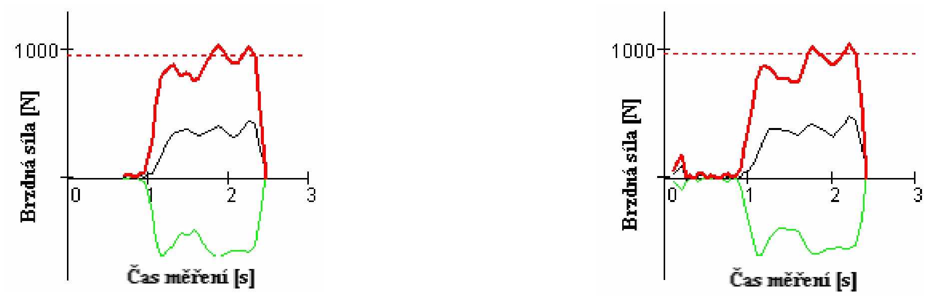

Figure. 2 - Back axle braking power (< left, right >)

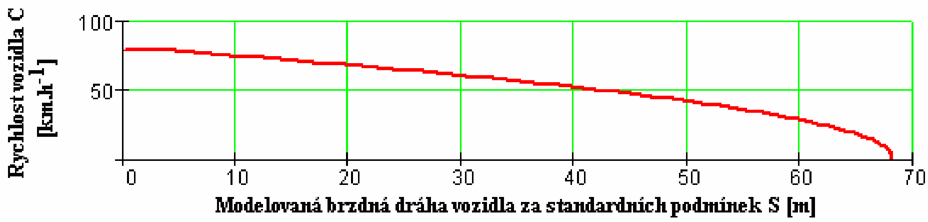

Figure. 3 - Braking distance of measured vehicle Škoda Octavia 1.9 TDI

On the basis of measured data and the fact, that it is nearly new Škoda Octavia, it is impossible to suppose that the braking distance is so long and is exceeded by complete 17,5 m, which constitutes more than 34 %. Simulated braking distance is demonstrated on figure no. 3.

The case of braking of a vehicle decelerating from initial speed of 130 km/h is presented in Fig. 4. The graph shows curves for standard adhesion conditions of dry road surface, 2 mm layer of water on the road surface (hazard of aquaplaning) and continuous layer of ice on the road surface. Due to lower adhesion coefficient for certain road surface conditions, the tyres are not able to wholly transmit the braking force $\mathbf{F_b}$ to the road surface and therefore it is necessary to limit the braking action accordingly. This limitation is possible by sensitive pressing of the brake pedal or automatically by means of ABS.

It is interesting that for longer stopping distance the requirement for brake effect drops to ca 16 %. If this level of brake effect was exceeded, the vehicle would get to skid. An experienced driver can roughly meet this requirement and almost achieve the predicted value of stopping distance $S_2 = 170.9$ m. However, as the braking pedal operating force exceeds or falls below the mentioned limited level of brake effect even for a short time, the stopping distance of the vehicle gets longer. The stopping distance will then be always longer and will only tend in limit towards the predicted value.

4 Model problems

From previous chapters it is resulting, that mentioned measurement system problem is above all in big weight of rotating cylinders and in relatively small weight falling on the front axle during this deceleration. As a compensation of this measurement system, it is possible to use one of these options:

- **Deceleration of only proper vehicle wheels measurement** – The first option is to measure deceleration of only unloaded vehicle wheels. This system would remove weighty cylinders, but it would breed some difficulties, as are bigger strain of half-axle and differential gear and also a problem how to spin the vehicle back axle, which is not operated.
- **Measurement on small circumferential weight cylinders** – The second option is to replace weighty cylinders by small cylinders that have smaller weight, compared with the vehicle wheel, diminished to their perimeter.
- **Braking power measurement using vehicle engine power** – The third option would be to use current test room with weighty cylinders, but to add yet next power for vehicles to overpower. This power may be own engine power, which would be transferred on wheels by suitable chosen speed gear.

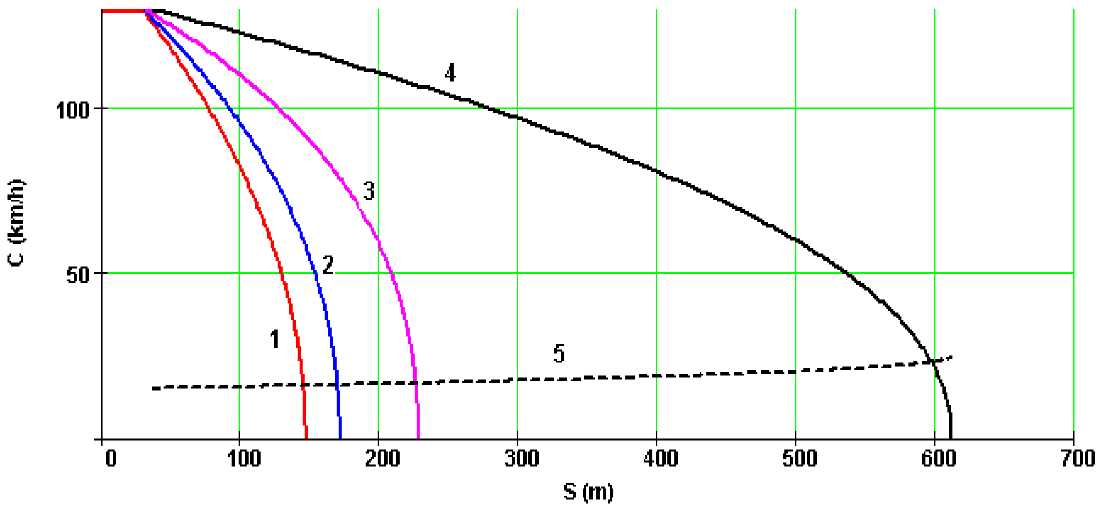

Figure. 4 - Model of braking of a vehicle in road traffic under various adhesion conditions

$v_o = 130$ km/h 1 = dry road, $S_1 = 59.4$ m
2 = 2 mm layer of water, tread depth 6 mm, $S_2 = 170,9$ m
3 = 2 mm layer of water, tread depth 1 mm, $S_3 = 227,4$ m
4 = continuous layer of ice, $S_4 = 610,8$ m
5 = percentage of usable braking force effect in case 4

5 Discussion and conclusion

Braking system checking is important in light of active safety of road traffic. Mentioned system of braking effect inspection has for its object a simple service application, which will provide objective information about a braking distance length not only in standard conditions, but even in selected operational conditions.

Information about the condition of the vehicle braking system as a unit, but also the actual effect of the condition on real operation would be given to user. That means, how long would the braking distance be in defined operational conditions.

Dynamic brakes control is since in a development stage and it is necessary to improve continuously it in practice. In present time, the main faults are in the area of tyres and their behaviour on the road.

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EMISSION COMPONENT OF SOLAR RADIATION AND THEIR INCIDENCE ON ROOF-CEILING DESIGN FOR DAIRY BARNS

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Roof-ceiling design through the emission component of solar radiation dominantly affects creating of internal environs quality in stall objects. The aim of this observation was pointing out on the possibility of passive forms of build-technical arrangements, which partially eliminates the emission component of solar radiation. Especially there were analyzed the possibilities of form designing, slopes and cardinal orientation, as well as proposal of the thermal insulation and the coloured modification of roof surface covering. By this introduced measures, the character of thermo-technical solution in the most meaning participates on mentioned quality of internal environs.

Keywords: foof structure, solar radiation, cow, heat stress

Introduction

The heat stress of animals affects the negative influence for health condition and dairy utility (Brouček, 1996, Knížková et al., 2002) et al. The stall objects are thermo-humidity exposed to frequently stress and they are demanding for thermal stability requirements (Vaverka et al., 2006). By advising of Šoch (2005), there is a necessary – on the project documentation level – to reflect on technological, microclimatic and specific continues of barns.

From this point of view the most exposed part of build covering coat in summer time is the roof structure (Chmúrny, 2003). Roof-ceiling design through the emission component of solar radiation dominantly affects creating of internal environs quality in stall objects.

Period of service, capital costs for building structures and operation costs of building facilities (ventilation, illumination) too can be influenced already during design by correct choice of materials for thermal insulation and absorbing capacity heat, by effective configuration in structure and by appropriate orientation of building to points of compass and direction of dominant winds. On thermo-technical calculations of roof and ceiling roof structures of stalls get great importance questions coupled with harmonic fluctuation of temperatures and heat flows. Temperature fluctuation of external air makes that thermal state of roof structures changes throughout a day, following creation of non-stationary state of heat transfer. Interaction of periodic varied temperature of external air and temperature state in building structure considerably influences temperature of internal air in stalls.

Material and Methods

From breeder and thermotechnical point of view in current era summer time happens for majority of our stalls fairly questionable. In lowland conditions can be observed trend to open structures by building-up of new stalls as well as by reconstruction of old ones. Increased danger of overheat in internal space threatens mainly in the cases of capital-nonintensive „light“ thermal naked buildings. Inadequate ability of roof construction to eliminate glow component of sun radiation multiplies heat incomes, that have to be damped by intensive constraint ventilation whether evaporation. Apparently, intensity extent of this actions has return negative impact on energetic severity of breeding.

From wide domain of thermotechnical judgement we concern in this contribution on judgement of temperature development in roof construction of chosen stall for dairy cattles assigned to general reconstruction. At theoretical thermotechnical judgement of constructions of this type is necessary to verify basic parameters which are:

- thermal resistance
- thermal absorption
- phase shift of thermal waves
- thermal stability of stall

Additional parameter is judgement of accumulation ability of building structures that create covering envelope of house. Theoretical judgement brings miscellaneous shoals concerning of proper estimate of conditions of real state in given structure (e.g. quantity of inbuilt or by building performance acquired humidity in building materials and thereby the necessity to calculations incorporate different values of coefficient of thermal conductivity in comparison with standardized, underfoot or dirty thermal insulation, different intensity of infiltration,...), but also difference of computational ways and obtained results (by comparison of computational ways at temperature onset whether cooling of judged structure according to computational ways of Krischer, Šklover, Laštovka...).

From listed above reasons we approached to experimental verification of real temperature behaviour in various layers of roof construction, in performance conditions, mainly in summer time. To presentation was from several observed roof constructions chosen double-cup roof of stall for dairy cattles marked K-200.

The stall is situated in lowland region and longitudinal axis of building is oriented in direction north-south. Measurement was performed at east oriented surface of saddle roof in neighbourhood of ridge during consecutive three summer days. On the ground of possible distortion of measuring data was chosen day with minimal sky. Detail of engineering solution of roof and location of places at which temperature was scanned is presented in Figure 1. Equipment used to data processing and recording scanned temperatures (Figure 2) was installed in roof skylight, additionally secured towards possible external atmospheric influences.

Result and Discussion

Measured course of temperatures is listed at the Figure 3. From graphical representation is evident daily development of temperatures in various layers of roof construction in non-stationary conditions of stall during observed day in summer time. From Figure 1 of construction solution of roof envelope follows, that in the roof envelope absents accumulated layer. This restriction of thermotechnical solution is evident also on mutual comparison of temperature difference at the covering surface and at the bottom surface of thermal insulation. This difference is documented by the form of equivalent temperature development of roof envelope, Figure 4. Time size of effects of heat profits is in interval from 5,20 hours to 15,20 hours. Temperature course with maximal increase 17,4 °C predeterminates observed roof envelope to category of thermotechnical undersized.

In the case of wider interest is possible to present also temperature courses of another chosen characteristic roof envelopes of stalls with judgement of their influence on course of equivalent temperatures.

From the point of view of failure rate of roofs can be stated, that the harmonic fluctuation of temperature of external air in time makes unequal fluctuation of temperatures in various layers of roofs. The layers so achieve their maximal whether minimal temperatures in different time. If in one layer reaches the maximal temperature, in next layer can occur already its cooling. Layers one after another slip, what increase risk of roof failure. Temperature slope in roof construction can cause layer shifts and deformations in perpendicular direction. It comes to this, that following obtained temperature courses in roof construction is possible to state intensity of horizontal whether vertical expansion and contraction. Gathering data about building structure behaviour in performance conditions is very important in making decision about convenience design of layers accession from the point of view of their no-failure usage and of achievement assumed technical period of service in new buildings whether reconstructions.

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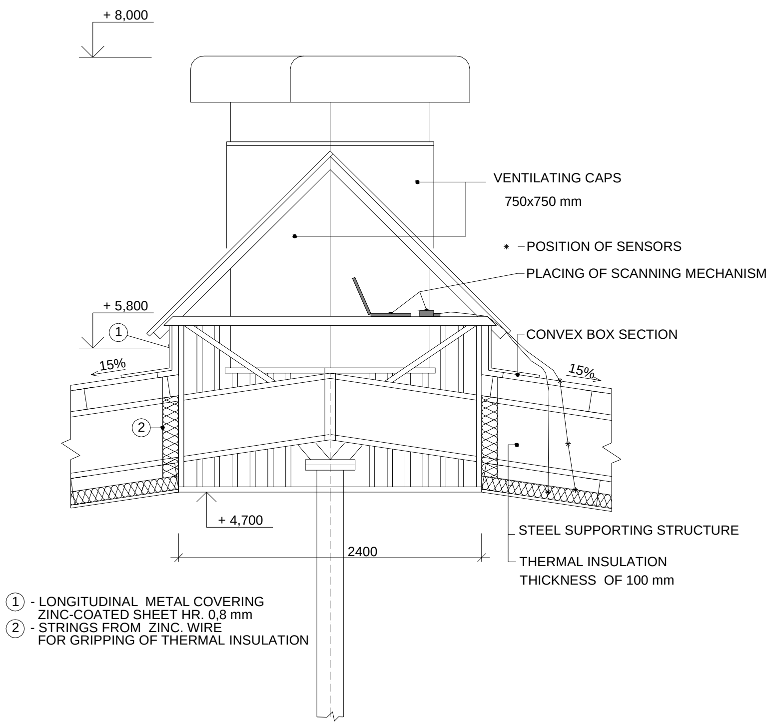

Fig. 1 Placing of scanning mechanism in skylight with ventilating caps

Fig. 2 Scaning mechanism interconnected with computer

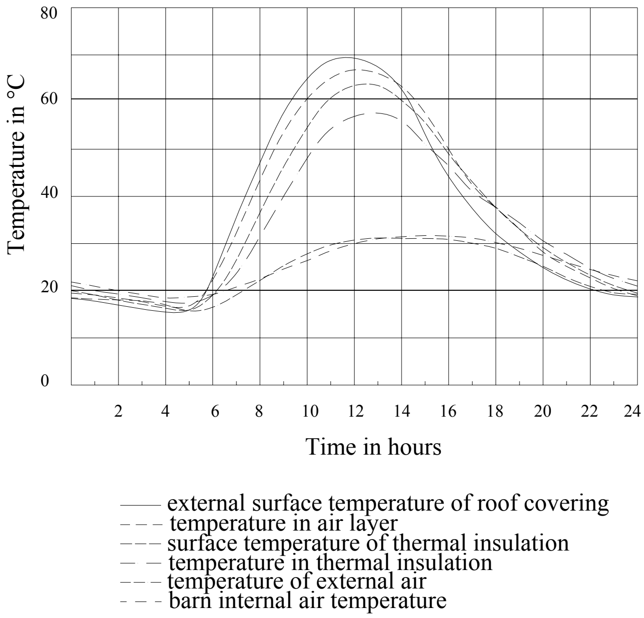

Fig. 3. Temperature course of roof construction in stall

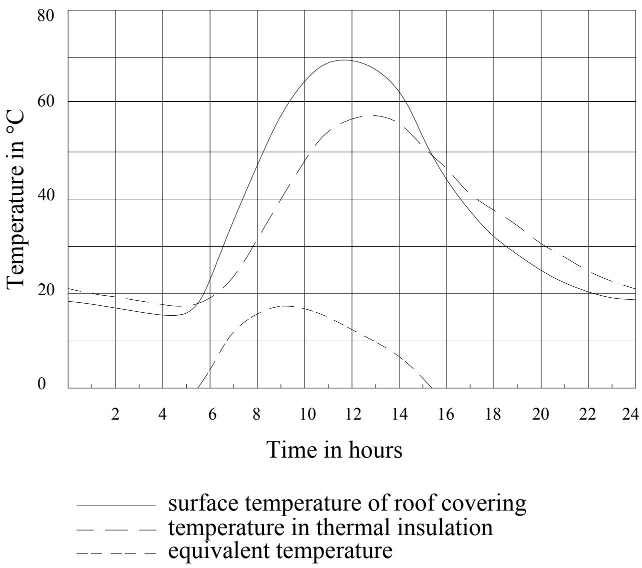

Fig. 4 Determination of equivalent temperature course in roof structure

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REDUCING OF COMSUMPTION OF ELECTRIC ENERGY

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This article is showing rationalizing methods for reduction of the electricity power. Their appliaction have a positive influence on reducing the electro energetical costs and on the economival effectiveness of the production.

Key Words: Electrical power consumption, rationalizing methods, reduction of the electrical power comsumption, specific electro-energetical costs, economical effectiveness.

Introduction

In order to ensure constantly tenable development in all the advanced states, it is necessary to provide a needed quantum of electrical power. But the alternating electrical power is not possible to be stored in a stockpile. It is necessary to dispose with so much electrical power in whatever time point how much its instant consumption is making. If this principle is not kept, then a needed equiponderance in the power supply system should happen, and a transition change of qualitative electrical power parameters is turning up, and it is persisting until a new system steady state is set.

Materials

The electrical power is obtained by means of being transformed from other kinds of energy, for example from the chemical energy of fossil fuels, from the kinetic energy of water streams, from the nuclear energy of uranium, from wind, biomass and so on. The higher is the quantity of partial transformation changes to obtain the electrical power, the lower will be the total efficiency:

$$\eta_c = \eta_n \eta_{n-1} \eta_{n-2} ......\eta_1 \qquad (1)$$

where: η_i is efficiency of the partial transformation change (i = 1,2, …..n) [%]

n is a number (quantity) of transformation changes

Energetic loses are describing the decreasing technical workability of monitored processes being a dimension of irreversibility. The energetic balance of transformation processes is the only evaluation tool of a process where the degradation is covered in the energetic balances.

Consumption of the so called raw energy W_s [J] for getting the effectively obtained energy $W_{už}$ is determined by the relation:

$$W_s = \frac{W_u}{\eta_c} \qquad (2)$$

An increasing trend of nuclear electro power-energetic and of increasing use of removable energetic sources is possible to be expected in the condition of the Czech Republic within the coming following years. The Czech Republic has undertaken in the frame of an agreement between the Czech Republic and European Union that the electrical power rate obtained from the removable sources would make 10% from its total rough consumption. The building of new nuclear power plants shall be evidently a must despite of the above mentioned fact and reminders of ecologists. Of course, a multiple reserve in failure-free operation security of nuclear power plants, treatment of used nuclear fuel with using – among others – form of its effective recycling, is obvious.

It is necessary to dedicate a corresponding attention to economize the specific electro-energetic costs of technological, manufacturing and production processes by means of proper realization of rationalizing measures rated to reducing of the power consumption. A must of introducing effective measures at all the consumer categories is ever more raising the planned growth index of power consumption scale prices where the consumption has to reach an index value of 1.24 rated for the year 2008 in the production plants and organizations, when with the year 2007 compared. The quoted 24% growth of electrical power prices may vent itself disagreeably in the economical effectiveness of production plant as well as in a competitiveness downfall of their manufactured products. The electro-energetic policy of the Czech Republic assumes that the power consumption prices should continue in their growing either after the year 2008 up on the electrical power price level practiced in the advanced EU countries.

Results and Discussion

In principle, the rationalization measures for electrical power consumption reducing are possible to be divided onto four areas:

In the supplier-consumer relations, it is necessary to realize in frame of the appropriated consumer organization:

- selection of the most suitable tariff in dependence on daily as well as monthly characteristic of the power consumption
- minimization of the power consumption while the top tariff is introduced, regarding used manufacturing technologies and production techniques;
- consequent operation blocking of power accumulating consumers by such a way that they could be connected to the power network in the course of low tariff only
- Setting the priorities for eventual switching the electrical consumer with higher consumption (more than 10 kW) off in order to not exceed the contracted quarter hour maximum rated consumption spell.

Compensation of limit exceeding idle power consumption of inductive character. The power consumption would have to be realized lastly with the neutral power factor value 0.íř, eventually with a value rated in the interval:

$\cos \varphi \in \langle 0{,}95;1)$

In a case that the power consumption should be realized with the power factor $\cos \varphi < 0{,}95$, the consumer will pay the power supplier felt price surcharges in tariff percentage for input and electrical power. The table 1 shows a selection of the above mentioned price surcharges regarding the power consumption.

Advantages of power factor compensation:

- Having realized the power factor compensation, it is possible to connect additional power consumers on the available unloaded power network.
- Voltage drop in the compensated power line is reduced linearly according to drawn electrical power reduction
- Power loses in the compensated part of the electrical line will decrease proportional to square of current intensity drop. Lower power loses influenced by reducing of heat loses are contributing to line life enhancement.

If the distribution network in a plant includes harmonic together, a filtration-compensating equipment is necessary to com true in order to prevent to rise of resonance of compensation condensers. It is usually sufficient to put a protective a series chock with resonance frequency which is sufficiently differentiating from those in the plant network. A grade of influencing the network with harmonic – so called “network contamination”: A level of contamination and the selection of suiting compensation equipment type is obtainable from:

$$u_k = \frac{S_{GH}}{S_N}.100 \qquad (3)$$

where: u_k is a level of the „network contamination“ with harmonic [%]

S_{GH} is apparent power of consumers generating harmonic [VA]

S_N is installed apparent power of feeding transformer in the plant [VA]

If :$u_k < 20\%$ then it is to deal with a „slightly contaminated“ network – an unprotected compensation switch board is possible to be used.

$20\% < u_k < 50\%$ then the plant network is „highly-contaminated“ and a protected compensating switch- board is necessary to be used;

$u_k > 50\%$ the plant network is „extremely contaminated“ and a tuned active filter is necessary to be used.

Tab.1 Selected price surcharge values for violation of prescribed neutral power factor value

Power factor cos φ [-]	Price surcharge [%]	Power factor cos φ [-]	Price surcharge [%]
0,95	-	0,65	48,58
0,90	5,85	0,60	61,40
0,85	12,38	0,55	76,56
0,80	19,74	0,50	94,70
0,75	28,07	Lower than 0,50	100,00
0,70	37,59		

Tab.2 Power input values of a compact fluorescent lamp and of a classical bulb.

Power Input [W]		Power Input [W]	
Classical bulb	**Comp. fluorescent lamp**	**Classical lamp**	**Comp. fluorescent lamp**
40	7	75	15
60	11	100	20

A third group of rationalizing methods is possible to be seen in the energetic-economical measures. It is primarily the matter of:

- replacement of electric motors with overdesigned output for the motors with corresponding power input and higher energetic efficiency of their operation. The motor power input is necessary to be set with regards to an allowed winding temperature elevation determined by the used insulation class. There, where the plant technology enables it, the high-speed three-phase asynchronous motors with short-circuit armature are of advantage in being used because having smaller dimensions and mass at the same power input value (se the empirical relation).

$$P_p \sim CD^2 ln \tag{4}$$

Where: C is engine constant

D is armature magnetic circuit diameter

l is armature magnetic circuit length

n is engine speed

- - replacement of classical lighting sources (bulbs, fluorescent lamps) for modern lighting sources with higher energetic efficiency. For example, a compact OSRAM DULUX EL fluorescent lamp with electrical ballast and E27 cap has following input power values (Tab nr. 2):

The replacement of classical lighting sources for the energetically lower-cost ones is still capital-intensive, however, its utility is resulting from the Tab. 2 despite of fact that the expended coffers should have a longer pay-back.

Cost-effective utilization of renewable power energy sources (RPES)

In the conditions of the Czech Republic, the technologies using the solar-thermal energy transformation of solar radiation for heating-up supply water and for heating of objects are mostly applied, either the energy of water, wind and biomass transformed to electrical power.

An increasing trend in utilization of the renewable power energy sources is caused by:

- problems of economic • price level growth in electrical power consumption
- ecological problems • fossil fuel economizing
- energetic problem of the greenhouse effect • minimization of emissions in the environment

Wider RPES application in practice are negatively influenced by:

- Low redemption prices of energies obtained from the RPES running;
- Legislation affairs (tax remissions, state grants)
- High capital expenditures
- Considerable dependence of RPES running upon external conditions (wind power, water flowage, solar radiation and so one).

Conclusions

Modernizing of equipment of manufacturing technologies with electrical consumers as well as the expansion of use of control, information and telecommunication techniques, are posing extended requirements on the electrical power consumption growth. An increasing consumption trend is calling up for a need of building new power stations, or eventually for completing the available power stations with additional power blocks – and from the point of view of the needed depreciation of specific electro-energetic costs for production processes related to an production unit, it needs either an efficient and effective business economics with the electrical power.

Application of the above mentioned rationalizing methods would have to be positively reflected on the level of production plants in increasing the economical effectiveness of used manufacturing and working processes and in n increasing of competitiveness of their products not on the inland market but also on the foreign ones. From the point of view of the National Economy seen, realizing of rationalizing methods in the electrical power consumption is helpful supporting stability of the power network run, being effectively contributing to abidance by assigned qualitative parameters of supplied electricity.

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CALCULATION MODEL FOR BIOMASS COMBUSTION

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Substantial part of the area of the Czech Republic allows quite significant usage of both waste and intentionaly grown energy plants. In comparision with other renewable sources in the Czech Republic biomass has the biggest potention of development. Research concerns energy use of biomass by way of direct combustion in boilers of lowest heat power which are most extended as a local sources of heat. The aim of the research is to evaluace and optimize combustion of different kinds of pressed biofuels. Calculation model is created on the basis of the experiment outcome which can be used for setting quantity and composition of emission during different biomass burning.

Key words: biomass, combustion, emission, calculation model.

Introduction

Significant marker for evaluation and optimisation of biomass combustion is an amount and composition of flue gases. It depends partly on burner construction and partly on fuel composition. Burning process calculation models steming from fuel elamentary analysis are important for solving many problems in burner designing and controling combustion process. It is possible to create calculation model by two ways:

1) with help of stechiometric equations and dates from elementary analysis,
2) with help of approximate equations based on fuel heat value.

In case of heterogenous fuels combustion only the first mentioned possibility could be taken into account. Outcomes of this model are total air amount, generated flue gases amount and its composition for 1kg of burned fuel. Model takes into acount perfect and imperfect burning.

Calculation model

An essence of the model is to describe combustion process of any solid fuel based on its elementary analysis considering perfect and imperfect burning. It is possible to compare dates from model with dates from experiment to see how the model reflects the reality.

Following volume content of air is considered for the calculation:

O_2 … 21,00 %, N_2 … 78,05 %, Ar … 0,0092 %, CO_2 … 0,0003 %

Perfect burning

Minimum oxygen volume for perfect fuel burning which contains related amount of elements C, H, S, O [kg.kg^{-1}]:

$$O_{2\min} = \frac{22,39}{12,01}\cdot C + \frac{22,39}{4,032}\cdot H + \frac{22,39}{32,06}\cdot S - \frac{22,39}{32}\cdot O \qquad [\mathrm{m^3.kg^{-1}}] \qquad (1)$$

Volume amount of each emission in flue gases:

$$V_{CO_2} = \frac{22,27}{12,01}\cdot C + 0,003\cdot V_{vv\min}\cdot \lambda_m \qquad [\mathrm{m^3.kg^{-1}}] \qquad (2)$$

$$V_{SO_2} = \frac{21,89}{32,06}\cdot S \qquad [\mathrm{m^3.kg^{-1}}] \qquad (3)$$

$$V_{H_2O} = \frac{44,81}{4,03}\cdot H + \frac{22,41}{18,02}\cdot W + \left(1,04-1\right)\cdot V_{vs\min}\cdot \lambda_m \qquad [\mathrm{m^3.kg^{-1}}] \qquad (4)$$

$$V_{N_2} = \frac{22,40}{28,01}\cdot N + 0,7805\cdot V_{vs\min}\cdot \lambda_m \qquad [\mathrm{m^3.kg^{-1}}] \qquad (5)$$

$$V_{O_2} = O_{2\min}\cdot \lambda_m \qquad [\mathrm{m^3.kg^{-1}}] \qquad (6)$$

where $V_{v\min}$ is minimal volume of air, λ_m is coefficient of excess of air.

Wet flue gases volume:

$$V_{sv} = V_{CO_2} + V_{SO_2} + \left[\frac{44{,}81}{4{,}032}\cdot H + \frac{22{,}41}{18{,}015}\cdot W + (1{,}04-1)\cdot V_v\right] + V_N + V_{O_2} \quad [\mathrm{m^3.kg^{-1}}] \qquad (7)$$

Imperfect burning

In the case of imperfect burning part of carbon burns to CO and part remains unburned. The part, which is burnt to CO:

$$a = \frac{V_{CO}}{1\cdot 10^6}\cdot\frac{12{,}01}{22{,}37}\cdot C \qquad [\ -\ ] \qquad (8)$$

where V_{CO} is CO concentration in flue gases [mg.m^{-3}].

The part, which is unburnt:

$$b = \frac{\Delta V_{v\min}}{8{,}81}\cdot C - \frac{a}{2} \qquad [\ -\ ] \qquad (9)$$

where $\Delta V_{v\min}$ is decrease of combustion air.

$$\Delta V_{v\min} = V_{v\min}\cdot\left(1-\frac{\lambda_{v\acute{y}p}}{\lambda_m}\right) \qquad [\mathrm{m^3.kg^{-1}}] \qquad (10)$$

Amount of oxygen is decreased:

$$\Delta O_{2\min} = 1{,}856\cdot\left(\frac{a}{2}+b\right)\cdot C \qquad [\mathrm{m^3.kg^{-1}}] \qquad (11)$$

and CO_2 amount in flue gases is lower:

$$\Delta V_{CO_2} = (a+b)\cdot 1{,}854\cdot C \qquad [\mathrm{m^3.kg^{-1}}] \qquad (12)$$

Then real oxygen demand is:

$$O_{2\min sk} = O_{2\min} - \Delta O_{2\min} \qquad [\mathrm{m^3.kg^{-1}}] \qquad (13)$$

and real CO_2 amount in flue gases:

$$V_{CO_2 sk} = V_{CO_2} - \Delta V_{CO_2} \qquad [\mathrm{m^3.kg^{-1}}] \qquad (14)$$

Minimum real amount of dry combustion air:

$$V_{vs\min sk} = \frac{100}{21}\cdot O_{2\min sk} \qquad [\mathrm{m^3.kg^{-1}}] \qquad (15)$$

Minimum real amount of wet combustion air:

$$V_{vv\min sk} = V_{vs\min sk}\cdot 1{,}04 \qquad [\mathrm{m^3.kg^{-1}}] \qquad (16)$$

Real amount of wet combustion air:

$$V_{vv\,sk} = V_{vv\min sk}\cdot\lambda_m \qquad [\mathrm{m^3.kg^{-1}}] \qquad (17)$$

Real volume amount of particular emission:

$$V_{CO_2 sk} = V_{CO_2} - \Delta V_{CO_2} \qquad [\mathrm{m^3.kg^{-1}}] \qquad (18)$$

$$V_{SO_2 sk} = \frac{21{,}89}{32{,}06}\cdot S \qquad [\mathrm{m^3.kg^{-1}}] \qquad (19)$$

$$V_{H_2O\,sk} = \frac{44{,}81}{4{,}032}\cdot H + \frac{22{,}41}{18{,}015}\cdot W + (1{,}04-1)\cdot V_{vs\min sk}\cdot\lambda_m \qquad [\mathrm{m^3.kg^{-1}}] \qquad (20)$$

$$V_{N_2 sk} = \frac{22{,}4}{28{,}013}\cdot N + 0{,}7805\cdot V_{vs\min sk}\cdot\lambda_m \qquad [\mathrm{m^3.kg^{-1}}] \qquad (21)$$

$$V_{O_2\,sk} = O_{2\min sk} \cdot (\lambda_m - 1) \qquad [\mathrm{m^3.kg^{-1}}] \qquad (22)$$

$$V_{Ar\,sk} = 0{,}0092 \cdot V_{vs\min sk} \cdot \lambda_m \qquad [\mathrm{m^3.kg^{-1}}] \qquad (23)$$

Real minimum flue gases volume:

$$V_{sv\min sk} = V_{CO_2\,sk} + V_{SO_2\,sk} + V_{N\,sk} + V_{H_2O\,sk} + V_{O_2\,sk} + V_{Ar\,sk} \qquad [\mathrm{m^3.kg^{-1}}] \qquad (24)$$

out of this dry flue gases

$$V_{ss\min sk} = 1{,}854 \cdot C + 0{,}6228 \cdot S + 0{,}8 \cdot N + 0{,}79 \cdot V_{vs\min sk} \qquad [\mathrm{m^3.kg^{-1}}] \qquad (25)$$

Wet flue gases volume:

$$V_{sv\,sk} = V_{CO_2\,sk} + V_{SO_2\,sk} + \left[\frac{44{,}81}{4{,}032} \cdot H + \frac{22{,}41}{18{,}015} \cdot W + (1{,}04 - 1) \cdot V_{vv\,sk}\right] + $$
$$+ V_{N_2\,sk} + V_{O_2\,sk} \qquad [\mathrm{m^3.kg^{-1}}] \qquad (26)$$

Volume concentrations of particular emission are:

$$CO_{2\,sk} = \frac{V_{CO_2\,sk}}{V_{sv\,sk}} \cdot 100 \quad [\%] \qquad N_{2\,sk} = \frac{V_{N_2\,sk}}{V_{sv\,sk}} \cdot 100 \quad [\%] \qquad (27)$$

$$SO_{2\,sk} = \frac{V_{SO_2\,sk}}{V_{sv\,sk}} \cdot 100 \quad [\%] \qquad O_{2\,sk} = \frac{V_{O_2\,sk}}{V_{sv\,sk}} \cdot 100 \quad [\%]$$

$$H_2O_{sk} = \frac{V_{H_2O\,sk}}{V_{sv\,sk}} \cdot 100\,[\%]$$

Indexes in equations are:
min … theoretical minimum amout
vs, ss … dry air, dry flue gases
vv, sv … wet air, wet flue gases
m … measured data
sk … real values – imperfect burning

Material and methods

Pellets and chopped straw from mixture of permanent grass hay and other fuels were used as trial fuel. List of fuel samples and its basic characteristics is enclosed in Tab. 1.

Measuring of burning characteristics of given samples were done during the experiment. Concentration of each fuel gases component were monitored by gas analyzator TESTO 350XL. Obtained values are defined as median from measured data during continual measurement of stabil state burner.

Tab. 1: Fuel sample and its elementar analysis

Fuel sample	**Water**	**Volatile combustible**	**Involatile combustible**	**Ash**	**Total fuel heat**	**Heating value**	**C**	**H**	**N**	**S**	**O**	**Cl**
	[%]	**[%]**	**[%]**	**[%]**	**[MJ /kg]**	**[MJ /kg]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**	**[%]**
hay + 10 % coal, pellets 15mm	8,7	66,8	18,5	5,9	17,7	16,1	44,3	6,4	1,1	0,1	33,1	0,3
hay + bark (1:3), chopped	8,3	68,3	19,6	3,8	17,5	16,1	43,5	5,4	0,4	0,1	38,6	0,1
hay + populus (1:1) + 20% coal, pellets 15mm	9,4	65,9	18,4	6,3	18,3	16,8	47,4	5,8	0,9	0,2	29,9	0,2
hay + populus (1:3), chopped	6,5	74,0	15,1	4,3	18,0	16,6	46,1	5,8	0,7	0,1	36,5	0,1
hay + sorrel (1:3), chopped	7,3	69,8	17,5	5,4	16,9	15,4	43,6	6,1	0,6	0,1	36,7	0,1

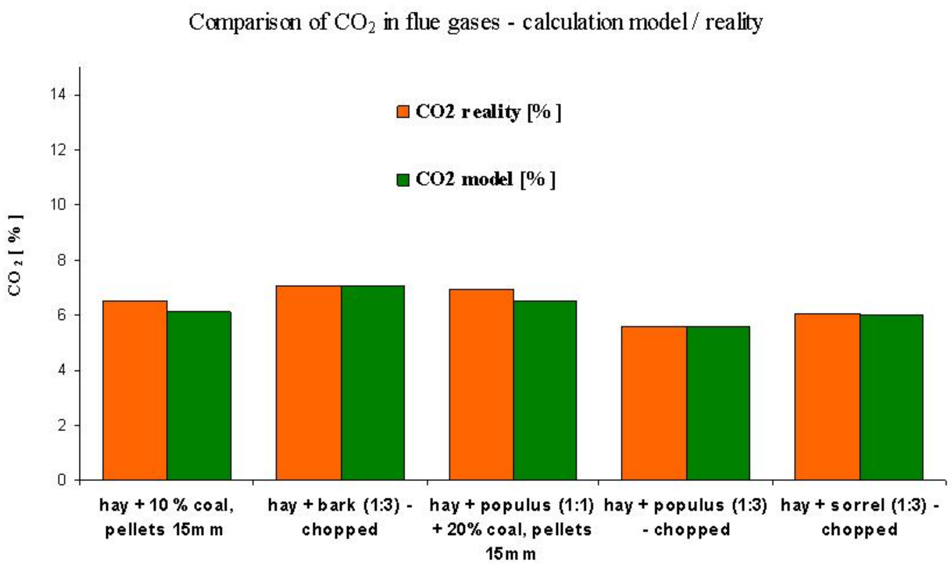

Fig. 1.: Comparison of model and reality

Discusion and conclusion

The results of calculation model were compared to data obained during experiment. Concentraion of CO_2 in flue gasses was used as a comparison value. This component is in majority of emission meassurement being calculated afterwards and thus its real amount usually stays a secret. Analyzator TESTO 350XL that we used is equipped by sensor for direct measuring of CO_2 and therefore this value could be used in the comparision.

Comparision of separate values, e.g. of model and reality is apparent from Fig. 1.

Obtained and calculated values differ in the maximum by 5 %, while this is valid for samples with worse burning stability. On the opposite, samples with good stability show smaller deviation, ranging 1 – 2 %. Calculation model with such a deviation is thus well suitable for approximate burning calculation. But for exact determination of separate items if would be probably necessary to adjust the calculation – apparently with regard to unburned fuel part.

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EVALUATION METHOD OF GEOMETRICAL QUALITY OF ROADWAY SURFACE

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Automobile roadway traffic takes a significant share in a total economic income of each national economy. It is also related to environment pollution, noise, vibrations as well as cause of traffic accidents which result in an injury or even death of many people. One of many factors which can affect mentioned issues are automobile drivers, passengers or else freights. Comfort of drivers and passengers has a distinct impact on their fatigue during transportation. Driver's fatigue has consequential influence of health state and traffic safety. Driver's comfort in traffic relates to geometrical quality of roadway surface. This paper pinpoints possibilities of quantification of suitable indicator with sufficient capability description of geometrical quality of roadway surface.

Key words: roadway surface, geometrical quality of roadway surface, geometrical quality of roadway surface characteristic

Introduction

Automobile roadway traffic is most widespread way of passenger as well as freight transportation and takes a significant share in total economic income of each national economy. Roadway traffic is closely related with many different problems from various spheres; such as environment, traffic safety as well as indirect costs of transport. Development of roadway traffic requires significant expenses for roadway construction and also for maintenance of existing roadways. Result of roadway investment is in many times disproportional to spent expenses. It was also conclusion of comparison research among EU countries. Reasons of this adverse state are several. One of the reasons could be insufficient qualitative inspection of new of repaired roadways as well as dereliction of continuous compounding of roadway state.

One of the objective, easily, cheaply and quickly detectable indicators of roadway surface quality could be force ratios between wheels of automobile and roadway lengthwise of automobile track induced uneven surface of roadway. These force ratios could be implied as vertical acceleration which has impact on vehicle, eventually part of automobile, when the wheels strike a bump. It is possible to measure vertical acceleration easily, conveniently, quickly, and relatively cheaply. Furthermore, it is possible to realize this measuring virtually continually with use of any vehicle. Even further, that would be real and relatively easily doable to use all vehicles for this purpose; use all automobiles which travel on the roadways and have board computer or board unit in order to collect electronic road-toll, [1, 2, 5]. It would be enough to add to vehicles one or two sensors (accelerometer) and module for continual record of measured data, [3]. Collect data would represent actual state of each roadway surface. Such a solution would provide data about nascent unevenness and consequently implement corrective measures or other precautions. This procedure would represent proactive approach for planning and implementation of roadway maintenance. In consequence of this procedure it would lead to decreasing company and communal expenses given for the roadway traffic.

The aim of this paper is to propose suitable qualitative indicator of roadway surface and way of its measuring and evaluation.

Operative Hypothesis – Initial Presumptions

Think of roadway flatness as quality of roadway surface; or more precisely deviation of flatness as a length comparable with vehicle length.

Let's assume that on the even roadway surface the wheel of vehicle is rolling, which weight is equal to unsprung weight of real weight of wheel and its suspension. Accelerometer is placed on the wheel (suspension) which measures vertical acceleration. According to figure 1, if the wheel strikes a bump it will gradually change radius of surface flexion. Consequently, vertical acceleration occur which take effect on the wheel with force influence. Wheel with the suspension diverge from balanced position against the spring force and shock absorber.

The process of vertical acceleration depends on the shape and height cross profile of the flexion. On the assumption that functionality of shock absorbers is perfect, then frequence of occurrence of vertical parts of acceleration will be comparable to frequency of flexions along of automobile track and automobile velocity, [4]. Graphical representation of process of vertical acceleration of wheel along the automobile track is consequential indicator of geometrical shape of roadway surface (geometrical quality of roadway surface).

Material and methods

For evaluation of suitability of indicator “vertical acceleration” in order to quantify roadway surface there was carried out experimental measuring for chosen sections of roadway. There was different quality of roadway surface of each section. There has been chosen of common asphalt road and there was placed metal cross retarder as it is shown on figure 1. Second part has blocked pavement with lengthwise track made of infiltration block parts on the right side of the road, figure 2. Third section was made of newly built with equipped raised cross retarder made of block parts, figure 3. Constant velocity was maintained with speedcontrol during the whole measuring.

Vertical acceleration was measured with micromechanical speedometers ANALOG DEVICES ADXL 210 ±10g. Accelerometers were towards into bottom swinging arm of suspension (unsprung weight) and towards top anchorage of shock absorber of suspension (sprung weight). Location of accelerometers was on both sides of the vehicle symmetrical.

The accelerometers were attached with support of measure model National Instruments NI 9215, which has multi-channel sampling of signal of particular sensors and this device is providing them with time marks and transmit them to connected computer. Central is controlled and set by program which was created in Lab View program. Lab View can set up basic parameters of central, frequence and all other needed functions. Data is stored in computer and it is possible to process them as well as represent them.

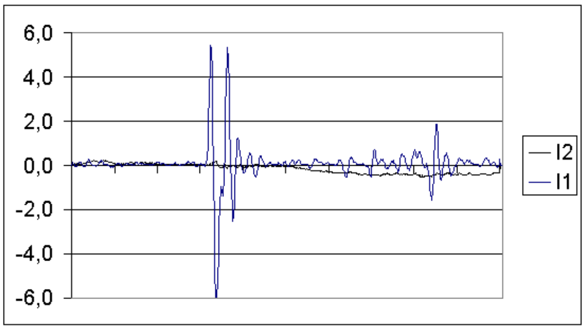
Common asphalt road, view and surface detail

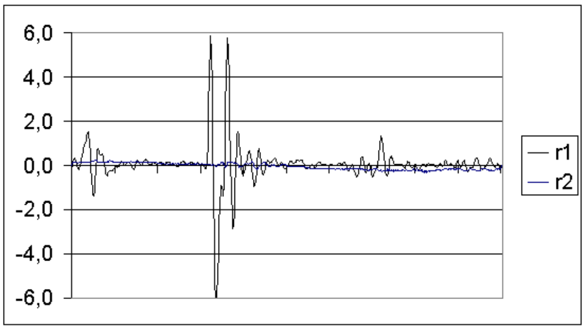
Paved road

Block paved retarder

Result and Discussion

Experimental drive and measuring were carried out in chosen sections of roadway. Frequence of data sampling of vertical acceleration components was set on 2000 data samples per second; it is data sample each 0,0005 second. Measured results of vertical acceleration components are shown on graphs 1-3. Data recorded from each section are represented each 3 seconds which is approximately equal to 15 meters distance. For emphasis graph 1a represents cut-out from the distance and contains measuring from retarder. This distance was traveled with vehicle in 0,3 seconds, which is approximately equal to 1,5 meters distance. Vertical axis represents measured acceleration in m.s^{-2}, horizontal axis represents amount of samples which represent traveled distance.

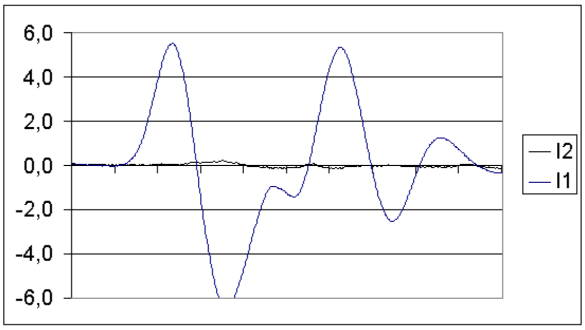


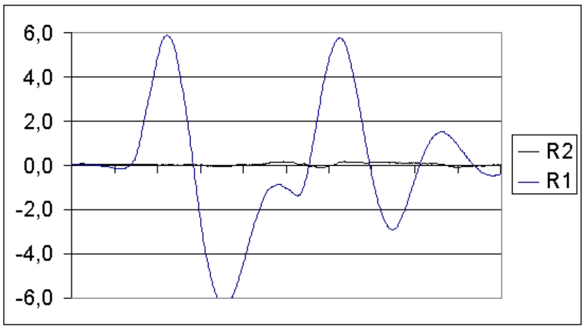


Common asphalt with metal cross retarder

l = left side wheel r = right side wheel

1 = bottom arm 2 = top anchorage of shock absorber

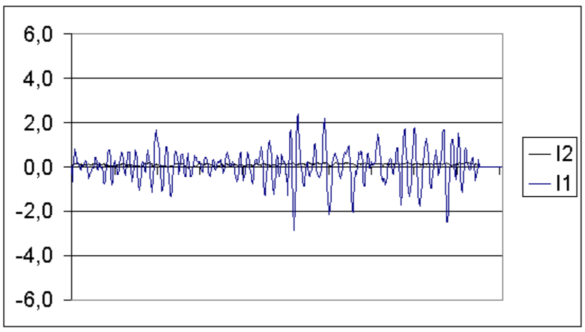


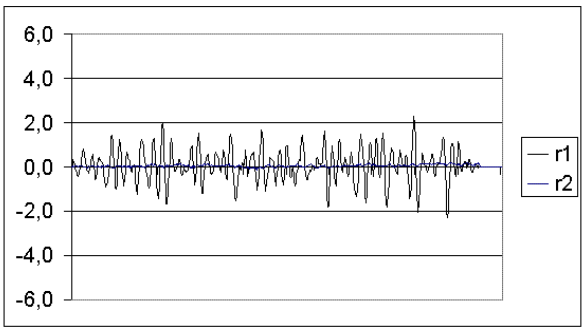


Common asphalt with metal cross retarder, cut–out

l = left side wheel r = right side wheel

1 = bottom arm 2 = top anchorage of shock absorber

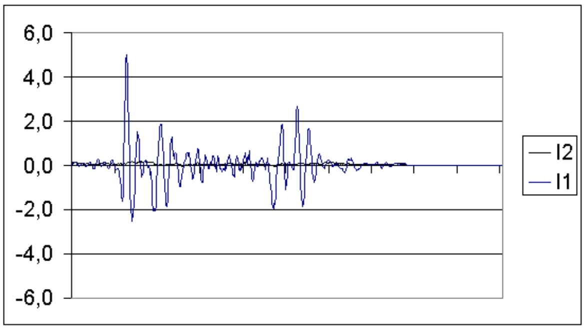


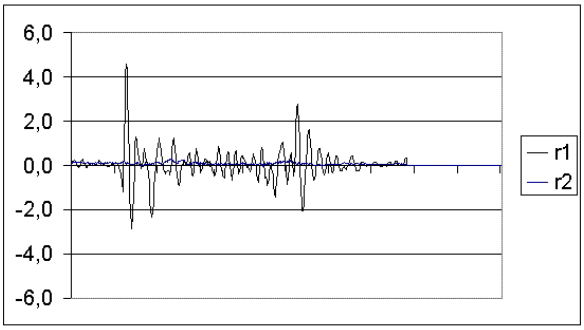


Block paved roadway

l = left side wheel r = right side wheel

1 = bottom arm 2 = top anchorage of shock absorber





Block paved retarder

l	=	left side wheel	r	=	right side wheel
1	=	bottom arm	2	=	top anchorage of shock absorber

Graphs clearly show that each asperity of roadway takes effect as vertical acceleration. It is significantly evident especially on unsprung parts of vehicle (i.e. wheel suspension). Acceleration of sprung part of vehicle is distinctly lower which is evidently caused with absorbance of substantial amount of energy of period excited by roadway asperity in shock absorber.

Measured behavior of vertical acceleration comport with presumption. Based on finished experiment it is possible to express that vertical part of acceleration (measured with unsprung weight of vehicle) is proportional to quantity of exciting tension of force impulsion excited by roadway asperity. In relation to exciting impulsions of roadway asperities occurred rarely and together with tire absorbing forces and shock absorbers induce time behavior of oscillation of vertical acceleration; then the whole time behavior oscillation represented by indicator of geometrical quality of roadway surface is not suitable. Suitable are only particular oscillations. By means of their amplitude it is possible to characterize size of roadway surface asperities as well as frequency of roadway surface asperities. Orientation of first oscillation it is possible to characterize type of asperity (bump or pit).

Conclusion

Realized experiment proved that vertical part of acceleration takes effect on unsprung weigth of vehicle and it is possible to characterize as well as quantify geometrical quality of roadway surface. It will be necessary to carry out statistically significant amount of measuring in order to obtain chance to quantification and comparison of different roadway or their various sections. Directions of each particular characteristic will be set based on these experiments.

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SOIL COMPACTION CAPACITY RATING OF OFF-ROAD TYRES

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The compaction capacity rating of tyres (further CC rating) is a numerical index expressing the risk of soft soil compaction by loaded wheels with tyres providing that the tyre parameters such as the size, load and inflation pressure are known. The CC rating is based on specifically performed laboratory measurements of soil compaction in terms of soil dry bulk density under the centers of round compression plates of different size and has, after processing into a full-scale situation, a realistic meaning as it compares the average soil compaction by an examined tyre in layers between 20 and 50 cm under the ground surface ρ_{ds} with the critical soil compaction ρ_{dl}. Considered as the standard reference soil is the Suchdol loam processed to the moisture content from 18.9 % to 20.3 % and precompacted in the testing soil bin to the homogeneous dry bulk density 1420 kg/m^3, corresponding to its critical density.

Keywords: Agricultural tyres, Soil compaction modelling, Compaction capacity, Tyre rating.

1. Introduction

At present, the professionals in the industry and farming still miss comparative technical data indicating the potential of agricultural vehicles and mobile machinery to inflict compaction damage upon the cultivated soil. The general trend is to restrict the excessive soil compaction by loaded wheels of farm power and machinery. This paper is based on the principal study of this problem by Grečenko (2003) which deals with the history, laboratory equipment, evaluation of the problem, fundamental theory and scenario of laboratory model experiments and presents the technique of tyre rating by means of the original index Compaction Number (CN) which simply reflects the compaction potential of any individual tyre contained in a tyre catalogue within the whole range of loads and inflation pressures. The experiments supported by further analytical work were conducted in the years 2005 and 2006. They resulted in setting up a databank of compaction functions (soil dry bulk densities as a function of depth below the centre of a loading device) and the system of their conversion in to the compaction profiles of tested tyres. A logical solution of the mentioned inadequacy is to relate the soil compaction directly to the acting tyre load avoiding the stresses. This can in principle be achieved by means of laboratory compaction experiments under controlled conditions.

2. Materials and methods

2.1. Compaction capacity of off-road tyres

Compaction capacity (CC) rating is a dimensionless number (referring to soft ground), assigned to complement each inflation pressure – nominal load combination listed in tyre catalogues (referring to hard ground). CC rating is computed from the same formula as the original Compaction Number CN, however, with simplified equation (Eq. (1)):

$$CC = 1000\,[(\rho_{ds} / \rho_{dl}) - 1]\ [‰] \qquad (1)$$

with

$$\rho_{ds} = ¼\,(\rho_{d20} + \rho_{d30} + \rho_{d40} + \rho_{d50}) \qquad (2)$$

where ρ_{dl} is the critical value of the dry bulk density and ρ_{ds} the average value from four ρ_{dx} readings at the depths 20, 30, 40, 50 cm below field surface. An inflation pressure – load combination with CC ≤ 0 would rate as soil friendly, whereas CC = 100 (meaning that the average soil bulk density is 10% above the critical bulk density) may suggest an upper limit for field operation of a tyre.

2.2. Principles and technique of compactor modelling

A sufficiently loaded wheel with tyre will produce a rut of a depth t_1 at the first wheeling. Every consecutive wheeling will deepen this rut due to reduced contact area. At the fourth wheeling the rut of the depth t_4 will be practically completed, i.e. rigid at the bottom (smallest contact area S_4, greatest contact pressure q_4), and the soil compaction (increase of bulk density) underneath reach its maximum. A rigid plate with equal contact area S_4 and contact pressure q_4 is capable to penetrate to the same depth t_4 and to inflict a corresponding compaction. This case can be modelled in the testing soil bin filled by the same soil of corresponding density and moisture content, using a round pressure plate of smaller size S_p and loaded to the contact pressure q_4. The resulting smaller depth of impression would produce a soil compaction pattern reduced in size and depth.

The testing soil bin of the laboratory compactor has a usable volume of 72 dm^3 (Fig. 1). The soil used in laboratory tests is the Suchdol loam (Grečenko, 2003) sensitive to compaction when sufficiently moist (moisture content between 85 and 90% of the Atterberg plastic limit). As the compaction modelling requires strictly homogeneous state of soil, the testing soil bin is filled from the bottom to the top by even soil layers 5 cm high and precompacted by a round compacting plate with specified generating pressure q_{sx} (Fig. 2).

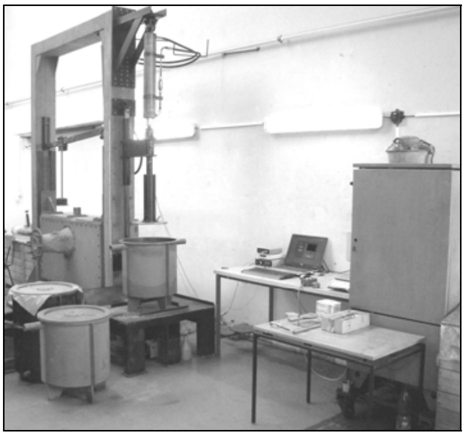

Fig. 1. Laboratory soil compactor with measuring and supporting equipment.

The precompaction is done by the compacting plate ***D***, sized 300 mm in diameter. The precompacted soil column represents a natural soil profile of uniform bulk density and moisture content. The virtual soil surface is then loaded by a selected smaller round pressure plate with desired mean contact pressure to produce the modelling imprint (Fig. 3).

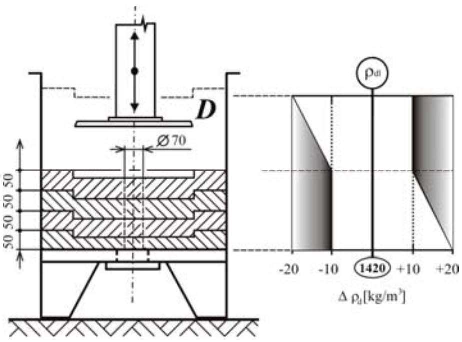

Fig. 2. Scheme of testing soil bin: filling and precompacting the charge.

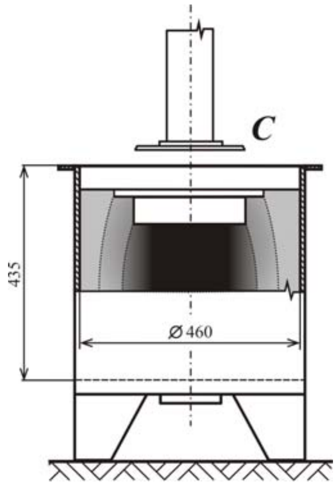

Fig. 3. Scheme of testing soil bin situation after the modelling imprint.

The surrounding less compact soil substitutes the natural environment providing for free soil deformation under load. The required soil column properties (bulk density corridor) based on the critical dry bulk density ρ_{dl} are shown in Figure 2, whereas Figure 4 gives an example of an achieved density corridor (ρ_{dl} = 1420 kg/m^3).

The precompaction of all soil layers by an uniform generating pressure would not be able to satisfy the density corridor so that the values of generating pressures must increase from the bottom to the top. A typical sequence of generating pressures q_{sx} for Suchdol loam at average soil moisture content 19,8% to achieve the dry bulk density near to ρ_d = 1420 kg/m^3 is for instance 65-70-80-80-80-80-50-97 kPa (altogether eight layers).

The Suchdol loam may serve, if necessary, as reference soil for evaluation of the CC rating on other principal soil types (e.g. clayey soil or sandy soil). Technique of compensation would consist of assigning different allowed CC ratings with respect to the reference soil. For example, on a sandy soil the maximum CC rating could be higher, on a clay soil lower than the conventional 100.

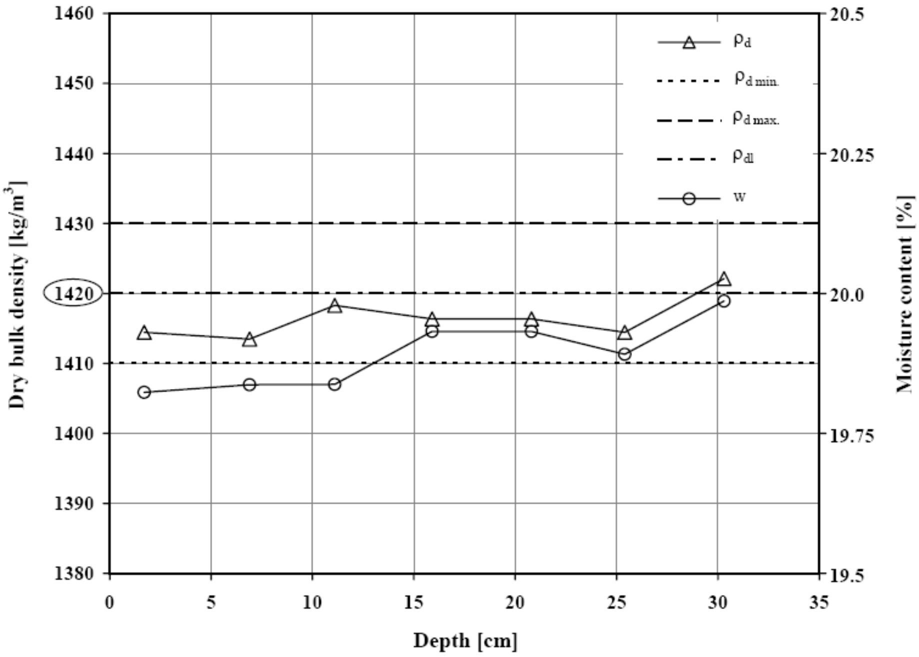

Fig. 4. Example of soil precompaction satisfying dry bulk density corridor.

3. Results

3.1. The verification of the conversion process

An example of this verification is shown in Figure 5. The problem was whether and how it would have been possible to convert the compaction functions measured with the pressure plates A and D at a specified mean contact pressure into the compaction functions measured with the plate C of a medium diameter. The positive outcome of this verification enabled to work out a reverse procedure, namely to predict the compaction function of an evaluated tyre using the databank of laboratory measurements and thus to determine the four important dry bulk density values of a tyre compaction profile, which are required to calculate its CC rating.

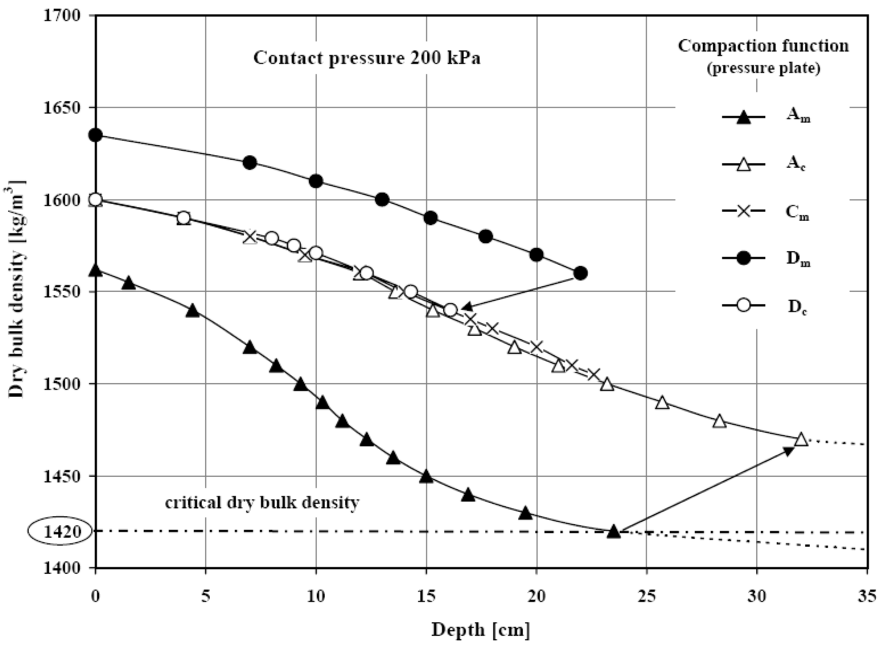

Fig. 5. Example of soil compaction profiles with verification of the conversion procedure.

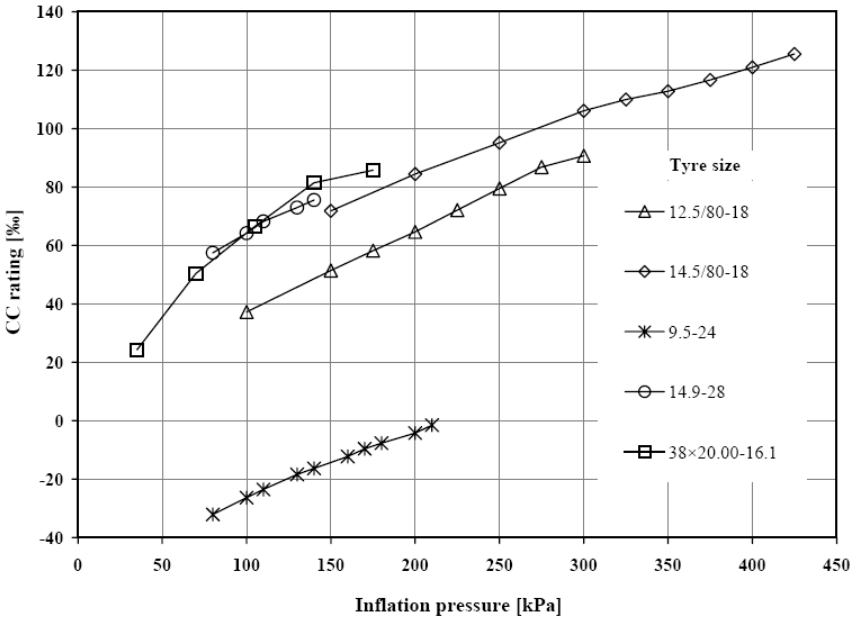

Fig. 6. The CC rating of selected agricultural tyres.

4. Discussion

4.1. Examples of CC rating

The application of CC rating is demonstrated on five tyre sizes in Figure 6. The main data of these tyres are as follows:

1. 12.5/80-18 (10 PR, S_t = 1110 cm^2)…agricultural machinery, driving;
2. 14.5/80-18 (12 PR, S_t = 926 cm^2)…heavy-duty trailers;
3. 9.5-24 (6 PR, S_t = 530 cm^2)…tractor, driving;
4. 14.9-28 (6 PR, S_t = 1395 cm^2)…tractor, driving;
5. 38 x 20.00-16.1 (8 PR, S_t = 1495 cm^2)…agricultural machinery, driving.

Considering the value of CC = 100 up to 110 as an upper limit, both the tyres for agricultural machinery and the tractor larger tyre display an acceptable CC rating, the tractor smaller tyre has an excellent negative CC rating (however, decisive for tractor application would be the higher value from both axles), while the trailer tyre has a recommended load limit of about 3010 kg at 300 kPa inflation pressure on soft ground.

4.2. Comparison of CC rating with original CN rating

The original CN rating (Grečenko, 2003) presumed the possibility of maximum soil compaction at a certain depth under the ground surface which, according to present experience, occurs only if the upper soil layers are less dense than the deeper soil. In homogeneous soil, the highest bulk density is regularly measured near to the imprint at the top. This means that the mean $\square_{ds}$ value mentioned above can simply be computed from four typical values (CC rating) instead of six $\square_d$ values (original CN rating). The computation formula of CC rating (Eq. (1)) is formally the same as the formula for CN rating, however, the CC values are somewhat lower than the original values (Fig. 7).

5. Conclusion

The soil compaction capacity (CC) rating of tyres has been developed as an engineering technique based on laboratory model soil compaction measurements using the Suchdol loam soil with textural composition on the boundary between loam – clay loam (after USDA). The goal of the CC rating is to provide comprehensive and credible technical information about the soil compaction inflicted by a loaded tyre, operating on cultivated ground, within the range of 20 to 50 cm depth below the field surface in terms of a single dimensionless number. The established databank of compaction functions enables to predict the compaction profiles (basis of CC rating) under evaluated tyres using the soil mechanics and new own findings.

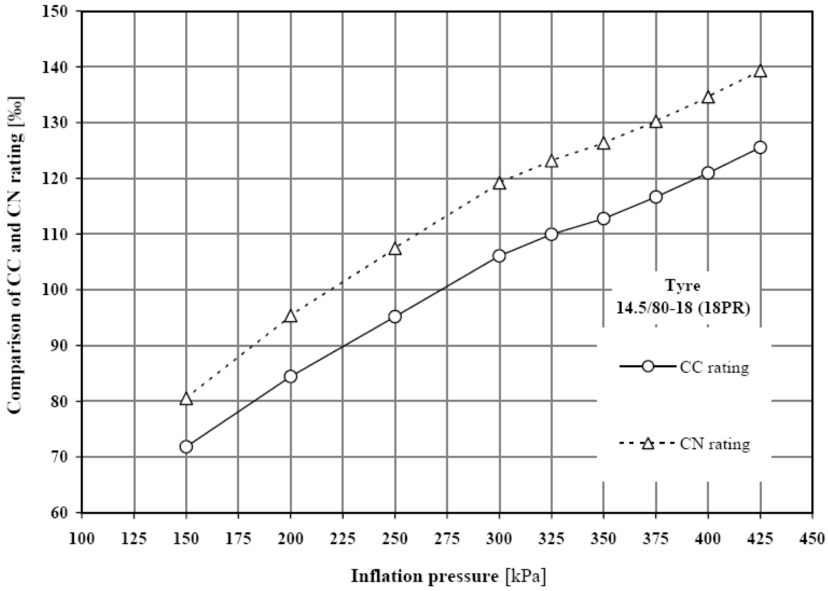

Fig. 7. Example of difference between the CC rating and the CN rating.

Actually it is possible to evaluate the CC rating of any tyre from these data:

- inflation pressure and load,
- circumferential area of the tyre contact patch on a firm, flat and smooth surface,
- principal dimensions of the contact patch: maximum length and width.

The authors believe that this rating, included into the tyre data catalogues, can help the industry and farmers to select the best tyre outfit for tractors and machinery.

Acknowledgements:

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THE EVALUATION OF SUNFLOWER GROWTH STAGE WITH USING OF AERIAL PHOTOGRAPHS

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The aim of this article is the evaluation of sunflower growth stage by aerial photographs from RC operated aircraft model image analysis. These data are compared with data acquired from ground research. The sunflower growth was established on experimental fields. The experiment variants are defined by different soil tillage before seeding: conventional tillage with ploughing, shallow non-inversion tillage, direct drilling. The seeding was performed by same seeding machine for all experiments. For all experiment variants were also observed the indicators of growth stage by the ground research after come up. The following data were observed: The number of come up plants in 5 meter segments, distance of plants and number of plant in 5 meter segments measured before harvest. These indicators also characterize the seeding machine work quality. The RC operated aircraft model equipped with digital camera was chosen for the monitoring of the experimental fields.

Keywords: The soil tillage, the quality of seeding, the aerial photograph, the sunflower growth

Introduction

In the precision farming system applied in practice, it is necessary to have as much information as possible, which is essential and is the basis for site specific crops treatments. This information is possible to gain in different ways, for instance from yield sensor on combine harvester, from soil sampling etc. In addition to these possibilities of obtaining data from on-ground measurement and observation, it is also possible to acquire data about a particular field covered with crop from remote sensing.

Aerial and satellite photographs provide high density measurement. According to current literature sources, the remote sensing are widely used for prediction of Nitrogen needs in cereals, for yields, soil moisture and in-soil organic matter estimation. Further, it can be used for weeds detection, for number of insect pests estimation and according to this the application rate of chemical agents determination, insect damage on crop assessment and also for sampling grid optimisation.

A relatively new method is the multispectral photography, which provides information in visible light continuous spectrum and in NIR and MIR wave scale. This information is usable for yields estimation, for distinguishing between crop plant and weeds between residues and mineral salts. It can be also used for quantitative measurement of water content in plants and for the LAI (Zhang et al., 2002). Techniques of spectral reflectance describe (Scotford et Miller, 2005).

For small heights and short distances the remote controlled airplanes could be used for the purpose of a crop and a soil conditions monitoring. Vegetation monitoring with using Remote sensing technology from unmanned helicopter were deal with Sugiura et al.(2005)

The shape and contours scanning of plants and soil top surface became a very efficient means for gaining information about a field, for the crop growth rate and soil state observation and also for better plant protection (Thomson, et al. 1999, Cox, 2002, Häusler, et al. 2002). Vellidis et al. (2004) were predicting yield maps from aerial photographs.

Material and methods

The experimental field was chosen in farm cooperative Klapý the height of this field is 230 m above sea level, soil type is chernozem. On this place were measured three experimental fields with dimension 16 x 75 m. These plots were separated an operational belt for rides of machines during vegetation. On these plots was accomplished harvest of previous crop winter rye in September 2004.

Description of established experimental variants:

<u>Variant A - shallow non-inversion tillage.</u>

The shallow soil tillage was accomplished after harvest preceding crop in September 2004 by sweep cultivator to deep 120 – 150 mm. The soil tillage before seeding was established by sweep cultivator to deep 120 mm in April 2005.

Variant B - direct drilling.

The shallow soil tillage was accomplished after harvest preceding crop in September 2004 by sweep cultivator to deep 120 – 150 mm.

Variant C - conventional tillage with ploughing.

The ploughing was accomplished after harvest preceding crop in September 2004 to deep 240 mm. The soil tillage before seeding was established by sweep cultivator to deep 120 mm on April 2005.

For all experimental variants was established seeding by seeding machine Kinze 3600 in April 2005, distance of rows was 750 mm, adjusted deep of seeding was 70 mm and number of plants on 1 ha was 60 000.

For all experiment variants were also observed the indicators of growth stage by the ground research after come up. The following data were observed: The number of come up plants in 5 meter segments, spacing of plants measured on the growth emergence and number of plants in 5 meter segments measured before harvest. These indicators also characterize the seeding machine work quality.

For the aerial photographs taking, a glider model powered with an electromotor was chosen. This model has 3100 mm in wing span and the wing surface is 84,1 dm^2 . The model length is 1455 mm. The model is powered with the driving motor „ Mega ACn 22/20/2 " with embodied gearbox „Mega Gear Planeta". The total airplane weight with a camera with attachment is 3980g. The five-channel Remote Control (RC) set is used for the operation control and the on-plane part is supplied with power from an accumulator consists of 4 NiMh cells with the capacity of 2100 mAh. The driving accumulator consists of 8 NiMh cells with the capacity of 3300 mAh. The engine is controlled by the regulator Jes 40 – P Opto. It is possible to control and regulate engine rpm, rudder, elevator and control unit of camera release. The aerial photography is provided by digital camera Olympus C-50 zoom. This camera is placed underneath one wing in a case. The control unit of camera release which is placed in aircraft model allows the periodic photograph taking. This function allows recording of the photographs with partial covering which make easier their following processing.

The aerial photographs (obtained 21. 6. 2005) were processed by tools of Adobe Photoshop program. On this aerial photographs were adjusted brightness and contrast. From aerial photographs are detected the number of come up plants in 5 meter segments.

Results

The observed crop of sunflower was evaluated from point of view indicators of seeding machine work quality and growth stage. On the crop after come up on 17. 6. 2005 were observed these indicators from surface: the number of come up plants in 5 meter segments, spacing of plants measured on the growth after come up. The number of the plants is observed in September 2005 from surface.

The number of the plant established from aerial photographs was compared with number of the plant obtained from surface survey.

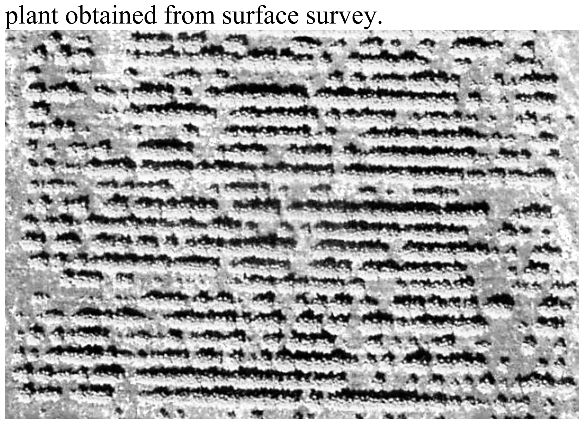

Figure 1. The aerial photograph after adjusting brightness and contrast.

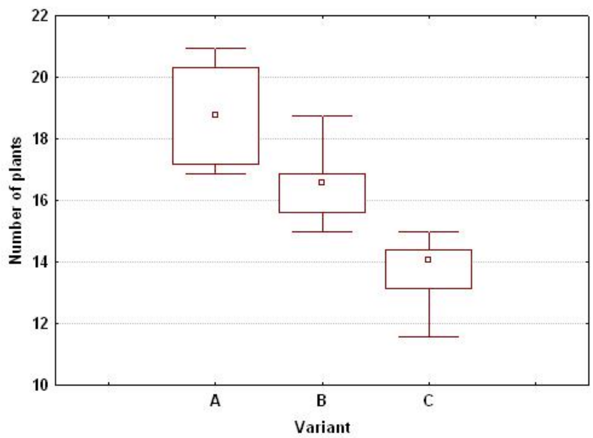

Figure 2. Statistical evaluation of the number of plants in 5 m segment, measured on the growth after come up, for three variants soil tillage.

Table 1. The average values of number of plant observed by the surface and from aerial photographs.

	The number of the plant in 5 meter segment		
	Variant A	Variant B	Variant C
Surface observing	19,38	16,98	14,48
Aerial photographs	18,23	16,15	12,92

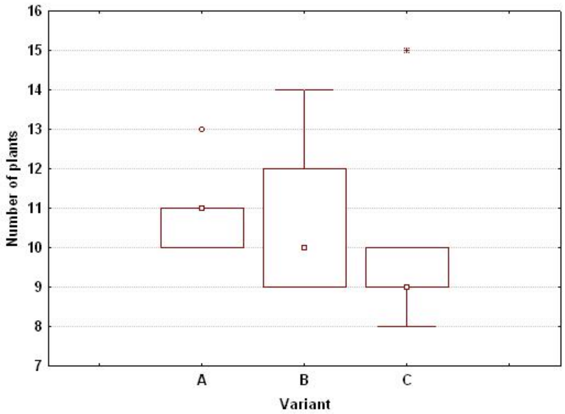

Figure 3. Statistical evaluation of the number of plants in 5 m segment measured before harvest for three variants soil tillage.

On the figure 1 is an aerial photographs of variant C - conventional tillage with ploughing after adjusting brightness and contrast. The graph in figure 2 shows the evaluation of the plants number in 5 meter segment, measured on the growth after come up, for three variants soil tillage. The least number of plants from all variants was observed by variant C (conventional soil tillage). The same trend between it is possible to observe by number of plants obtain from aerial photographs. In the table 1 is the average values the number of plant observed by the surface and from aerial photographs. For the evaluation was used the One-Way-Analysis of Variance method. At the statistical data evaluation was found-out statistically insignificant difference between number of plant observed by the surface and from aerial photographs. The graph in figure 3 shows the evaluation of the plants number in 5 meter segment, measured before harvest, for three variants soil tillage. The evaluation of the spacing of plants is in graph in Fig. 4. The least spacing of plants it is possible to observe by variant A (shallow non-inversion tillage) this is correspond with number of plants, measured on the growth after come up, where is most number of plants. The inverse case is by variant C (conventional tillage with ploughing) where was the most spacing of plants.

Conclusion

The evaluation of aerial photographs by image analysis method allows registering of the irregular sunflower growth. These variations were compared with data from the surface research. From point of view of obtained results, where the surface research and data from aerial photographs are compared, it is possible to say, for this research, that remote sensing substitute the surface research. Existing results of verification RC operated aircraft model for growth and soil surface aerial photograph recording show the applicability of this method for evaluation of site heterogeneity selected signs.

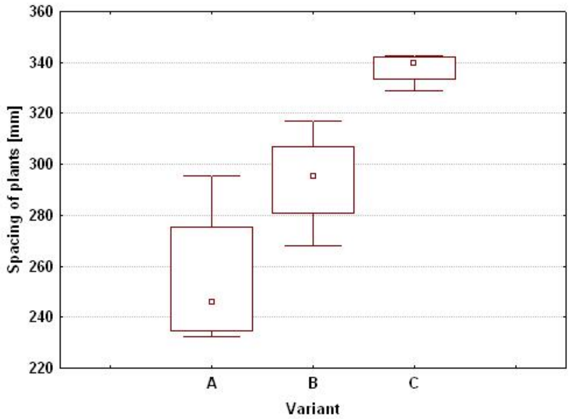

Figure 4. Statistical evaluation of the spacing of plants for three variants soil tillage.

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SIMULATION OF LAND SUBSIDENCE DUE TO GROUNDWATER WITHDRAWAL IN RAFSANJAN PLAIN

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The Rafsanjan basin is located in the nearly central part of Iran, with a general elevation between 1400-1500 meters above the sea level. This basin has an area of totally 10905 square kilometers, 4636 km^2 plains and 6269 km^2 mountains. The discharge of more than 737 million cubic meters of groundwater in a year mainly for irrigation has caused a severe decline of groundwater level. The increase in effective pressure by groundwater reduction induced compaction of underground unconsolidated soil layers and finally land subsidence in Rafsanjan basin. Land subsidence caused earth fissures, cracks in buildings and failure of well casings. In this research, groundwater flow and land subsidence have been modeled by using Pmwin and a subroutine of Pmwin called IBS1, respectively. The simulation model is calibrated using observed data from September 1996 to September 2004. The results of this model contain prediction of groundwater level variations and land subsidence for 17 years to come. Processing the result of the two successive measurements of land subsidence showed that the decline of groundwater level is the main cause of land subsidence in Rafsanjan basin and there is a linear relation between land subsidence and decline of groundwater levels.

Keywords: Rafsanjan, groundwater, subsidence, Pmwin

Introduction

Land subsidence is gradual or sudden lowering of land surface due to deformation and movement of soil materials that result from different causes such as mining, oil and gas extraction, and groundwater withdrawal. The importance of land subsidence due to groundwater withdrawal over the world has been realized, such as the cases in shanghai in mainland china, Taipei basin in Taiwan, Cheshire district in Great Britain, Venice in Italy, Mexico city in Mexico, Bangkok in Thailand, San Joaquin valley and Santa Clara valley in California USA, Wariake in new Zealand, Far west in south Africa, Latrobe valley in Australia (Poland, 1982).

In Iran, the overdraft of groundwater produces major groundwater problems in Rafsanjan area today. Since about 1980 the use of groundwater for irrigation in this area has increased rapidly. When the pumping is excessive, management of groundwater resources in the basin presents numerous problems of various degree of complexity in each area. In Iran, Regional Water Organization (RWO) in every province is responsible for surface and groundwater management. Rafsanjan is under the responsibility of RWO in Kerman province. The base data and information for this study were supplied by this organization (Khamehchiyan, 1995).

Land subsidence exists throughout of Rafsanjan plain. Although in most of the reports published about the Rafsanjan plain, groundwater withdrawal has been mentioned as the main factor of land subsidence, one report has also proposed tectonic factors as an important cause (Nikdel 1992).
Many problems such as earth fissures increase in the salinity of groundwater, cracks in buildings and roads and damages to groundwater extraction equipments (well casings have come up) are caused by land subsidence due to groundwater overdraft. Some examples of the damages are shown in Figure 1.

In this article groundwater flow and land subsidence are modeled using Pmwin and a modular subroutine of Pmwin called the Interbred Storage Package-1 (IBS1) respectively. The simulation model is calibrated using observed data from September 1996 to September 2004. The results of this model contain prediction of groundwater level variations and land subsidence for 17 years to come.

In this area reduction of groundwater pumping volume must be considered by several ways such as: changing the irrigation method to trickle irrigation, using surface water instead of groundwater, and transporting of surface water from other area.

Study area

The Rafsanjan basin is located in the nearly central part of Iran, with a general elevation between 1400-1500 meters above the sea level. This basin has an area of totally 10905 square kilometers, 4636 km^2 plains and 6269 km^2 mountains. This basin is roughly rectangular in shape, and locally divided to three plains: Rafsanjan-Kabutarkhan plain, Anar-koshkuieh plain, and Nugh plain. Rafsanjan city is located in the north west of the basin. The main agricultural product in the area is pistachio, and because of high price of this product inside and outside of Iran, many wells have been drilled recently for developing of agricultural area for this product. Therefore the base of quaternary deposits in this area is lacustrine sediments that are consist of silt and clay accompanied by salt and fine gypsum crystals, and they also outcrop in the middle of plains. Other quaternary sediments are low terraces; young gravel fans, wind deposits (sand dunes), mud, salt flats (Figure 2). In general, alluvial materials deposited in the Rafsanjan basin consist of heterogeneous unconsolidated mixture of clay, silt, sand and gravel that locally contain cobble, salt, and gypsum. Figure three shows the geological section along the line pass through investigation wells (1, 2 and 3) drilled by RWO. On the basis of geophysical investigations, the maximum thickness of alluvium is 320 meters in the place that groundwater inters the Anar-Koshkuieh plain from Rafsanjan-Kabutarkhan plain (Khamehchiyan, 1995).

The groundwater table lies within the alluvial materials resulting in a groundwater surface that slopes gently away from the mountain fronts and Rafsanjan–Kabutarkhan plain toward the Anar–Koshkuieh plain. Good aquifers (quantitatively and qualitatively) develop in the coarser alluvium deposits especially in southern and western parts of the plain. Many field and laboratory works have been done by Regional Water Organization in this plain, which has estimated the storage coefficient, S (average 5%), and Transmissivity, K (100 to 3500 m^2/day), in the Rafsanjan plain on the basis of pumping test data (RWO). Since ancient times, groundwater has been used for drinking and irrigation by underground channels (called Kariz or Qanat in Persian) and handmade wells in Iran. Drilling of deep wells in the Rafsanjan plain using boring machine started in 1953. As Table 1 shows, the number of wells increased between 1969 and 1999. Total number of wells has increased from 209 to 1798 in the period of 1969–1999. On the basis of the last count of the wells, the numbers of drinking, agricultural, and industrial wells have been 151, 1526, and 121 respectively, or 8.4%, 84.9%, and 6.7% of the total number of the wells (Musavi, 2001). The consumption of groundwater in the Rafsanjan plain was increased about six times from 1969 to 1999. Groundwater level has dropped as a result of the increase in pumping rates. This excessive pumping of groundwater, mainly for agricultural uses, has caused the groundwater level to decline about 25 m in the Rafsanjan plain. Since 1973, the groundwater level has been measured monthly in the basin. Borehole distribution in study area is shown in Figure (4).

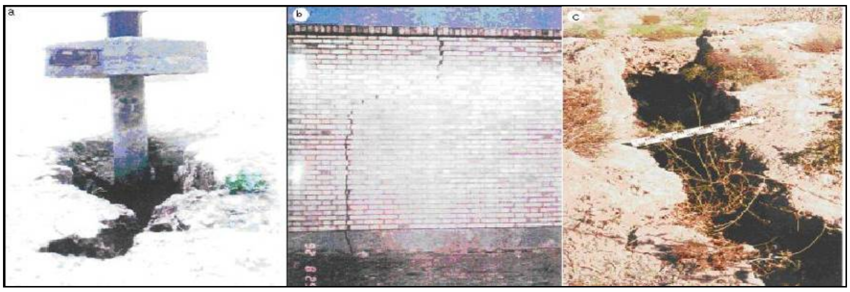

Figure (1): a) coming up well's casings b) Cracks in buildings c) earth fissures

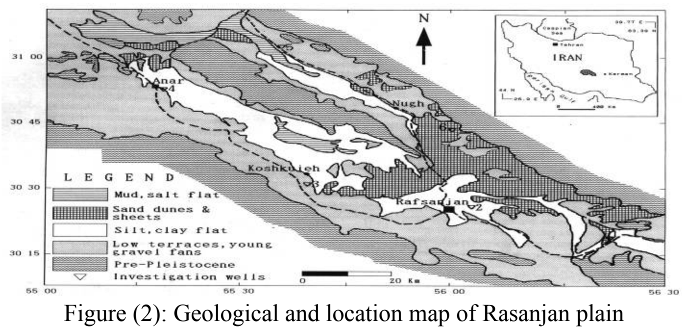

Figure (2): Geological and location map of Rasanjan plain

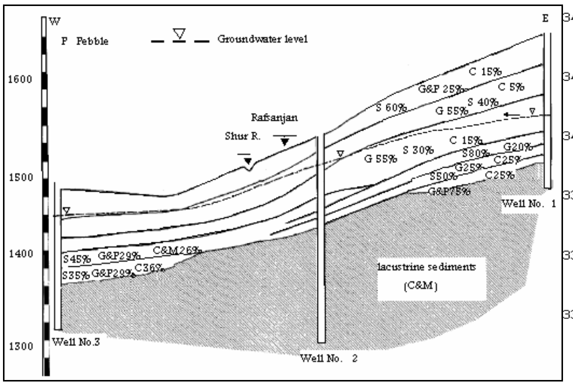

Figure (3): Geological cross section

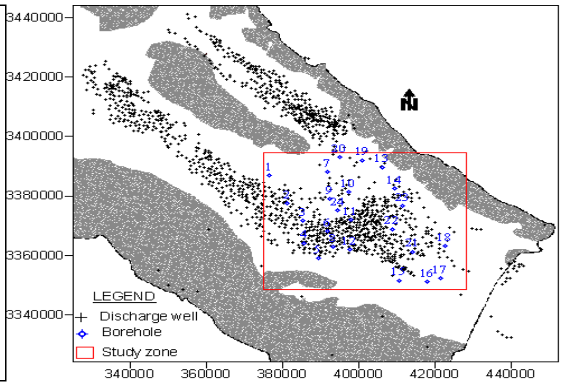

Figure (4): Well and borehole distribution in Rafsanjan basin

Table (1): Total discharge of groundwater in Rafsanjan plain

Year	Discharge (Mm^3)	Number of wells
1969	149	209
1971	337	587
1973	320	625
1975	393	908
1976	424	1032
1981	713	1503
1983	652	1258
1986	686	1478
1989	760	1539
1993	799	1621
1996	821	1719
1999	839	1798

Land subsidence measurement using GPS technologies

The first report about land subsidence in the Rafsanjan plain was from farmers in 1977, due to protruding of their water wells casings. Unfortunately, there had not been any systematic instrumentation for measuring ground level changes until 1999. The only available information had been from farmers who have to cut the protruded parts of casings of their wells every year. The ground surface in this area has been subsided up to 0.90 m. To monitor land subsidence, considering the west area of the Rafsanjan plain, more than 100 GPS (Global Positioning System) stations are needed to be established at the plain, but due to the time and financial limitation, 35 stations were established through the first stage of the monitoring program (Mousavi, 2001). Figure five shows the network of GPS stations (which is called Pillar).

The construction of the pillars started in May 1998. The pillars were left for about one month to remove any variation in concrete volume because of factors such as climate, shrinkage and cracking of the concrete, and interaction between concrete and soil. This period was long enough for the pillar to settle under its own weight and any factor other than land subsidence. Then the elevations of GPS stations were measured for the first time, and recorded within 15 days in August 1998. All the stations were simultaneously monitored by five receivers, which were established at five different points in the plain. Another set of measurement was taken in April 1999 (8 months later) at the same stations, and the new elevations were established (Musavi, 2001). The difference between two subsequent elevations at the same station gave the magnitude of the ground subsidence at that station. The monitoring program is scheduled to continue on a regular basis. Regional Water Organization also monitors the groundwater level monthly using 80 piezometer wells spread over the Rafsanjan plain.

Global positioning system (GPS) is a worldwide, earth orbiting, all-weather satellite navigation system developed by the U.S. Department of Defense (DOD). GPS includes a collection of 24 satellites that rotate around the Earth and send special waves that can be received by special geophones. Every satellite travels through a circle orbit 17491 km from the Earth during a 12-h period (Endres and Chilingarian 1995). The surveyor should understand the superior performance of GPS and adjusts survey methods to meet real requirements. At the same time, the surveyor should realize that GPS offers the opportunity to upgrade the precision for many surveys without any appreciable increase in cost. However, the balance between increased productivity, accuracy, and reliability must be consistent with GPS surveying just as with any other method (Czerniak and Reilly 1998).

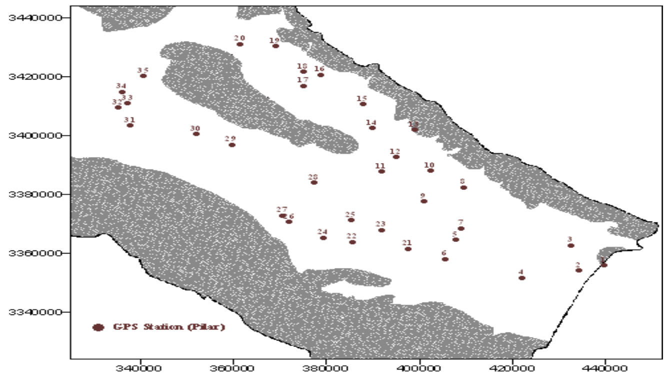

Fig (5): Network of GPS stations (pillars).

Groundwater and land subsidence model design

The governing flow equation for three-dimensional saturated flow in saturated porous media is:

$$\frac{\partial}{\partial x}[K_{xx}\frac{\partial h}{\partial x}]+\frac{\partial}{\partial y}[K_{yy}\frac{\partial h}{\partial y}]+\frac{\partial}{\partial z}[K_{zz}\frac{\partial h}{\partial z}]-Q=S_s\frac{\partial h}{\partial t} \quad (1)$$

where, K_{xx}, K_{yy}, K_{zz} = hydraulic conductivity along the x, y, z axes which are assumed to be parallel to the major axes of hydraulic conductivity; h = piezometric head; Q = volumetric flux per unit volume representing source/sink terms; S_s = specific storage coefficient defined as the volume of water released from storage per unit change in head per unit volume of porous material.

The governing equations for groundwater systems are usually solved either analytically or numerically. Analytical models contain analytical solution of the field equations, continuously in space and time. In numerical models, a discrete solution is obtained in both the space and time domains by using numerical approximations of the governing partial differential equation. Various numerical solution techniques are used in groundwater models. Among the most used approaches in groundwater modeling, three techniques can be distinguished: Finite Difference Method, Finite Element Method, and Analytical Element Method. All techniques have their own advantages and disadvantages with respect to availability, costs, user friendliness, applicability, and required knowledge of the user.

A three-dimensional finite difference model (Pmwin) was set up and applied for simulating groundwater flow. Processing MODFLOW for Windows (PMWIN) is a complete simulation system. It comes complete with a professional graphical preprocessor and postprocessor, the 3-D finite-difference ground-water models MODFLOW-88, MODFLOW-96, and MODFLOW 2000; the solute transport models MT3D, MT3DMS, RT3D and MOC3D; the particle tracking model PMPATH 99; and the inverse models UCODE and PEST-ASP for automatic calibration. A 3D visualization and animation package, 3D Groundwater Explorer, is also included.

The east northern and west southern boundaries are simulated as a no flow boundaries. The model configuration comprises 92 nodes in x direction and 92 nodes in y direction with a spacing of 1000, 500 and 250 m. Several pumping tests in the well fields were previously conducted by the water company. Results show that the transmissivity value varies from 100 to 3500 m^2/day. Note that the bedrock level obtained from geophysical investigations performed in 1349-50. Measured groundwater levels from 80 piezometers are available for calibration. The groundwater model is calibrated on two steady state and unsteady state conditions: September 1996 and September 2004. The 8-year period is subdivided in stress periods of six months and time periods of one month each. Calibration is performed by using automatic method and Pest code. Fig. 6 shows the calibration results, in terms of scatter plots by comparing the observed heads in the piezometers to the calculated heads in the grid cells. After model verification, groundwater table variation has predicted.

Land subsidence is modeled using a modular subroutine of MODFLOW (McDonald and Harbaugh, 1988) called the Interbed Storage Package-1 (IBS1) (Leake and Prudic, 1991). The IBS1 package is based on the one-dimensional consolidation theory of Terzaghi (1925).

Results & Conclusion

Calibration results are shown in Figure 6 as a comparison of calculated and observed head in a scatter diagram for some boreholes. The variance of calculated and observed head is 0.023 and .084 in borehole 22 and 23 respectively.

Also comparison of calculate and observed subsidence in a period with length of 8 months is shown in Figure 7.

Considering the well discharges and recharge to be constant, groundwater level has predicted in 6 months later and results compared with measured

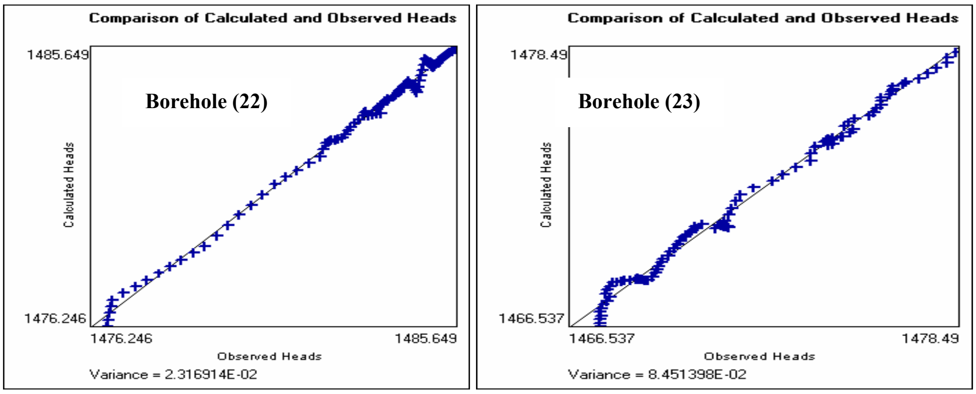

Fig (6): Comparison of calculated and observed head

data. Fig. 8 shows comparison of calculated and observed heads. Therefore, validity of the designed model obtained and used for prediction of groundwater decline and land subsidence. Table (2) shows drawdown and land subsidence calculated for 25 years from September 1996 to September 2021.

During the 8-month interval between the two successive measurements, the largest decline in groundwater level has been about 1 m. During the same time, different points of the plain have subsided from less than 10 mm to about 80 mm. Land subsidence near the city of Rafsanjan has been about 0.040 m during the 8-month interval between two successive measurements. The analysis of the results suggests that the magnitude of land subsidence is approximately 10% of the magnitude of decline in the groundwater level. Also, at some stations, land subsidence did not follow accurately the decline of groundwater level. Processing data showed that the groundwater withdrawal is the main cause of land subsidence in Rafsanjan plain. Subsidence of different points of the soil body due to groundwater withdrawal is not the same. Land subsidence is influenced by many factors, such as the thickness of aquifer, soil structure, interlaying manner of sublayers, and groundwater level. As these factors are different at different points of the plain, it is expected that the responses at different points to a unique phenomenon be different. Therefore if the declines of groundwater level at two points in the plain are the same, it does not necessarily lead to the same subsidence at those two points. To finding a relation between groundwater decline and land subsidence, Rafsanjan plain is divided into three parts based on the (land subsidence / groundwater decline) ratio. It is observed that the relation between land subsidence and groundwater decline is linear (Fig. 9). Note that considering the long-term nature of subsidence, the measured subsidence is not due to groundwater decline during the 8-month period only.

The above-mentioned results are based on two successive measurements over an 8-month interval. Definite results require detailed information concerning the magnitude of land subsidence in the Rafsanjan plain over a longer period, and also doing complementary and necessary field and laboratory tests to measure the hydrological characteristics at different points within the plain.

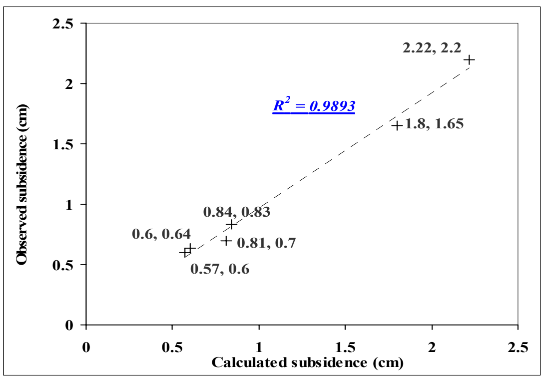

Fig (7): Comparison of calculated and observed subsidence

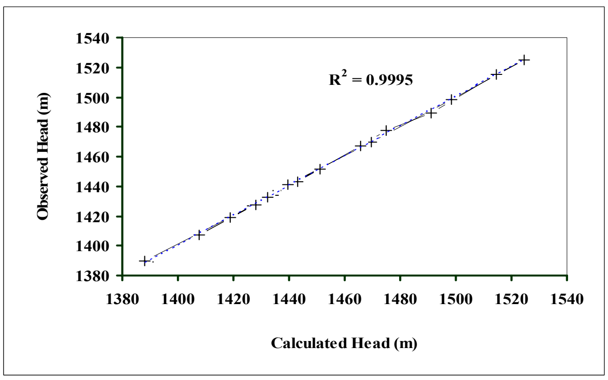

Fig (8): comparison of calculated and observed heads

Table (2): Drawdown and land subsidence calculated for 25 years

Borehole No.	7	8	9	12	22	23
Drawdown	12.42	15.76	25.63	23.21	51.96	40.94
Subsidence	0.621	0.504	0.359	1.160	0.520	0.819

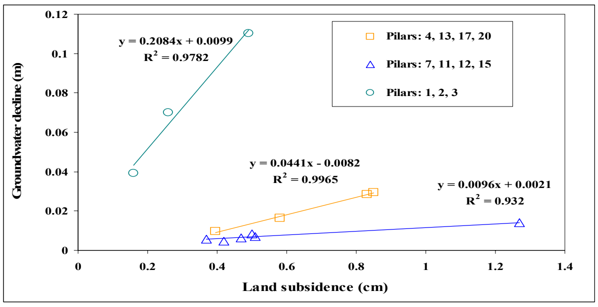

Fig (9): relation between land subsidence and groundwater decline

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GUIDELINES FOR CONTROLLING THE THERMAL DISINFECTION OF HORTICULTURE BACKING WITH DEEP PENETRATION METHOD

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In order to provide for the plants with healthy backing in shielded soil cultivation, the disinfection performing becomes necessary. From a number of methods, thermal disinfection from the ecological viewpoint and the wide spectrum of action is mostly favoured. To provide the high efficiency, with possibly low heat consumption, it should be carried out in accordance with the recommendations of the most recent literature and newest technologies should be used. The paper presents the guidelines and sources allowing the elaboration of the program making possible the control of the disinfection process of the horticulture backing with the deep penetration method. The factors and their actions on the disinfection process have been described. Their significance has been highlighted and the scopes of application given. While describing the particular factors, references have been made to the details found in the literature mentioned. Particular emphasis has been put on efficiency and energy consumption aspects in the backing disinfection process performed with the use of the deep penetration method.

Keywords: thermal disinfection, deep evaporation, backing, control, automatics.

Introduction

In conventional shielded cultivations, the horticulture backing is the factor having significant influence on the yield size and quality [Ślusarski 1977, Wargocki 1980]. As the shielded facilities are used for entire year, most frequently without changing the plants cultivated, the number of soil pathogens dramatically increases. This factor has been the reason of introducing cultivations on the inert backings, which should be replaced following each cultivation cycle. A problem occurred of what should be done with the artificial backing originating from the cultivation liquidation. On the other hand, it should be remembered that the backings used do not have much in common with the nature to which the population tends to come back. The growing and growing interest in the so-called health food may be seen on the market. If we plan to return to the cultivation on the natural backing, the problem of how to disinfect this backing needs to be solved. There are three methods, notably chemical disinfection, thermal disinfection and backing replacement. Thermal disinfection is seemingly the most reasonable as the application of chemicals in the cultivation should be restricted in line with EU directives. The backing replacement suffers from the impossibility of getting rid of pathogens. If the thermal disinfection is planned to be applied, it should be performed such that it is the most efficient with minimum energy consumption. In order to obtain the objective assumed, the research into thermal disinfection of the horticulture backing made to date should be refined to let the go-ahead for the elaboration programme for disinfection process control on these grounds.

As shown by the research [Hege et al 1972, Kosek et al. 1993, Rutkowski 1995], the efficiency of the disinfection process mostly depends on the level of knowledge in this area, held by the contractor. Another factor having influence on the efficiency and energy consumption is the proper selection of the parameters of the heating agent and the proper preparation of the horticulture backing. According to the research [Kosek et al. 1993, Rutkowski 2004, Wargocki 1980], the efficiency of the disinfection, expressed in terms of the percentage share of the backing in which the temperature of 95°C has been obtained with relation to the volume of backing where the disinfection has been planned to be performed, is very diversified in practice. Frequently, these values differ from one another by two or three times. The situation as regards the energy consumption is similar. In spite of so big differences expressed in measurable magnitudes, there is yet another serious threat that leaving some places not treated with disinfection process produces the conditions for significantly faster development of soil pathogens as would be the case where the proceeding with the treatment is abandoned.

Presentation and substantiation of the problem

Facts as presented above show that in order to obtain the satisfactory results of the disinfection process the program should be elaborated on the grounds of the existing knowledge, which would allow to include all the factors having influence on the energy consumption and the efficiency of the process. The program architecture should be such that changes may be made to it while acquiring new information in the field of the backing thermal disinfection. The information presented below will facilitate work on elaboration of the program model.

The scope of report covers the package of information in the field of thermal disinfection performed with use of the deep penetration method, by means of the perforated tubes. The material presented has been taken from the industry specific literature, as well as from broad proprietary research. The results provided originate from laboratory testing, as well as from broad operation tests.

While performing operation tests, a lot of information was obtained, regarding the process, but also a number of questions and doubts arose. Therefore, in order to clarify these issues, the laboratory station was completed allowing performing the disinfection with the concurrent recording of process parameters. The designed and completed station, described in details in the Rutkowski's paper [2000], was equipped with the computer assisted process control system on the grounds of knowledge available in the then phase of research. Currently, the larger resource of information is available, which will allow to elaborate the professional program to control the disinfection process. In order for the program to implement the expected function, the basic conditions necessary for the process to proceed must be fulfilled. These include:

- holding equipment for generation of steam with parameters required,
- holding the necessary equipment for steam distribution,
- relevant preparation of the backing dedicated for disinfection,
- holding information regarding the composition and humidity of the backing,
- holding the broad access to information in the field of disinfection,
- holding the controller (equipped with the program) incorporating the required input-output conditions,
- the trained and responsible personnel at the disposal.

While disinfecting the backing by means of the overheated water vapour, the appliance is necessary, allowing the generation of steam with parameters 140-200°C. The boiler or the set (boiler + super heater) should be equipped with the capability of rapid change to steam parameters. The fulfilment of this criterion will allow to obtain good energy (consumption) results. It is recommended that the temperature of the steam delivered may be changed from 30 to 40°C per hour, while the change to the capacity of the boiler should amount to 20-30% within one hour [Rutkowski 1995]. The capacity of the boiler should be strictly correlated with the area adopted for evaporation. It should be adopted that where the deep evaporation is considered, the rate of 20-40 kg of steam per hour should be delivered [Rutkowski 2004 A]. The evaporation area improperly selected with relation to the capacity of the steam source causes the non-uniform heating of the backing, bringing as a result the deterioration of the process efficiency and increases the consumption of heat delivered in the form of steam [Rutkowski 2004 B].

The deep evaporation by means of the perforated tubes involves the delivery of steam to the conduits (tubes) located at the height equal to 2/3 of the intended disinfection layer. The important factor having impact on the uniformity of heating the backing along the length of the field-patch is the diameter of tubes distributing the steam in the backing. According to the proprietary research, where the 50 DIA tubes are used, the disinfection may be performed for the field-patches with length up to 20 m. With this length, the differences in heating the backing are insignificant. Where the line segments of evaporation are longer, larger diameters are recommended, as well as diversification of the distributing tubes cross-section [Kosek et al. 1993, Wargocki 1980]. Where the evaporation is applied to horticulture backings with significant content of organic compounds, the openings with diameter 5 mm are recommended in the distributing tubes [Rutkowski 2004 A]. The lower diameter of openings may be applied in evaporation of backings with small contents of organic compounds [Rutkowski 1995]. The important factor having influence on the uniformity of the lateral distribution is the spacing of distributing tubes. In this case, the structure of backing and humidity should be taken into account. Approximately, the spacing of 50 cm may be adopted, but where the humidity increases the spacing reduces as is the case for the disinfection of backings holding significant rates of clay in their composition. More information on this subject is available in the Kosek, Rutkowski [1993] publication.

As provided by a number of authors [Hege 1972, Rutkowski 1995], the relevant preparation of the backing exerts significant influence on the efficiency and energy consumption of the process. Soils loosening, which requires a lot of regard [Rutkowski 1995, Wargocki 1980], determines the uniformity of heating the layer being evaporated. In order to re-evaporate of the assumed backing layer, the loosening measures should be performed at least to the depth of 5 cm higher than the assumed evaporation depth. The agglomerated backing requires the longer evaporation time and variability of temperature as otherwise the lumps are not going to be re-evaporated. The backing dedicated for disinfection should hold the relevant humidity, which, to a significant extent, depends on the contents of organic compounds. The larger rate of organic compounds, the more humid backing may be. The detailed information about the humidity with the pre-defined backing composition may be found from Rutkowski [2004 A] publication. The results of research presented will allow to select the parameters of steam for soil conditions. It should be remembered that the more humid backing, the bigger the temperature of steam.

Prior to entering for the thermal disinfection of the backing, maintaining and equalizing its humidity should be aimed at. The humid backing requires the delivery of larger rates of heat and makes it more difficult to distribute the steam in the spatial configuration. Where the backing is too dry, the penetration of heat is slow and there is a big probability that the soil pathogens may transform into resting spore forms, which prevents their liquidation. Therefore, prior to entering for proceeding with the treatment, the accurate measurements of humidity should be performed in order to draw up a map allowing the selection of steam parameters proper for the existing conditions. Similarly, the map with organic compounds content should be prepared. They will determine the temperature and the rate of flow of steam delivered. The examples of parameters selection may be found in the Rutkowski' paper [2002, 2004 A] .

As shown by the research, the overheated steam with temperature 140-200°C should be applied for horticulture backing disinfection. Although the literature provides the information that lower temperature may be used [Ślusarski 1977], the results of disinfection so applied produce a lot of doubts. The broad range of temperatures applied allows the thermal disinfection of backings with diversified content and humidity and allows, where the organization of the process is good, to obtain high efficiency with less energy consumption. The deep evaporation with the use of perforated tubes requires that the flow of steam be many times higher in terms of units of the area than is the case for the surface evaporation. The upper limit of the steam flow arises from the fact of creating the channels towards the surface of the soil which triggers the non-uniform distribution of temperature in the soil space and increased losses of energy. The selection of the magnitude of the flow depends, to a significant extent, on the composition of the backing, in particular, on the content of organic compounds [Rutkowski 2004 B]. As provided by the author of the application mentioned, the flow steam rate should be applied which still prevents the generation of ducts upwards causing that the steam emerges from the soil as early as in the preliminary phase of the evaporation process. The measurement and the detection of temperature backing is recommended in the preliminary phase of the process, directly underneath the shield surface, as well as the information about the increments of temperature around the tubes distributing the steam. The flow properly selected should ensure the uniform increments of temperature in the space of the backing being evaporated, which is seen in the figure 2 of the paper discussing the above-mentioned issues [Rutkowski 1999]. As the magnitude of the steam flow is strictly correlated with the magnitude of the pressure as measured in the feeding pipeline, therefore the latter magnitude is used in practice. The measurement of the pressure is technically easier and this is why this impulse is applied for controlling the capacity of the steam source, which most frequently takes place through the change to the thermal capacity of the burner of the steam generator. While adjusting the capacity of the steam generator (in the two-stage appliance for steam generation) the concurrent adjustments of the burner overheating the steam should be remembered as the temperature of steam, except for the preliminary phase, is most frequently the constant value. The proper selection of the steam parameters determines to a significant extent the heat consumption, which becomes more and more expensive. The pro-ecological, shielded cultivation, reaching for the thermal disinfection, should take into consideration that the impact on the environment should be minimized and this is why the temperatures higher than recommended by the industry-specific literature should be avoided. At the same time, it should be remembered that basic principles should be maintained, involving the prevention from the threat of secondary contamination of the soil, directly after the treatment completion. Taking into consideration the contradictory reports in the available literature, regarding both the range of temperatures applied and the methods of preparing the horticulture backing, prior to entering for the disinfection treatment, the most recent literature should be consulted and the handling personnel familiarized with the relevant details.

Summary

The issues reported, where the reference is made to the individual papers regarding the thermal disinfection with the deep penetration method, have been aimed at refining the question and indication of the sources of information. While using this method, it is recommended to elaborate the program allowing controlling the disinfection process. This will permit to obtain the satisfactory results with the lowered outlays for energy, whose basic flow is the heat delivered in the form of the water vapour. The literature referenced expressly highlights how big energy savings may be obtained where the individual recommendations from the conclusions gained from the research and tests performed are followed. Performing the test into using the new neural networks [Langman et al 1998] prove that reaching for the state of the art methods of disinfection process control is definitely purposeful and highly recommended. The controller completed and operated for a number of years [Rutkowski 2000] should be modernized and introduced into the broad production.

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THE SOLUTION STRATEGY TRANSFORMATION OF THE CONSTRUCTIVE-TECHNICAL TASKS WITH USE OF COMPLICATIONS

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On the basis of the main ways, methods of the solution strategy of the task solution is formed. Transformation of the solution strategy of the constructive-technical tasks with use of complications is considered.

Keywords: creative thinking, transformation of strategy, constructive-technical task, solution of tasks, complication

Introduction

The improvement of complicated technical and natural systems occurs, as a rule, on the basis of a knowledge deepening of the world around which makes an essence of scientific and technical progress. The need of techniques puts all new and new tasks before a science.

Therefore modern education should prepare the specialists, capable to be responsible for the professional future, capable to confirm themselves in conditions of a competition in the labor market. The basic purpose of vocational training and education consists in training specialists who own skills and knowledge for satisfaction of market needs of labor; specialists who are prepared for creative professional activity that would have constant aspiration to the best, more improved.

As V.O. Molyako marks, "creativity should become norm of professional activity and training to it, i.e. in a final variant we speak that each skilled specialist should be the creative specialist" [5].

At the given stage of economic and social development of our state, the becoming of young specialists should occur in view of those complicated conditions in which they will live, and will work. At students, and in our article we shall speak about students from a countryside who study at the faculties of Mechanical-Technological and Construction and Design at National Agrarian University; there is no sufficient psychological training to a real life with its complexity, difficulties, and atypical situations. If to consider a problem of students' training to technical creative work for a given time there is many unsolved tasks.

One of the main tasks of psychological of students training to technical the development of the stable positive attitude of students to creative activity is possible.

Training of the future specialists for labor activity should be based on the solution of its constructive-technical, technological, organizational tasks which would display situations of real work.

The solution of different scientific, practical, art, constructive and other tasks which arise in a life of people, demands knowledge by them not only external properties of objects, and their internal connections and attitudes. Therefore, as G.S. Kostyuk marked, "a problem of the development of thinking, and especially the development of creative thinking which differs originality and creativity is very important presently" [2].

Materials and Methods

The purpose of article is to reveal features of cogitative activity, functioning of strategy during the solution by the students of the first course of technical specialties of constructive-technical tasks with use of complications.

Proceeding of it, the primary goals of our research consist in definition of influence on cogitative of students' activity of complications introduction during the solution of the constructive-technical tasks.

Ability to think is a property of the person. The thinking arises during interaction of the person with an external world and serves its successful realization. It is generated, first, by the need to understand any new situation to the person, new object to it that is given to it in alive contemplation, or represents or is described by words. The creative thinking is a search and opening new. For creative work, it is necessary to own ability independently and critically to think, get into essence of subjects and the phenomena, to be inquisitive, that appreciably provides productivity of cerebration.

The problem of creative thinking development is in the center of attention of many scientists during all development of a psychology-pedagogical science about creativity (L.S. Vygodskyy, J. Gilford, O.S. Yermakova, A.B. Kovalenko, G.S. Kostyuk, S.D. Maksymenko, O.M. Matyushkin, V.O. Molyako, A. Osborn, Y.O. Ponomaryov, R.O. Ponomaryova, S.L. Rubinshteyn, E. Torrens, M.G. Yaroshevskyy, etc.).

One of the methods of students training to technical creativity is the solution of constructive-technical tasks which display tasks of manufacture both on engineering, and at an executive level. Such approach is named as determining in works of many scientists (T.V. Kudryavtsev, A.F. Esaulov, Y.O. Ponomaryova, V.O. Molyako, etc.).

Based on continuous studying design activity on professional level, V.O. Molyako has offered the system of creative training of students during their training for technical labour activity [3, 67]. The component of creative training method is the using of complications during the solution of constructive-technical tasks. We shall consider the psychological features of this process.

In the system-strategy concepts of the activity developed by V.O. Molyako, strategy is defined as "more or less flexible system objectively and situationally defined actions in which the tendency to subject advantage of one mental action to another prevails" [3, 18]. Thus, the term "strategy" can be applied to "to the description of all solution process of the solution in which the dominating tendency of the person mental activity concerning a specific target is realized" [3, 17].

V.O. Molyako separates the contents of concept "strategy" from categories "method" and "way". He does not consider them as synonyms, as a way and a method, unlike the strategy, abstracted from the personality.

In the structure of strategy of V.O. Molyako allocates: 1) studying of task's condition; 2) search of the solution way; 3) an embodiment of a hypothesis solutions [3, 64-64].

As the strategy is a dynamic, remedial formation, the following basic stages are allocated in it: 1) studying of a task's condition; 2) check of a condition by concrete knowledge – correlation of a new task with system of the knowledge and experience of practical actions; 3) a choice of a hypothesis about possible structural and functional transformations of the set components; 4) "designing" of a hypothesis on all conditions as a whole and its localization concerning a place of concrete application; 5) check of a hypothesis by means of tactics stipulated by it and auxiliary methods; 6) detailed elaboration [3, 69].

The person, as a rule, realizes and mentally determines the basic moments of cogitative activity besides there is always a certain attitude of the person to the process of the solution, i.e. this process is always emotionally painted. Actually, based on the basic methods of the solution and confidence of the actions the strategy of the solution of a constructive-technical task is formed. Cogitative strategy consists of complete formation of the person ability, a disposition that defines a character of actions and the tendency of mental behavior as a whole.

In I.G. Shupeiko's research laws of evolution and transformation of the solution strategy of tasks during the process of studying. As the result of carried out research it was established, that the process of formation of effective solution strategy represented the alternation of evolution stages and strategy transformation which are "intermediate" concerning "basic" which acts in the form of studying. It was also established, that the character of dynamics, i.e. process of effective strategy formation could be operated [8].

The essence transformation theories of operators studying, offered by V.F. Venda is the process of effective strategy formation of the solution during training represents some sequence of evolution stages and transformation of intermediate strategy. In the opinion of the author of this concept, process of strategy mastering depends on the amount of intermediate strategy and duration of their mastering, and of peculiarities of transition from one strategy to another [1].

We consider, that the definition of strategy by means of such terms as the set of rules, plan, the general scheme, some structure, etc. is little productive as these terms designate the certain set of methods which fixed firmly in activity, i.e. something static. The approach to strategy which associates with the general orientation of mental activity, its dynamics takes place in the works G.S. Sukhobska, Y.M. Kulyutkin and V.O. Molyako.

The viewing strategy of the tasks solution as structured formation that operates the process of the solution at its all stages is of great importance at the solution of constructive-technical tasks.

Result and Discussion

Two groups of students (20 in each) have taken part in the experiment. They are the students of the 1 course of Mechanical-Technological and Design and Construction faculties of National Agricultural University of Ukraine.

According to the structure, the experiment consisted of such stages: theoretical training, the solution of tasks on acquainting, the solution of tasks with complications and the solution of tasks of a control series.

We have taken the constructive-technical tasks of V.O. Molyako's thesis research.

The solution of the constructive-technical tasks causes in students steady interest, as they are interested in novelty, originality of tasks, and the opportunity to make use of the practical experience.

Some possible methods of complications use at the solution of the constructive-technical tasks are offered, namely: limit of time, new variants, prohibitions, information insufficiency and so on [3, 82].

The results of research received by V.Z. Skakun, testify that the introduction of sudden prohibitions influences mental actions of the subject, thus, that there is faster change of variants in cogitative activity, ordering of interrelations between structures and functions aside of their optimum association [15].

In a situation with complications the great value has how quickly and successfully the subject finds a way out of the created situation, what methods are used, how complications influence on its emotional condition, on its behavior in general [7, 55].

It is possible to allocate such groups of students according to the reaction on introduction of the complicated conditions:

- Students in which cogitative activity is broken, some of them refuse the solution of tasks;
- Investigated that try to solve tasks in that way, as before the introduction of complications;
- Students for whom the stimulating factor of cogitative activity is the introduction of complications.

On results of research carried out by us the majority of students concern to the third group (76 %).

In our experiment, we used a method of information insufficiency and a method of a prohibition. These methods are expedient for introduction at the stage of studying of a condition of a task as for stimulation of creative activity it is important to make active thinking at the initial stages of the process of the solution of a task.

The method of information insufficiency was used in several forms:

- The direction of the manipulation of one of the structural elements (functional insufficiency) was not marked;
- The task was given only in the text form;
- Complications were combined: functional insufficiency with the text form of a task.

The text form of a task stimulates the subject to renderline the main structural element with unequivocally defined functional property, which meets the requirements of a task.

Functional insufficiency forces the subject, besides the allocation of a structural element, to allocate a functional attribute and to subordinate to the course of thinking. Therefore, during cogitative activity at the stage of condition studying of a task and plan formation the subject the most optimal unites structural elements with functional.

The solution of the constructive-technical tasks is inconceivable without use of graphic activity. Nevertheless, a level of graphic training of students is low. In addition, students are not able to display correctly a structural element in a projection. The essence of difficulties is that the students are not able to transfer correctly a structural element (as a product of figurative thinking of the subject) to graphic activity.

At modern school Drawing it is not studied, and consequently there are difficulties

At students at the initial stages of studying at high school on technical specialties, and especially at students from countryside, most of them have low level of training from disciplines behind the school curriculum.

Information insufficiency stimulates cogitative activity, thus, that the subject during thinking process, and then, having convinced of the choice correctness, uses such structural element from the mental stock which most full answers both to a condition of a task, and its graphic skill.

At introduction of information insufficiency, the role of graphic activity during the solution of the constructive-technical task is decreased. It is very difficult to allocate during the solution the stages of understanding of a condition and formation of a plan without specially given experiment. We shall notify only, that such method of information insufficiency is an effective stimulator of cogitative activity and all or a significant part of cogitative actions are directed to the searches of necessary structurally functional elements at the stages of understanding of condition and origin of intention. This idea is also confirmed by the fact that at the solution of a task on graphic activity is spent less than 40 % of time.

Within the limits of research the experiment with the purpose of features revealing of process of the solution of is constructive-technical tasks with use of a method of a prohibition has been carried out.

Transforming influence of sudden prohibitions can be connected with the change of that "tool", by means of which the pupil solved a task at the previous stages of work, and which represents less or most measure the organized system of constructive actions (in an ideal – strategy), directed on construction of the required solution, in particular analogy, a combination, reconstruction [6].

During of tasks solution by the students use the certain stamps and give advantage to structurally functional elements, ways and methods of the solution.

We considered, that introduction of a prohibition at the certain stage of solution process of the constructive-technical task makes active thinking of the subject, will destroy stamps in the choice of structural and functional elements and will qualitatively improve the solution of a task. A prohibition was introduced at the stage of studying of a task condition: carried out research earlier tasks solved by the subject, we forbade applying that type of transfer, which was used more often. Researches testify, that the prohibition positively influences on productivity of thinking, assists of activization of thought process, – helps "to extract" more remote structures and functions that increase the probability of optimal association of structurally functional elements and the correct solution from memory.

The task solutions are the solutions in analogies for the students. During the process of a prohibition method using beside with the solution of tasks in analogies, combinatory actions appear then, and they become steady in using.

V.O. Molyako marked that in technical creativity the advantage is given to combinatory actions [3, 100]. Our researches have shown: if it doesn't pay attention to quality of solutions of tasks with use of combination theory, and to take the fact of its use for a basis, and frequency of combinational actions realization in cognitive activity of students has increased up to 20 % at the solution of constructive-technical with complications.

Conclusion

So, our researches have shown, that introduction of complications during the solution of the constructive-technical tasks stirs up the cogitative activity of students, assists to enlarge the forms of necessary structurally functional groups searching, assists of construction of optimal variants of the solution of tasks.

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A SURVEY-BASED ON THE ANALYSIS OF SUGAR BEET PRODUCTION METHODS USED IN POLAND AND IN CZECH REPUBLIC

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Technical equipment and size of plantation are the basic factors that render possible to select the appropriate technology for sugar beet production, the one that might ensure a proper quantity and quality of the crop. According to the good manufacture practice (GMP) rules, valuation, and comparison of the technical equipment as well as of the method of sugar beet production may serve the purpose of their improvement. The purpose of this study is the analysis of production technology and technical equipment of farms specializing on sugar beet production. The study was carried out in 13 selected farms in Poland and in the Czech Republic. The main criterion for selecting the farms was the acreage of the plantation and long history of crop production. Based on the documentation carried out at Czech farms and surveys of Polish farms, the production processes were chiefly analysed. Also, the productivity of the machines used in the agricultural procedures was examined. A production technology complexity index was determined and the crop yield was converted at 16% sugar content. Significant differences in production volume and technical equipment between farms in both countries were identified. In Poland, sugar beet is chiefly grown with the use of traditional technology and older machines with a lower productivity. The beetroot yields obtained are higher and more stable in the Czech Republic.

Keywords: sugar beet, machinery, capacity, technology

Introduction

In the conditions of sugar overproduction and reduction of reference prices in the European Union countries, the production scale is controlled by the EU and national regulations. In 4 years' time, the minimum raw material purchase price will be reduced from 32.86 EUR/t to 26.29 EUR/t (Council Regulation (EC) No 318/2006). The compensation in the form of a sugar payment will partially only compensate the losses in the growers' incomes (Council Regulation (EC) No 319/2006). In the view of the above situation, the application of production technology that enables obtaining high yield and crops of good quality is essential for maintaining profitability of sugar beet growing. The technology differentiation is so high, especially in Poland, that it is necessary to analyse the reasons for application of various technologies (Bzowska-Bakalarz et al., 2005, Przybył et al., 2004, Szeptycki, 2005, Šařec et al., 2004). The comparison of sugar beet growing levels and technologies applied may serve the purpose of improving the production process (Bzowska-Bakalarz et al., 2005).

Production results for the last three years in Poland and the Czech Republic are proof of significant differences in volumes of beet crops and sugar productions (Table 1). Poland, being the third producer of sugar in the European Union, achieves definitely lower crops of sugar beet (by 10 % on the average) and lower sugar yields (by 1.9 t/ha on the average) in comparison with the Czech Rep. The Czech Rep. has the highest beet production from among the new EU member countries (Chudoba, 2007). Large plantations (ca. 70 ha) and a small number of growers in the Czech Rep. proves that there are high-production farms there, whereas in Poland, in spite of a decreasing trend in the number of planters, the average cultivation area is only 3.8 ha.

The beet growing area is definitely diminishing (in the years 2004-2006: Poland - by 19%, the Czech Rep. – by 21%). This is caused chiefly by sugar overproduction and organization of the European sugar market. In the economic years 2007/2008, sugar production will be further restricted due to withdrawal from the market of a part of the quota sugar (13.5%) (Commission Regulation (EC) No. 290/2007). In the Czech Rep., as many as three sugar factories resigned from production (Listy cukrovarnické a řepařské, b). In spite of the above situation, many sugar beet planters are still interested in acquiring additional production quota due to the economics of sugar beet. However, the maintenance of sugar beet growing level is related to the necessity of choosing a proper cost-reducing production technology.

Table 1 – Comparison of cultivation area, plantation area, number of planters and production results in Poland and in the Czech Rep

	Poland				Czech Rep.		
	2004/05	**2005/06**	**2006/07**		**2004/05**	**2005/06**	**2006/07**
Cultivation area [thou. ha]	297	278	240		71.095	65.569	55.81
Average plantation area [ha]	3.81	3.81	3.8		76	73	67
Number of planters	78000	73000	62000		935	901	837
Beet yield [$t.ha^{-1}$]	43.2	44.3	48.3		50.57	54.31	53.64
Sugar yield [$t.ha^{-1}$]	no data available	8.0	8.2		9.37	10.16	9.87

Source: Authors' elaboration based on (Cukier i skrobia 2006, Mucha, 2007, Listy cukrovarnické a řepařské, a)

The purpose and method of the study

The purpose of the paper is to analyse and compare production technologies and technical equipment in selected Polish and Czech farms specializing in the production of sugar beets.

Thirteen farms from the Czech Republic and the eastern part of Poland were selected for the study. These were developing farms capable of maintaining the sugar beet production in the next few years. The conditions for sugar beet cultivation in the both countries' farms were similar. The criterion of plantation size was adopted as the main criterion for farm selection.

In 2005, the analysis of main stages of sugar beet production (after-harvest cultivation, fertilizing, and soil preparation in autumn and spring, sowing, protection, and harvest) was carried out. In Poland, the analysis was carried out based on questionnaires filled by planters, whereas in the Czech Rep. based on production documentation carried out in farms.

To compare production effects of examined farms, the volume of root crop was calculated at the 16% sugar content according to the below formula (Eq. (1)). In EU countries, the volume of admissible sugar losses is assumed based on ministerial regulations. A three-percent volume of losses was adopted for calculations.

$$P = \frac{P_K \cdot (Z_C - 3)\%}{13\%} \left[t \cdot ha^{-1}\right] \qquad (1)$$

P – root crop at 16% sugar content,
P_K – mass of roots collected [$t.ha^{-1}$],
Z_C – sugar content in sugar beet.

A production technology complexity index was applied for production technology (Eq. (2)). The technology complexity is understood as performance of an appropriate number of technological procedures complying with quality recommendations, i.e. guarantying a high quality of the crop (Harasim, 2006 after Klepacki).

$$W_{kt} = \frac{Zw \cdot 100}{Zp} [\%] \qquad (2)$$

W_{kt} – production technology complexity index,
Zw – number of procedures actually performed,
Zp – standard number of procedures and recommendations for proper production technology.

The technical equipment was compared through confronting average productivities of machines used for subsequent stages of the production process in Poland and the Czech Rep.

Results and Discussion (characteristics and comparison of production results of farms)

Cultivation areas in the farms selected for analysis are similar, yet the differentiation of acreage in Polish farms is higher (standard deviation 22.7 ha) (Table 1). In Czech farms, crops are higher by 13.9 $t.ha^{-1}$ as compared with the Polish ones and the spread of root crop volumes between the objects examined is lower by 2 $t.ha^{-1}$. The average sugar content in roots from Polish plantations is higher by 0.5 %, yet the spread of results is almost twice as high (standard deviation 1.3 %), which is evidence of unequal production levels in those farms in comparisons with the Czech ones.

The sugar beet crop at the assumed 16% sugar content amounted to 68 $t.ha^{-1}$ in the average in the Czech Rep., i.e. it exceeded by 14.2 $t.ha^{-1}$ the results obtained in Poland, in spite of the fact that the average content of sugar in plants cultivated in Poland is higher. Attention should be paid to the fact that the inequality of crop yielding in individual farm is higher by 5.8 $t.ha^{-1}$ in Polish plantations when compared with the Czech ones, which also suggests that the technological level is more differentiated. On allocating the farms examined to the intervals established on the basis of the crop volume (at 16 % sugar content), one can observe that four Czech farms obtained crops above 70 $t.ha^{-1}$, which was achieved only in two Polish farms. Crops in the range of 60-69 $t.ha^{-1}$ occurred in the Czech Republic in eight cases, whereas in Poland only in two cases. Seventy percent of Polish farms gather crops above 60 $t.ha^{-1}$ and only 8 % in the Czech Rep.

Table 2 – Comparison of cultivation areas and crops obtained at plantations examined in the year 2005

Farm no.	Poland					Czech Rep.			
	Cultivation area [ha]	Collected roots yield [t.ha^{-1}]	Sugar content [%]	Roots yield at 16% sugar content [t.ha^{-1}]		Cultivation area [ha]	Collected roots yield [t.ha^{-1}]	Sugar content [%]	Roots yield at 16% sugar content [t.ha^{-1}]
1	12.6	58.44	20	75.1		18	53.85	18.6	63.9
2	58	47	20.02	60.5		72.87	67.93	18.7	81
3	32	45.8	20.9	61.8		36	55.61	18.4	65.1
4	100	32	18.2	37		58	67.09	18.1	77.2
5	51	49.51	18.4	58		57	51.1	18.1	58.8
6	32	59	19.6	74.2		50	60.1	18	68.7
7	20.5	36.32	18	41.5		11	59.6	17.9	67.7
8	44	32.14	15.9	31.9		40	46.6	20.15	60.4
9	20	42	18.3	48.9		58	50.9	18.5	60
10	28.3	42.43	20.1	54.9		31.95	64.26	18.86	77.4
11	25	38.99	17.7	43.7		30	59.43	17.23	64.7
12	30.40	44	20.4	57.8		30	55.7	18.95	67.4
13	12.5	44.2	19.3	54.6		10	60	18.6	71.1
y	35.9	44.0	19.0	53.8		38.7	57.9	18.5	68.0
σ	22.7	8.1	1.3	12.6		18.8	6.1	0.7	6.8

Table 3 – Production results obtained in relation to plantation scale

Area intervals	Poland				Czech Rep.		
	Collected roots yield [t.ha^{-1}]	Sugar content [%]	Root yield at 16% sugar content [t.ha^{-1}]		Collected roots yield [t.ha^{-1}]	Sugar content [%]	Root yield at 16% sugar content [t.ha^{-1}]
Up to 20 ha	48.2	19.2	59.5		57.8	18.4	67.6
20 – 40 ha	44.4	19.5	55.7		56.3	18.7	67.0
Above 40 ha	40.2	18.1	46.9		59.4	18.3	69.1

When analysing production results in relation to the sugar beet cultivation area, it can be observed that in the Czech farms, the highest crop (with 16% sugar content) was gathered from the largest plantations (Table 3). In Poland, an opposite relation can be observed – a larger mass of roots and higher sugar content was obtained in smaller plantations. It follows from the above that in the Czech Republic, the growth in the plantation scale is accompanied by improvements in production technology.

To assess the technologies applied, subsequent cultivation procedures carried out on selected plantations were analysed and productivities of machines applied were compared. In the examined farms in Poland, only conventional method of soil cultivation with winter ploughing is applied, whereas in the Czech Republic, 46 % of the farms surveyed applies a simplified soil cultivation – which prevails there chiefly for ecological reasons so (retention of water in soil, lower soil packing), as well as economic ones (lower fuel consumption) (Przybył, 2004, Zimny, 2007, Ružbarský, Šařec 2005).

Table 4 contains the list of criteria taken into consideration for appraising complexity of the vegetable production technology as compiled in compliance with the integrated agriculture rules. In Table 4, only those farms from both countries were compared that apply conventional production technology.

Table 4 – List of procedures and technological recommendations for appraisal of sugar beet production technology complexity

Production procedures and technological recommendations	**Farm number**																				
	Poland														**Czech Rep.**						
	1	2	3	4	5	6	7	8	9	10	11	12	13		1	2	4	7	9	11	13
Proper pre-crop	+	+	+	+	-	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
Stubble cultivation (cultivator, disc harr.)	-	-	+	+	+	+	+	+	-	-	+	-	-		+	+	+	+	+	+	+
Deep ploughing	-	+	-	+	-	+	+	+	+	-	+	+	-		-	-	-	-	-	-	-
Fertiliser rates based on soil analysis	+	+	+	+	+	+	+	+	+	+	+	-	+		+	+	+	+	+	+	+
Mineral fertilising PK	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
Organic fertilising	-	-	-	-	+	-	+	+	+	+	+	-	-		-	+	+	+	+	+	+
Intercrop sowing	-	-	-	+	-	+	-	-	-	-	+	-	-		-	-	-	+	-	-	-
Pre-winter ploughing	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
Application of rotating plough	-	-	-	+	+	+	+	+	+	+	-	+	-		+	+	+	+	+	+	+
Application of twin wheels in tractors	-	-	-	+	+	-	+	-	-	-	+	-	+		+	+	+	+	+	+	+
Pre-sowing cultivation with an aggregate	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
Chemical protection	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
Fertilising with N	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
Sowing with accurate seeders	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
Weeding	+	-	+	-	-	-	-	-	-	-	-	-	-		-	-	+	+	-	-	-
Single-stage harvest	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
Number of criteria met	**10**	**10**	**11**	**14**	**12**	**13**	**14**	**13**	**12**	**11**	**14**	**10**	**10**		**12**	**13**	**14**	**15**	**13**	**13**	**13**
Technology complexity index (%)	**62**	**62**	**69**	**87**	**75**	**81**	**87**	**81**	**75**	**69**	**87**	**62**	**62**		**75**	**81**	**87**	**94**	**81**	**81**	**81**

Source: Authors' elaboration based on (Harasim, 2006, Przybył, 2004).

Production technology complexity indices in both countries range from 62 to 94 %. In the Czech Republic, the average index is 83 %, while in Poland; it is lower by 9 %. The index should be theoretically strictly related to the effects and quality of the final production. However, in some farms in Poland having a higher technology complexity index, then worse crops are gathered. For instance the farm that achieved the lowest converted yield per hectare, i.e. 37 t.ha^{-1}, had the production technology completeness index at a level of 87 %. Table 4 does not include such basic recommendations for appropriate cultivation as selection of a stand, proper terms, and precision in the procedure performance, etc. Hence, it can be assumed that the planter's knowledge and skills can have an equally high impact on the crop's quality and volume as the production technology chosen.

Machines are means of production that frequently have a decisive impact on the quantity and quality of crops. The average exploitation productivity of the machines used in the examined farms in Poland and the Czech Republic are presented in Table 5. Most of machines used in Polish plantations have a lower productivity when compared with the Czech ones. The highest disproportions occur when machines for after-harvest, pre-sowing, sowing, and chemical protection procedures are compared. The equipment used in Poland consists, to a significant extent, of old type machines used for many years. For instance, for after-harvest cultivation procedures, skimming ploughs are often used instead of first

Table 5 – Average exploitation productivity of machine sets applied for individual procedures

Agrotechnical procedures	**Average machine exploitation productivity [ha.hour^{-1}]**	
	Poland	**Czech Republic**
After-harvest cultivation	1.2	4.5
Mineral fertilising	3.6	5.3
Organic fertilising	0.3	0.6
Ploughing	0.8	1.2
Deep ploughing	1.0	1.9
Before-sowing cultivation	1.7	4.5
Sowing	1.7	3.3
Chemical protection	3.5	7.3
Harvest	0.9	1.0

ploughing aggregates that are much more effective. Individual procedures are performed with machines with a narrow working width, which requires a higher number of passes in the field. The fact that more and more farms are interested in outsourcing of services (77 % of Polish farms examined rent sugar beet harvesters) is very promising. This is the only solution that makes it possible to improve the production technology with such high fragmentation of agricultural holdings.

Conclusions

Based on the comparison of selected farms specializing in sugar beet production, authors observed a significant differentiation of the technical equipment and production results achieved on Polish and Czech plantations. The volume of the beet yield (at 16 % sugar content) gathered from Czech plantations is high (by almost 14 % higher than the one in Polish plantations) and the comparable between-farm variability of results obtained is insignificant (6.8 t.ha^{-1}), which suggest an even level of production. As much as 46 % of Czech farms apply modern cultivation technology, and the conventional technology complexity index is high (83 % in average).

Even though the production level of Polish farms is lower (lower yields, the absence of modern simplified technologies, low machine productivities, a low production technology complexity index), generally, the crops gathered are close to European mean indices (the yield at 16 % sugar content amounts to 53.8 t.ha^{-1}). The differentiation of production results among individual plantations is very high in Poland (up to 12.6 tons of roots per hectare). One of the reasons of this fact is that the application of traditional technology doesn't comply with all of the production recommendations (the production technology complexity index is 74 %).

The even level of production in the Czech Republic allows to gather higher and higher yields, depending on the scale of cultivation area. However, in Poland, smaller farms, below 20 ha, achieve the highest production indices. This is the evidence of their high potential capabilities.

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COMPARISON OF TRADITIONAL AND SOIL CONSERVATION TECHNOLOGY OF CULTIVATION OF MAIZE FOR GRAIN

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The paper presents the results of field trials that assess influence of various technologies of maize-for-grain cropstand establishment on not only its yield, but as well on labour and fuel consumption, and individual cost components. The field trials have been carried out since the year 2004 in all maize-growing regions of the Czech Republic. Farm businesses are monitored that perform either conventional technology of soil cultivation comprising ploughing or reduced-tillage technology. Te trials showed no significant differences in grain yields between both technologies in question. On the other hand, labour consumption demonstrated highly significant differences, i.e. 56.2 % in favour of reduced-tillage. Significant differences in favour of reduced-tillage technology were proved as well with regard to fuel consumption, and machinery and total costs.

Keywords: maize, grain, reduced-tillage technology, ploughing, costs

Introduction

History of maize (Zea mays) extends nine thousand years backward, particularly in South America. Obviously, it had a significant influence on development of South-American culture. In spite of its tropical origin, maize is a crop that is grown nowadays in various climatic conditions. This practice has been enabled by evolvement of breeding, which resulted in the fact that solely hybrid seed is applied at the present time. Maize growers are thus wholly dependent on specialized seed improvers. Maize grown for grain plays an important role in alimentation of population, but as well in livestock feeding where it ranks among the most important feeding crops (Vrzal, J., Novák, D. et al., 1995).

In the Czech Republic, maize cultivation area increases yearly, e.g. from around 40 thousand hectares in the year 2000 to 100 thousand hectares in 2006.

Choice of a suitable variety depends mainly on nature and weather conditions of a grower. In the Czech Republic, varieties appropriate for various production areas are tested regularly. The key feature of a hybrid seed is the length of vegetative period that is indicated using the FAO scale as a number in proportion to a standard. The number therefore doesn't represent any absolute length of vegetative period in days. In the conditions of the Czech Republic, a range of varieties starting with very early hybrids with 200 FAO, i.e. 120 days of vegetative period, to late hybrids with 600 FAO, i.e. 142 to 148 days of vegetative period, is used (Petr, J., Húska, J., 1997).

Moth-resistant Bt maize is one of the few genetically modified crops allowed for growing in the Czech Republic at the moment. From the selection of farm businesses where the field trials in question has been carried out, four farms use genetically modified seed already.

Materials

The aim of the field trials, located in all regions of the Czech Republic, is to evaluate major technologies of crop stand establishment of maize grown for grain with respect to its yield, fuel and labor consumption, and costs, but as well other variables not mentioned in the paper such as soil compaction, soil pH, soil nutrition content, weed infestation etc.

The trials have been carried out in ten farm businesses where either conventional technology of soil cultivation comprising ploughing or reduced-tillage technology is applied. Besides ploughing, the two technologies in question differ as well according to organic fertilizer application, i.e. manure or slurry application. At all selected farms within one year, one field is monitored, or even more fields in the case of different soil cultivation technologies used.

Data that are monitored within the trials (see Figure 1) concern overall characteristics of farm and field in question as well as particular information on plant and soil, and on all field operations that were carried out. The latter enables to enumerate costs of maize growing.

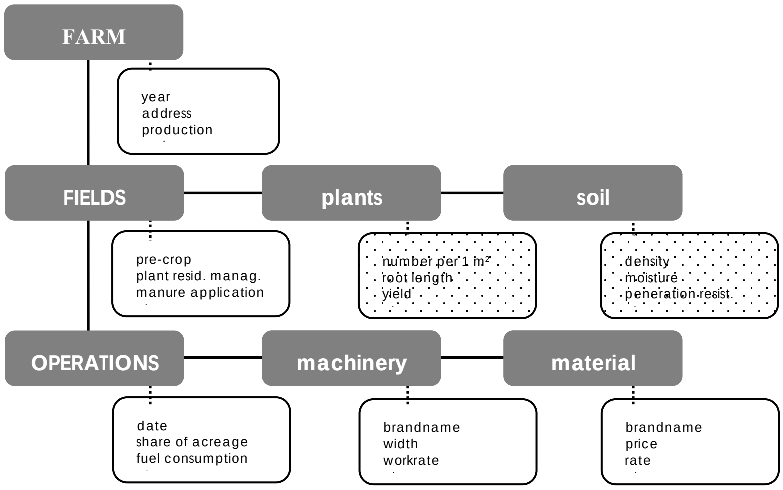

Figure 1 – Chart describing the structure of field-trial data (items in dotted boxes are gained by measurement)

Results and Discussion

Example of a model technology for conventional as well as reduced-tillage technology is shown in Table 1. Some farm businesses applied manure or slurry prior soil tillage. The latter one could be applied as well after plant emergence. In those cases, unit costs show progressive trend with respect to the organic fertilizer rate.

Within reduced-tillage technologies, the most common tillage technology comprised of two cultivations, or of two cultivations followed by a seedbed preparation in spring. Cultivation to medium depth of around 0.08 to 0.010 m accounted for half of the soil tillage operations. An operation of deeper soil loosening (chiselling) was applied on one third of the fields treated by reduced-tillage technology. Maize yield from those fields reached in average 12.5 % higher figures.

Within conventional technology, the most common process comprised one stubble cultivation, one ploughing and one ore two operations of seedbed preparation. Hereat, medium ploughing was the most frequent tillage operation. Compared to reduced-tillage technology, the share of soil tillage operations within conventional technology increased.

Table 1 – Basic model variants of field operations of conventional and reduced-tillage technologies monitored within the field trials

Field operation	Example of machinery and materials used
CONVENTIONAL TECHNOLOGY	
Stubble cultivation	JD-8200 + Horsch Phantom (6 m width)
Ploughing	Services: plough PHX 35
Mould clearing	JD-8200 + Horsch Phantom (6 m width)
Ferlilization	JD-6720 + Amazone (24 m width, carbamide 300 kg.ha^{-1})
Fertilizer treatment	JD-8200 + Horsch Phantom (6 m width)
Sowing	Services: accurate seeder Kinze (seed 60 kg.ha^{-1} + carbamide 30 kg.ha^{-1})
Spraying	Hardi Alpha Twin (30 m width, Guardian 2.5 l.ha^{-1} + Atranex 50 SC 1.5 l.ha^{-1})
Harvest	JD 2064 (six-row cornhead)
REDUCED-TILLAGE TECHNOLOGY	
Stubble cultivation	JD-8200 + Horsch Phantom (6 m width)
Cultivation	JD-8200 + Horsch Phantom (6 m width)
Ferlilization	JD-6720 + Amazone (24 m width, carbamide 300 kg.ha^{-1})
Fertilizer treatment	JD-8200 + Horsch Phantom (6 m width)
Sowing	Services: accurate seeder Kinze (seed 60 kg.ha^{-1} + carbamide 30 kg.ha^{-1})
Spraying	Hardi Alpha Twin (30 m width, Guardian 2.5 l.ha^{-1} + Atranex 50 SC 1.5 l.ha^{-1})
Harvest	JD 2064 (six-row cornhead)

Over the whole period of three years of trials, the average maize grain yield of all the thirty-five trial fields attained 8.52 $t.ha^{-1}$. Table 2 shows average maize grain yields according to the cultivation technology and year. In all the three years, reduced-tillage technology reached higher average yields than conventional one. When compared to the conventional technology, the average yield of reduced-tillage technology was higher by 8.2 % over the three years. Uneven location of trial fields into production areas might have adverse effect on the results reached by conventional technology. Corn production area demonstrated the highest average yield that surpassed 10 $t.ha^{-1}$, but within this area particularly reduced-tillage technology with new machinery of high workrate has been employed. Average grain yield varied in individual years, though the differences were only minor.

Table 3 present average fuel and labour consumption, material and machinery costs and total costs as the sum of both prior mentioned, and finally average costs per one ton of maize grain produced.

Higher fuel and labour consumption was noted at conventional technologies. Overall difference in fuel consumption over the three trial years was by 24.1 % lower for reduced-tillage technology. Even higher difference, i.e. 56.2 % in favour of reduced-tillage technology, could be noted within labour consumption. The differences' extent was influenced by field operations of ploughing done within conventional technology where there were as well organic fertilizers applied more often.

Concerning economic aspects, reduced-tillage technology demonstrated lower material and machinery costs, thus as well lower total costs. Over the monitored period of three years, the difference in favour of reduced-tillage technology proved to amount to 8.5 % for material costs, 10.2 % for machinery costs, and 9.4 % for total costs. Since reduced-tillage technology generally reached higher maize grain yield, the costs per one ton of grain produced by reduced-tillage technology was by 14.9 %, i.e. by 243 $CZK.t^{-1}$, lover compared to conventional one.

All the differences among variable averages in Table 2 and Table 3 were statistically tested with respect to cultivation technologies within each year, to cultivation technologies for all three years together, and finally with respect to the year of cultivation. The latter one, i.e. the year of cultivation, didn't prove to influence significantly any of the mentioned variables, not even the grain yield. Within individual years of cultivation, only labour consumptions of different cultivation technologies varied significantly, and they did so within each of the three years in question (probability level $p = 0.007882$ in the year 2004, $p = 0,000632$ in the year 2005, $p = 0.034244$ in the year 2006). Over the whole period of three years of trials, differences between averages of variables with respect to different cultivation technologies proved significant for fuel consumption ($p = 0.008912$), for labour consumption ($p = 0.0000000003$), for machinery costs ($p = 0.020860$), and for total costs ($p = 0.012028$).

Table 2 – Average maize grain yields of technologies in question within individual years and in total

Technology	Maize grain yield ($t.ha^{-1}$)			
	2004	2005	2006	2004-2005
Reduced-tillage	8.89	8.48	9.05	8.81
Conventional	8.20	7.93	8.28	8.14
TOTAL	8.59	8.24	8.72	8.52

Table 3 – Average values of fuel and labour consumption, of individual cost components and of costs per a unit of production, i.e. a ton of maize grain, according to cultivation technologies and years

Year and technology	Consumption			Costs ($CZK.ha^{-1}$)			Costs per production unit ($CZK.t^{-1}$)
	fuel ($l.ha^{-1}$)	labour ($hour.ha^{-1}$)		material	machinery	total	
YEAR 2004							
Reduced-tillage	75.8	3.65		5638	6358	11995	1398
Conventional	99.7	8.25		6233	6747	12980	1596
YEAR 2005							
Reduced-tillage	74.9	3.49		5580	6225	11805	1425
Conventional	98.6	8.05		6300	7073	13373	1716
YEAR 2006							
Reduced-tillage	73.5	3.41		5590	6114	11704	1328
Conventional	97.0	7.79		5840	6993	12833	1568
YEARS 2004-2006							
Reduced-tillage	74.7	3.52		5603	6232	11835	1384
Conventional	98.4	8.03		6124	6938	13062	1627
TOTAL	84.9	5.45		5826	6535	12361	1488

Conclusions

Within the conditions of the Czech Republic, field trials focused on maize grown for grain were carried out in the years 2004 to 2006. These trials proved that maize can be cultivated using conventional as well as reduced-tillage technology. Reduced-tillage technology attained good results regarding labour and fuel consumption as well as regarding material and machinery costs. Costs of one ton of maize grain, which is the key criterion of successful growing for any farm business, were by 14.9 % lower within reduced-tillage technology compared to conventional one. Both cultivation technologies reached high quality grain yield, but there are still substantial reserves with respect to genetically modified seed.

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YIELDS AND HARVEST LOSSES OF SUGAR-BEET VARIETIES IN THE YEARS 2005 AND 2006

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For several years already, field trials on harvest losses of various sugar-beet varieties have taken place in Agro Slatiny. Each year with approximately 35 sugar-beet varieties, the following items have been measured and calculated: biological yield, plant number per 1 m^2, sugar content of beets, real yield harvested by HOLMER Terra Dos, polarisation sugar yield, losses connected with not dug up beets and with beets left in the field and total losses. This paper discusses the results from the years 2005 and 2006. The development of weather in the year 2005 was favorable in terms of sugar beet growing. Soil penetration resistance in the harvest period was lower compared to the previous years, which resulted in low harvest losses ranging in general from 0.4 (Gyda)to 3 % (Solea) or 4.9 % (Attraction). The variety Robina attained the highest biological yield (122 $t.ha^{-1}$). The highest yield at 16% sugar content reached by mechanized harvest was produced by the variety Broncos (98.01 $t.ha^{-1}$). In the year 2006, sugar beet was sown three weeks later than usual. Further weather development during sugar-beet growing and harvest was again favorable, characterized by warm June and July and cold and wet August. Harvest losses ranged in general from 1.49 (Monza) to 5.64 % (Merak). The variety Imperial attained the highest biological yield (114 $t.ha^{-1}$). The highest yield at 16% sugar content reached by mechanized harvest was produced by the variety Antilla (90.87 $t.ha^{-1}$).

Keywords: sugar beet, variety, harvest losses, soil moisture, biological yield

Introduction

The field trials focused on harvest losses of various sugar beet varieties have been established in Agro Slatiny in the Czech Republic each year since 1994. Generally, more than 30 varieties are tested each year. Composition of the varieties changes from year to year considerably due to a high number of newly introduced ones. Mechanized harvest has been always done employing a six-row harvester by Holmer. In the year 2005, a new type of harvester, i.e. Holmer Terra Dos, was used for the first time. The field speed of the harvester thus increased to up to 9 to 10 $km.hour^{-1}$ according to soil moisture and sugar beet yield. For all the varieties, the following variables are measured or calculated: biological yield, plant number per 1 m^2, sugar content of beets, real yield harvested by HOLMER Terra Dos, polarisation sugar yield, losses connected with not dug up beets and with beets left in the field and total losses. Harvester bunker is emptied into tractor trailers during harvester's turns at both headlands. The trailers commute between a field and a disposal site where they are weighed prior emptying. During harvest in a field, harvest losses due to not-dug-up beets and due to beets left on the surface of a field are measured. The sum of the both of them returns total harvest losses. Further on, assessment of beets harvested mechanically is done with respect to quality of cutting, degree of beet damage and gross to net weight ratio.

Materials

All the varieties are sown, fertilized, sprayed and harvested in the same manner. A twelve-row drilling machine BECKER is used for sowing, a six-row sugar beet harvester Holmer Terra Dos is used for mechanized harvest. One variety takes most often a plot of 24-row width depending on the field size and shape. Individual plots are located side by side in the same field and growing technology is invariable for all the varieties within a year.

When evaluating harvest, biological yield of beets is measured first. In the same time, number of plants per 1 m^2 is measured as well. A rectangle of 10 m^2 is demarked. If there is a row spacing of 0.45 m, the rectangle takes six rows of 3.7 m length. Beets are dug up manually, then cleaned and counted, and beet leaves are cut off. Harvested beets and leaves are then weighed.

Evaluation of harvest losses, i.e. losses due to not-dug-up beets and due to beets left on the surface of a field, is carried out straight after the mechanized harvest. A rectangle of 10 m^2 is demarked again. Firstly, all beet material from the surface is collected, and then all beet remains are dug up from topsoil to the depth of 0.25 m. Both fractions are weighed and total losses enumerated as their sum. Measurements are repeated five times. Beet yield of mechanized harvest is determined by weighing the tractor trailers. Values found are converted to weight units per one hectare. Additionally, measurements of soil moisture and soil penetration resistance are done.

When evaluating sugar beet variety results, it is important to take into account not only beet yields (BY), but as well sugar content (SC). Beet yield converted at 16% sugar content (CBY, see Eq. (1)) covers both above mentioned outputs and thus gives better possibility for comparing varieties. Moreover, higher sugar content requires less material handling relatively to sugar gained.

$$CBY = \frac{BY \cdot (SC - 3)}{13} \left[t \cdot ha^{-1}\right] \qquad (1)$$

Results and Discussion

Harvest Conditions in the Years 2005 and 2006

Harvest conditions, e.g. soil moisture, soil compaction, belongs to the key factors influencing the extent of harvest losses. Therefore, the above mentioned variables are measured each year and Table 1 shows their values. During harvest in both years in question, soil moisture reached optimum values, and in general, harvest losses proved to be very low, particularly in the year 2005. The field speed of the harvester Holmer Terra Dos reached to up to 9 to 10 km.hour^{-1} in both years in question.

Harvest Yields in the years 2005 and 2006

Table 2 and Fig. 1 show that the best results of the year 2005 in terms of mechanized harvest yield combined with sugar content were reached by the varieties Broncos and Casata. From the same point of view, i.e. from the point of view of converted beet yield, the varieties Riposte and Solea proved the worst. The relative differences between manual and mechanized harvest yields of the successful varieties Broncos (20.7 %) and Casata (15.5 %) were lower than the average, i.e. than 25.29 %. On the other hand with Riposte and Solea varieties, the differences between manual and mechanized beet yields were the highest, i.e. 46.5 % respectively 50.4 %. Even some of the successful varieties such as Eureka or Robina demonstrated high differences, thus showing good potential for mechanized harvest improvement.

Generally, the bigger the difference between manual and mechanized harvest, the less suitable a variety is for mechanized harvest by a beet harvester. Number of plants per 1 m^2 may be one of the factors influencing the extent of the difference, since longer distance between plants in a row may have adverse impact on the work of cutting and lifting mechanisms. This may be the case of for example Solea and Robina varieties. In the year 2005 in Agro Slatiny, the average sugar content in beet reached the highest value 18.54 % occurred since the beginning of trials in the year 1994.

Table 1 – Soil moisture and soil penetration resistance in a sugar beet row prior harvest in the years 2005 and 2006

Measurement Depth [m]	Soil Specific Moisture [%]		Soil Penetration Resistance [MPa]	
	2005	2006	2005	2006
< 0.20	19,8	19,3	1,6-3,5	1,4-4,2
> 0.30	20,1	19,9	5,3-6,8	5,7-7,6

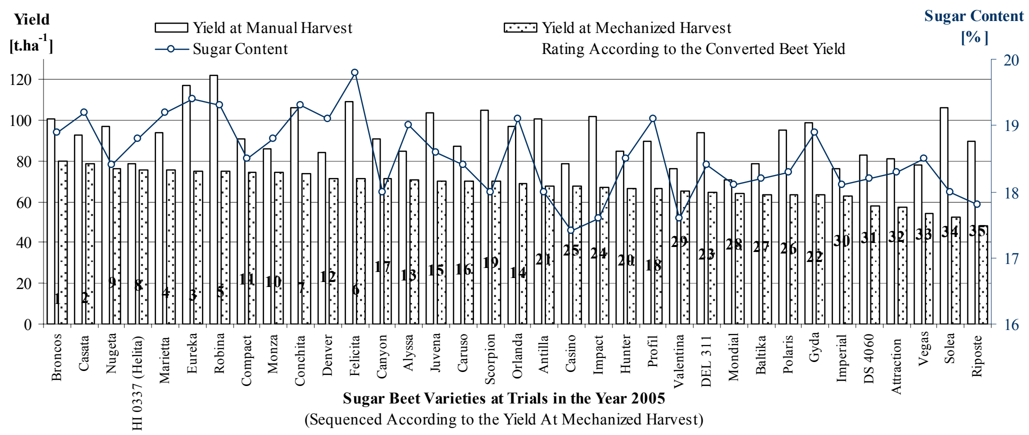

Fig. 1 – Graph of sugar beet yields at manual and mechanized harvest, and sugar content in the year 2005

Table 2 – Yields and other indicators of sugar beet variety trials of manual and mechanized harvest in the year 2005

Variety	Plant Number $[10^3.ha^{-1}]$	Manual Harvest		Mechanized Harvest				Rating According to Converted Beet Yield
		Beet Yield $[t.ha^{-1}]$	Beet Leave Yield $[t.ha^{-1}]$	Beet Yield $[t.ha^{-1}]$	Sugar Conten t [%]	Polarized Sugar Yield $[t.ha^{-1}]$	Converted Beet Yield* $[t.ha^{-1}]$	
Alyssa	87	85	44	70.66	19.0	13.43	86.97	13
Antilla	87	101	43	67.86	18.0	12.21	78.30	21
Attractio n	80	81	36	57.66	18.3	10.55	67.86	32
Baltika	82	79	58	63.58	18.2	11.57	74.34	27
Broncos	100	101	38	80.13	18.9	15.14	98.01	1
Canyon	92	91	44	71.20	18.0	12.82	82.15	17
Caruso	88	87	28	70.00	18.4	12.88	82.92	16
Casata	98	93	45	78.57	19.2	15.09	97.91	2
Casino	78	79	42	67.74	17.4	11.79	75.04	25
Compact	80	91	37	74.61	18.5	13.80	88.96	11
Conchita	85	106	48	73.63	19.3	14.21	92.32	7
DEL 311	83	94	44	64.80	18.4	11.92	76.76	23
Denver	97	84	28	71.58	19.1	13.67	88.65	12
DS 4060	73	83	41	58.28	18.2	10.61	68.14	31
Eureka	90	117	47	75.36	19.4	14.62	95.07	3
Felicita	93	109	58	71.53	19.8	14.16	92.44	6
Gyda	90	99	54	63.19	18.9	11.94	77.29	22
HI 0337	96	79	44	75.96	18.8	14.28	92.32	8
Hunter	84	85	47	66.43	18.5	12.29	79.21	20
Impact	92	102	51	67.04	17.6	11.80	75.29	24
Imperial	77	76	40	62.94	18.1	11.39	73.11	30
Juvena	80	104	38	70.22	18.6	13.06	84.26	15
Marietta	97	94	41	75.66	19.2	14.53	94.28	4
Mondial	85	71	32	63.91	18.1	11.57	74.23	28
Monza	84	86	42	74.32	18.8	13.97	90.33	10
Nugeta	89	97	34	76.40	18.4	14.06	90.50	9
Orlanda	84	97	63	68.96	19.1	13.17	85.40	14
Polaris	96	95	53	63.26	18.3	11.58	74.45	26
Profil	86	90	40	66.28	19.1	12.66	82.09	18
Riposte	91	90	43	48.19	17.8	8.58	54.86	35
Robina	79	122	43	75.13	19.3	14.50	94.20	5
Scorpion	93	105	35	69.96	18.0	12.59	80.72	19
Solea	69	106	53	52.56	18.0	9.46	60.65	34
Valentina	83	76	46	65.19	17.6	11.47	73.21	29
Vegas	74	78	26	54.55	18.5	10.09	65.04	33
Average	**86.28**	**92.37**	**43.03**	**67.92**	**18.54**	**12.61**	**81.35**	

Note: * Beet Yield Converted at 16% Sugar Content (Eq. (1))

In the following year 2006 (Table 3 and Fig. 2) in terms of converted beet yield, Antilla and Python varieties attained the best results. Though Nancy variety produced the highest beet yield harvested by Holmer harvester, due to its low sugar content it ended merely forth. On the other hand, Julietta and Tanisha varieties showed the lowest results in this respect. The relative differences in beet yields between manual and mechanized harvest proved for the successful varieties Antilla (21.0 %) and Python (18.7 %) slightly below the average 21.7 %. Generally, the differences between manual and mechanized harvest yields of successful varieties ranged below or around the average one, whereas varieties having showed worst results demonstrated as well higher than average differences.

Table 3 – Yields and other indicators of sugar beet variety trials of manual and mechanized harvest in the year 2006

Variety	Plant Number [$10^3.ha^{-1}$]	Manual Harvest		Mechanized Harvest				Rating According to Converted Beet Yield
		Beet Yield [$t.ha^{-1}$]	Beet Leave Yield [$t.ha^{-1}$]	Beet Yield [$t.ha^{-1}$]	Sugar Content [%]	Polarized Sugar Yield [$t.ha^{-1}$]	Converted Beet Yield* [$t.ha^{-1}$]	
Antilla	104	106	55	83.78	17.1	14.33	90.87	1
Attraction	81	98	57	66.82	17.5	11.69	74.53	27
Baltika	100	92	35	71.51	17.2	12.30	78.11	23
Broncos	102	97	32	76.30	18.0	13.73	88.04	3
Canyon	96	84	31	70.30	17.7	12.44	79.49	20
Caruso	105	101	43	72.30	17.0	12.29	77.86	24
Casata	95	98	46	73.17	17.3	12.66	80.49	18
Casino	101	91	47	73.17	18.0	13.17	84.43	6
Compact	99	96	57	70.73	16.4	11.60	72.91	31
DEL 419	99	102	48	73.95	17.2	12.72	80.78	15
DEL 526	98	83	34	69.95	16.9	11.82	74.79	26
Esperanza	96	95	59	73.95	17.4	12.87	81.91	11
Felicita	108	85	57	62.99	17.9	11.28	72.20	33
Gyda	102	102	50	67.51	17.8	12.02	76.86	25
Harietta	89	102	47	68.90	16.8	11.58	73.14	29
HI 0337	96	83	40	72.65	17.5	12.71	81.03	14
Impact	100	82	43	73.17	18.2	13.32	85.55	5
Imperial	91	114	62	72.38	16.1	11.65	72.94	30
Julietta	97	95	37	65.86	16.8	11.06	69.91	35
Lucata	102	86	35	75.30	17.5	13.18	83.99	7
Merak	101	96	41	71.86	17.9	12.86	82.36	8
Mondial	77	92	51	76.73	16.6	12.74	80.27	19
Monza	99	98	51	71.82	17.6	12.64	80.66	16
Nancy	98	85	49	83.95	16.4	13.77	86.53	4
Nugeta	97	92	51	70.73	17.5	12.38	78.89	21
Pingus	94	94	41	73.17	17.0	12.44	78.80	22
Pohoda	94	86	39	71.76	17.6	12.63	80.59	17
Polaris	90	80	46	65.08	17.5	11.39	72.59	32
Protecta	96	78	37	68.30	17.1	11.68	74.08	28
Python	104	100	38	81.35	17.1	13.91	88.23	2
Scorpion	96	102	41	73.95	17.3	12.79	81.35	13
Tanisha	92	79	40	65.34	17.1	11.17	70.87	34
Valentina	96	103	42	77.52	16.8	13.02	82.29	9
Vantura	100	92	44	74.47	17.3	12.88	81.92	10
Viktor	95	89	37	70.73	18.0	12.73	81.61	12
Average	**96.86**	**92.95**	**44.42**	**72.33**	**17.29**	**12.50**	**79.45**	

Note: * Beet Yield Converted at 16% Sugar Content (Eq. (1))

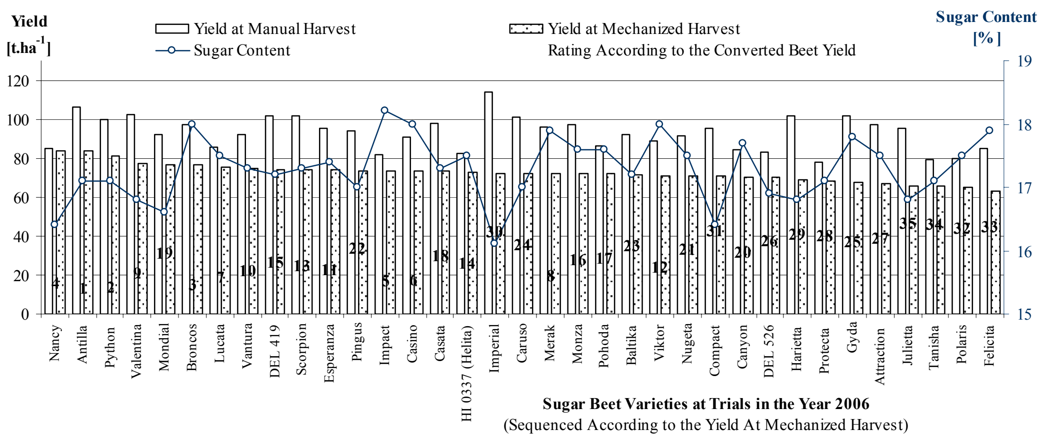

Fig. 2 – Graph of sugar beet yields at manual and mechanized harvest, and sugar content in the year 2006

Table 4 – Harvest losses of sugar beet variety trials in the years 2005 and 2006

Year 2005						Year 2006				
Variety	Harvest Losses [%]			Rating by Total Harvest Losses		Variety	Harvest Losses [%]			Rating by Total Harvest Losses
	Not Dug up Beets	Beets Left on the Surface	Total				Not Dug up Beets	Beets Left on the Surface	Total	
Alyssa	0.15	0.50	0.65	5-9		Antilla	2.86	0.33	3.19	15-16
Antilla	0.25	0.65	0.90	16-17		Attraction	3.14	1.32	4.46	30
Attraction	2.85	2.05	4.90	35		Baltika	2.34	0.59	2.93	13
Baltika	0.20	0.55	0.75	12		Broncos	3.28	0.63	3.91	23
Broncos	0.30	0.35	0.65	5-9		Canyon	2.70	0.10	2.80	11
Canyon	1.70	0.60	2.30	31		Caruso	3.80	0.41	4.21	27
Caruso	0.10	0.60	0.70	10-11		Casata	2.19	0.66	2.85	12
Casata	0.20	0.80	1.00	18		Casino	1.50	0.41	1.91	4
Casino	0.95	0.25	1.20	20-21		Compact	1.63	0.20	1.83	3
Compact	0.60	0.25	0.85	15		DEL 419	2.60	0.77	3.37	17
Conchita	0.20	0.60	0.80	13-14		DEL 526	4.62	0.61	5.23	34
DEL 311	1.15	0.70	1.85	28		Esperanza	1.89	0.23	2.12	6
Denver	1.25	0.30	1.55	26		Felicita	3.49	0.32	3.81	21
DS 4060	0.90	1.00	1.90	29		Gyda	2.37	0.37	2.74	10
Eureka	2.00	0.70	2.70	33		Harietta	1.16	0.44	1.60	2
Felicita	0.00	0.70	0.70	10-11		HI 0337	3.17	0.26	3.43	18
Gyda	0.25	0.15	0.40	1		Impact	2.12	0.57	2.69	8
HI 0337	0.70	0.50	1.20	20-21		Imperial	3.45	0.97	4.42	29
Hunter	1.55	0.70	2.25	30		Julietta	4.28	0.88	5.16	33
Impact	0.35	0.15	0.50	3-4		Lucata	1.86	0.20	2.06	5
Imperial	0.15	0.50	0.65	5-9		Merak	4.87	0.77	5.64	35
Juvena	0.10	0.55	0.65	5-9		Mondial	2.80	0.39	3.19	15-16
Marietta	0.30	0.75	1.05	19		Monza	1.00	0.49	1.49	1
Mondial	0.50	0.90	1.40	23-25		Nancy	3.28	0.36	3.64	20
Monza	1.00	0.75	1.75	27		Nugeta	2.12	0.17	2.29	7
Nugeta	0.40	0.10	0.50	3-4		Pingus	3.55	0.55	4.10	24
Orlanda	0.45	0.95	1.40	23-25		Pohoda	2.44	0.53	2.97	14
Polaris	1.75	0.60	2.35	32		Polaris	4.00	0.26	4.26	28
Profil	0.05	1.25	1.30	22		Protecta	1.83	0.88	2.71	9
Riposte	0.25	0.40	0.65	5-9		Python	4.30	0.34	4.64	31
Robina	0.10	0.35	0.45	2		Scorpion	3.45	0.38	3.83	22
Skorpion	0.10	0.80	0.90	16-17		Tanisha	4.29	0.77	5.06	32
Solea	2.55	0.45	3.00	34		Valentina	3.48	0.64	4.12	26
Valentina	0.55	0.25	0.80	13-14		Vantura	3.75	0.36	4.11	25
Vegas	0.40	1.00	1.40	23-25		Viktor	3.07	0.54	3.61	19
Average	**0.69**	**0.62**	**1.31**				**2.93**	**0.51**	**3.44**	

Harvest Losses in the years 2005 and 2006

Table 4 shows harvest losses in the years 2005 and 2006. For all the varieties, particularly in the year 2005, the harvest losses were low compared to previous years of trials [Šařec, O, Šařec, P., 2004]. Favourable soil moisture enabled the beet harvester to work at a high field speed of 9 to 10 km.hour^{-1}. This resulted in beet harvester's higher workrate and lower fuel consumption than in the previous years. Average total harvest losses, i.e. sum of losses incurred due to not-dug-up beets and beets left on the surface of the field, were 1.31 % in the year 2005 and 3.44 % in the year 2006. In the year 2005, Gyda (0,40 %) and Robina 0.45 %) attained the lowest total losses, whereas Attraction (4.90 %) and Solea (3.00) demonstrated the highest ones. In the year 2006, Monza (1.49 %) and Harietta (1.60 %) total losses were the lowest ones, and Merak (5.64 %) and DEL 526 (5.23 %) on the opposite the highest ones.

Conclusions

In both years in question, i.e. 2005 and 2006, weather conditions for sugar beet growing and harvest were advantageous at Agro Slatiny. In the year 2005, the attained average sugar content in beets was exceptionally high (18.54 %). Therefore though the average beet yield gained by mechanized harvest was lower in the year 2005 (67.92 t.ha^{-1}) than in the year 2006 (72.33 t.ha^{-1}), average beet yield converted at 16% sugar content was on the other hand higher in the year 2005 (81.35 t.ha^{-1}) than in the year 2006 (79.45 t.ha^{-1}). Ratings of individual varieties are stated in tables

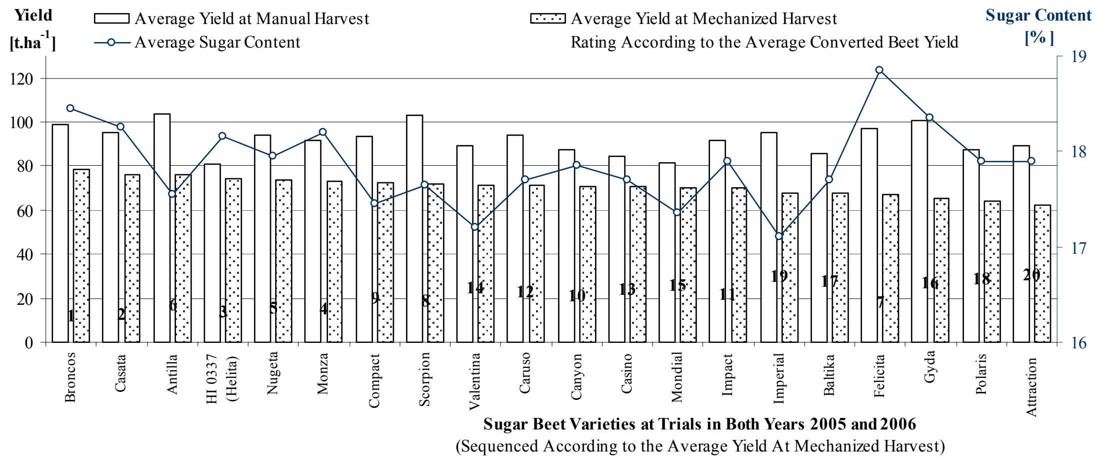

Fig. 3 – Graph of sugar beet yields at manual and mechanized harvest, and sugar content for the varieties having occurred in both years 2005 and 2006

and figures above. There were 20 out of 35 varieties each year that were tested repeatedly in both years in question (Fig. 3). Broncos and Casata varieties proved best results in terms of yield and sugar content in both years in question, i.e. attained converted beet yield of 93.02 t.ha^{-1}, respectively 89.20 t.ha^{-1}. Average converted beet yields of Attraction (71.20 t.ha^{-1}), Imperial (73.02 t.ha^{-1}) or Polaris (73.52 t.ha^{-1}) varieties were on the other hand the lowest. There was no apparent relation disclosed between the differences between yields gained by manual and mechanized harvest of individual varieties on one side and the ratings of individual varieties from the view of converted beet yield on the other.

In the years 2005 and 2006, harvest conditions were favourable, particularly in terms of soil moisture. Total harvest losses were therefore relatively low and ranged from 0.40 % (Gyda) to 4.90 % (Attraction) in the year 2005 and from 1.49 (Monza) % to 5.64 % (Merak) in the year 2006. In suitable harvest conditions and with quality harvest machinery, it is possible to attain low harvest losses, and reduce fuel and labor consumption as well.

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MATHEMATICAL MODEL FOR TRANSPORTING SUGAR BEET ROOTS TO SUGAR FACTORY

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The aim of the paper is to propose a model for transporting sugar beet roots from a post-harvest storage to a sugar factory during the period of sugar campaign. Within the up-to-date technology of sugar beet harvest, roots are transported to the factory only after being cleaned in the grower's field. The model includes therefore a cleaner-loader that will have to be moved only in a minimal degree. Moreover, it was assumed that daily delivery of roots must correspond with a 24-hour demand of the sugar factory. The proposed model can be used for creating the plan of delivery of the beet from the storage sites to the sugar factory during the campaign. Then over time, the model already used many times will encompass a smaller and smaller set of storage sites. In the initial period of the campaign, there is a considerable possibility of choosing the storage sites where the total beet mass will equal the daily processing amount. However, it is possible that the set of solutions is be very poor or single, which implicates little possibility of making the length of the route of the cleaner-loader minimal.

Keywords**:** sugar beet, transport, cleaner-loader, sugar factory

List of important symbols

- x_i taking into consideration the given storage site in order to estimate the optimal route of a daily drive (value 1 or 0)
- t_i reciprocal distances between the storage sites (km)
- u_{ii} the time of loading of beet on transporting machines (min)
- m_i the time of drive of a cleaner-loader between storage sites (min)
- c_{ii} the mass of beet located in a pile (t)
- A the value of a daily demand for beet (t)
- B the acceptable value of deficiency /excess of beet when compared to the daily demand

Introduction

Beet dug out during good weather conditions consist, depending on the cleaning unit of the combine, of 5-8 % of soil and by high soil humidity – even a dozen or so percent. There is no point in transporting dirty roots to the sugar factory. Therefore, when organizing the harvest and carriage of the roots one should consider a several-day or even longer storage of the beet in piles in the place of gathering. The beet can be cleaned and loaded on the lorries with the help of special cleaner-loaders, only after drying.

There are two types of cleaner-loaders: attached and self-propelled ones. The first ones are temporarily pulled by a tractor as the number of beet in the pile decreases. Such machines need loaders for proper loading. The second ones have their own loading unit. According to the producers, the cleaner-loaders produced by Ropa, type Euro-Maus and Kleine, type SF-200, work with the efficiency of 200 $t.hour^{-1}$. It enables loading of a vehicle with the capacity of 25 tons, in 5-8 min. The self-propelled cleaner-loader produced by Gebo, Kleine and Thyregod work with the efficiency of 140-160 $t.hour^{-1}$.

Using cleaner-loaders enables transporting beet to factories with lorries with large load capacity (18-25 tons), carrying the material in a given time, without cleaning and if it's possible, without storing the roots on a square. Such transportation simplifies the process of taking the delivery on in the factories, due to e.g. a smaller number of weighing activities, taking samples and chemical analyses. Moreover, transporting clean roots reduced the costs of transportation and the process of sugar production. Moreover, the farmer does not dispose of rich soil.

Using efficient and expensive cleaner-loader requires such transport logistics that will fully make use of their efficiency and will imply daily deliveries of the beet to the loader and lorries, taking into account the mass of beet gathered in individual piles and the length of routes leading to the storage sites.

Aim and Materials

The aim of this study is to work out a model for transporting sugar beet roots from the after-harvest storage to a sugar factory. This encompasses the period of sugar campaign. Due to the fact that in the present day technology of sugar beet harvest, roots are transported to the factory only after cleaning them on the grower's field, it was assumed that there is a need for a cleaner-loader that will have to be moved only in a minimal degree. Moreover, it was assumed that daily delivery of roots must correspond with a 24-hour demand of the sugar factory.

Results and Discussion

Let's examine a case where we have the following technical equipment:

- lorries for carrying the roots from the place of gathering to the place of processing in the sugar factory;
- cleaner-loaders that eliminate excessive impurity of the beet in the place of storage and load the roots onto the lorries which are to carry the beet during the campaign;
- the given p- number – the number of places of deploying of the beet in a certain spacious – territorial layout.

These places are situated nearby roads. At the same time, technical abilities of the factory to take on a certain amount of beet are also known.

We are only interested in such technical organization that will enable everyday carriage of the given amount of beet to the reception point in the factory. We assume that engaging the stuff, giving it's structure and the range of duties are a separate case which do not belong to this study.

In reality, there is usually unlimited access to means of transport, i.e. lorries, within the process of sugar beet carriage. Due to this fact, it is important to estimate the demand for such vehicles. To make our discussion easier we assume that the means of transport are of one type. In dynamic planning, which is the subject of the study, the demand for the means of transport differs every day and between various beet carriage plans. This results from the fact that the number of means of transport stands for the derivative of the efficiency of cleaner-loader and the distance between the beet gathering sites and the factory. The lorries cover the distance between the gathering sites and the factory. Assuming the lorries are fully loaded in each and every gathering site ant the optimal traffic net between the two points is known, the costs of the transportation may be referred to as constant.

Every cleaner-loader due to some technical-utilization reasons moves within the whole campaign only between the gathering sites. In each of them it does all the activities in a certain inseparable period of time. This actually means that it can be characterized with a sequence of names of gathering sites, between which it moves during the campaign. The number of possible sequence equals p!. It means that it is important to estimate the optimal order of gathering sites. Without any harm for the whole study, we can consider a situation where we use only machine for cleaning and loading the beet.

Let's examine therefore a case where we look for such cleaner-loader working organization during the whole beet campaign, which will enable minimal movement of the machine. Simultaneously it is necessary to find the order of the distance between certain gathering sites out of the total p of existing gathering sites, which must be reached by a cleaner-loader during the campaign.

Let's assume that we known the following tables: X = … and C = … standing respectively for: taking into consideration – 1 (not – 0) of the given gathering site in order to find the optimal route of a daily drive; reciprocal distances (in km) between these gathering sites, the time of loading the beets on the transporting vehicles (in min), the time of the drive of cleaner-loader between the gathering sites (in min), the mass of beet measured in the gathering site (in tones) and the figures of balance variables in the system of limitations of model, where i = 1, 2 …, p.

Moreover, we must introduce some symbols: A – the value of daily demand for beet (it tones) for the processing in factory; B – acceptable value of deficiency/excess of beet (in tones) in ratio with the daily demand for beet; q (y, z) – permutation of components of vector Y= (y_k), where k = 1, … v; z – the number of kilometers covered by the cleaner-loader for the given permutation of gathering points.

The mathematical model, which is to solve our case, can be written down in three commonly accepted parts: the objective function OF, constraint_conditions CC and boundary conditions BC. Decisive variables are the elements of vector X, which amount for 0 or 1. In turn, this model belongs to the type of full-number models. The character of reciprocal reactions of decisive variables cause that the mathematical model can be further on classified as a full-number non-linear one [Garfinkiel, Nemhauser 1978; Grabowski 1980, Seidler et al. 1980:]. The specified versions of the subsequent parts of the model are depicted by the following forms:

$$OF:\begin{cases}\sum_{i=1}^{p-1}\sum_{j=i+1}^{p} c_{ij}x_i x_j & \text{(min)}\\ q(y,\sum_{k=1}^{v-1} dy_k, y_{k+1}) & \text{(min)}\end{cases} \tag{1}$$

The function of aim (Eq. (1)) is a lexicographical one, characterized by two criteria. The first of theme makes the sum of the first p(p-1)/2 balance variables of the model solution minimal. In consequence, for the optimal solution we chose the decisive variables, corresponding with the beet gathering sites, of which the sum of reciprocal distance is the smallest. The second criterion estimates such permutation of gathering sites in the set of permutations of gathering sites, existing in the optimal solution of the first criterion, that makes the number of kilometers covered by cleaner-loader in a given work day, minimal. The elements of vector Y stand for the numbers of the gathering sites, whereas the corresponding vector X elements make the first criterion minimal and amount for 1.

The system of limiting conditions looks like as follows:

$$CC: \begin{cases} x_i x_j d_{ij} \le d_{ij} \quad (i=1,2,\dots,p-1; j=i+1,\dots,p) & c1,\dots,c\dfrac{p(p-1)}{2} \\ \sum_{i=1}^{p} m_i x_i \ge A-B & c\dfrac{p(p-1)}{2}+1 \\ \sum_{i=1}^{p} m_i x_i \le A-B & c\dfrac{p(p-1)}{2}+2 \\ \sum_{i=1}^{p} t_i x_i + \sum_{i=1}^{p-1}\sum_{j=i+1}^{p} u_{ij} x_i x_j \le 1440 & c\dfrac{p(p-1)}{2}+3 \end{cases} \qquad (2)$$

The right side of the CC- relation (Eq. (2)) gives the symbols of balance variables, which turns the inequalities into equalities in the model.

The first system p(p-1)/2 of conditions depicts the distances between any two beet gathering sites. The next two conditions depict minimal (respectively maximal) delivery of sugar beet to processing sites, in accordance with the assumed daily processing and acceptable deviation of the size of the deliveries. The last condition imposes the time of delivery realization within 24 hours, allowing for earlier completion than exactly 24 hours after starting the work.

In most of the practical cases, just as this time, we form a natural condition on the present tables that their elements cannot have negative values, which is depicted as follows:

$$BC: \quad m \ge 0, t \ge 0, u \ge 0, c \ge 0, d \ge 0, x \ge 0 \qquad (3)$$

It should be noticed that the vector of solution stays binary, where the value: 1 stands for the gathering site considered in a given day to estimate to movement of the cleaner-loader and the value: 0 for all the remaining sites.

It is obvious that the solution we obtained on the basis of this model is useful on condition that the balance variables of two middle CC (Eq. (2)) do not deny simultaneous fulfilling of these conditions. Otherwise it would be necessary to introduce in the CC system a limitation depicting reciprocal relation between the balance variables of middle two CC.

It is also noticeable that so presented mathematical model is a non-linear one. In turn, the algorithm of the solution must base on gradient methods within the non-linear full-number programming.

Conclusions

The presented model can be used for creating the plan of delivery of the beet from the storage sites to the sugar factory during the campaign. Then, the model used many times will with time encompass a smaller and smaller set of storage sites.

Discussing this model we can state that when using this model in planning the movement of a cleaner-loader in the initial period of the campaign it is possible to take the B parameter equaling zero. It is owing to the fact that there is such a possibility of choosing the storage sites where the total mass beet will equal the daily processing amount. However, it is possible eleven that the set of solutions will be very poor or single, which implicates little influence on making the length of the route of the cleaner-loader minimal.

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ASSESSMENT OF WORK QUALITY AND ENERGY INPUT OF COMBINED CHISEL TILLER

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For the machine set of tractor CASE 7250 with combined chisel tiller CASE III. Ecolo-Tiger 530B we have assessed diesel fuel consumption in dependence on adjusted cultivation depth in the half-operational trial on plot with long-time shallow soil tillage. The cross surface and bottom profiles of cultivated soil layer by profilograph were assessed as a work quality indicator as well as reached soil roughness. The data on diesel consumption from employed flow-rate meter EDM 1404.02 were electronically recorded together with those from receiver GPS by the geographic coordinates, instantaneous working speed and time. The acquired data were processed in the program products GIS TopoL and Statgraphics. For the adjusted cultivation depth in range from 150 to 250 mm the average depth of processed soil profile from 59 to 169 mm was found. The diesel consumption per 1 hectare in dependence on average depth of soil processed profile have had a linear model of function y = 0,046x + 4.73, where x - average depth of soil processed profile.

Introduction

Recently in the processes of soil tillage with zero ploughing is still more and more utilized the periodical soil loosening by the chisel tillers to depth comparable with ploughing or up to 0.4 m without earth lifting to the soil surface. The reason for introduction of that operation is occurrence of compacted soil layer under the regular shallow loosening depth in the minimization technologies. Results of the deeper soil tillage with zero ploughing show suitability of gradual loosening into the increasing depth performed in some other working operation. It may be assumed that the combined chisel tiller chosen for work and energy consumption evaluation can be used for medium deep soil loosening connected with the soil surface adaptation. This was a reason for choosing that tiller of new generation for measurement and evaluation.

Conditions of effective compacted layer loosening in the soil profile are determined by Lhotsky (2000). It regards mainly the need to respect boundary of suitable soil moisture for appropriate soil type. The deeper loosening has a character of improving measure and the soil protection against unfavourable soil profile compaction must be still kept in mind (Arshad 1999, Sommer 1997).

Materials and methods

Evaluation of work quality indicators was carried out for the combined tiller CASE Ecolo-tiger 530B with working width of 4 m during the tillage after rapeseed harvest. This tiller consists of some sections with various working organs for gradual soil tillage. The first section consists of disc harrows serving for primary soil surface breaking and crop residua dislocation. Tillage depth of that first section ranges between 80-120 mm. Other section consists of two rows of chisel bodies for deeper soil tillage. The first row consists of four chisels and the second one of five arrow-shaped chisels. The first row of chisels operates to depth of 150-200 mm, the second row is set up to final processing depth of 200-300 mm. Other section consists of the discs for soil surface levelling after the chisel blades loosening. The final section consists of the three rows of bar harrows for ultimate surface levelling and crop residua dislocation.

For the combined tiller determined for gradual deep soil tillage the three set up depths of 150, 200 and 250 mm were evaluated. The set with determined tillage depth has performed four mutually connected travels. Evaluated were: crop residua amount on the soil surface and in tilled layer, cross profile of both surface and bottom of tilled soil surface, real depth of soil tillage with respect to the set up depth, soil surface roughness and fuel consumption. All the measurements were implemented immediately after the relevant working operations. The soil samples were taken off for purpose of soil basic physical properties specification.

The method of machines operation monitoring developed at the Research Institute of Agricultural Engineering (Kovaříček, Hůla 2003) was used to data recording for the machines utilization during their operational exploitation in the agricultural enterprise and to find out the motor diesel consumption. For data recording the registration device with microcomputer was used. This system has allowed to record the geographical coordinates, working speed and time from the GPS receiver with built in GSM module for data sending and recording device function set up. Besides the GPS data further is recorded the diesel consumption. The resource of coordinates, time and instantaneous working speed data was the GPS 35-PC Garmin device. The diesel consumption was measured by the flow meter with the circulating piston EDM 1404.02 Kienzle with output of 322 pulses per 1 l of diesel. The data are stored in normal text format and after their transfer to the table computer are statistically and graphically processed in GIS (Geographical Information System).

For the surface cross profile and soil layer bottom measurement the laser profilograph was used. Its scanning length is 2 m with 200 scanning points and a pitch of 20 mm. The scanning sensor height above the measured surface is recorded in the memory medium. The digital record allows the mathematical and graphical representation of the measured surface. The sensor height is gradually recorded in the vertical plane perpendicular to the machine travel direction and before and after the soil tillage as well as the tilled soil bottom layer after its outcrop. The distance between the travel route beginning and the profilograph cart with laser distance meter is measured by the measuring tape from the basic point stacked out for the measuring plane close to the tiller bed and the height of travel trajectory above the basic point is measured by means of the laser water level.

The soil surface roughness when measured by the profilograph can by expressed in form of the arithmetic mean of distance R_{zg} among the 5 highest peaks and 5 deepest roughness holes in the soil surface profile within the length of 1 m (Fig. 1 - Kovaříček 2005).

$$R_{zg} = \frac{(R_1 + R_3 + ... + R_9) - (R_2 + R_4 + ... + R_{10})}{5} \qquad [1]$$

Where: R_{zg} = soil surface roughness (mm)
R_1, R_3, R_5, R_7, R_9 ………. = height of 5 highest peaks within the soil profile length of 1 m (mm)
R_2, R_4, R_6, R_8, R_{10} ………. = height of 5 deepest holes within the soil profile length of 1 m (mm)

Results and discussion

On the plot of average declination 3-4° after winter rape harvest the values presented in table 1 were measured. For the 3 depths the values of volume weight, soil moisture and porosity were measured. The measurements were carried out on the plot with the soil granularity composition corresponding to sandy-clay and sandy soils. The long-time shallow soil tillage to depth of 150 mm can cause the negative soil surface compaction under the tilled layer. This is a reason for deeper tillage.

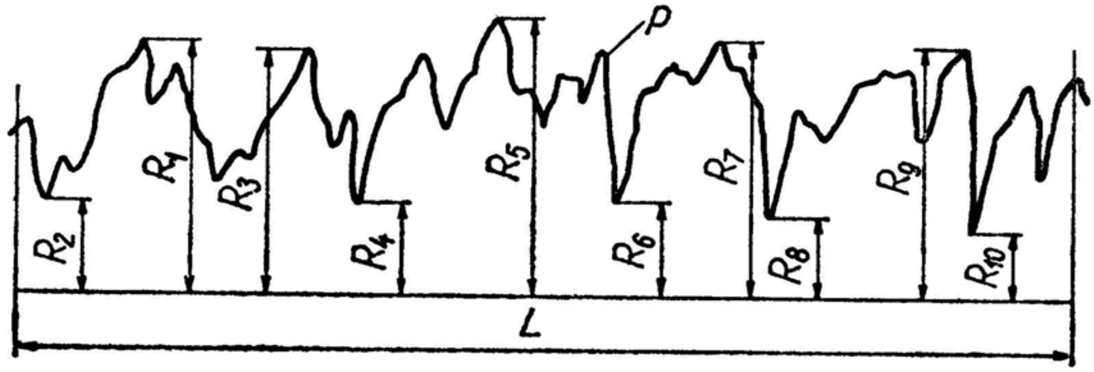

Fig. 1 Schema of graphical process for soil surface roughness determination

p = soil surface profile
L = measured section of soil surface within 1 m
R_{zmax} = soil surface roughness (mm)
R_1, R_3, R_5, R_7, R_9 ………. = height of 5 highest peaks within the soil profile length of 1 m (mm)
R_2, R_4, R_6, R_8, R_{10} ……… = height of 5 deepest holes within the soil profile length of 1 m (mm)

Table 1 Measured values of chosen soil physical properties before tillage

Variant	Depth	Volume weight red.	Moisture	Porosity
	[mm]	[g.cm^{-3}]	[% by vol.]	[% by vol.]
A	250-300	1.64	9.1	35.0
B	150-200	1.59	10.6	37.2
C	50-100	1.45	10.4	42.8

For the variant A with soil tillage depth of 250 mm was soil penetration resistance to depth of 440 mm (Fig. 2). The thick line represents the course before the soil tillage the thin line then represents the course after the soil tillage. The values were considered by average of 20 stabs. The course of the soil penetration resistance before the tillage is characterized by its growing in depth of 160 mm. After the deepening tillage (thin curve) the lower penetration resistance was found out in that depth what signalized the tilled layer breaking and loosening.

In the Fig. 3 is illustrated the output of the soil surface profile and soil tilled layer bottom for Variant A. The tiller set up depth is 250 mm. After the soil tillage its surface cross profile was measured. The solid line represents the soil surface average value. After the soil surface profiles measurement the tilled part of land was removed up to the hard non-tilled bottom. The bottom profile has ranged in depth from 100 to 245 mm for set up depth of soil tillage. For the soil tillage set up depth of 250 mm the average measured depth value was 169 mm.

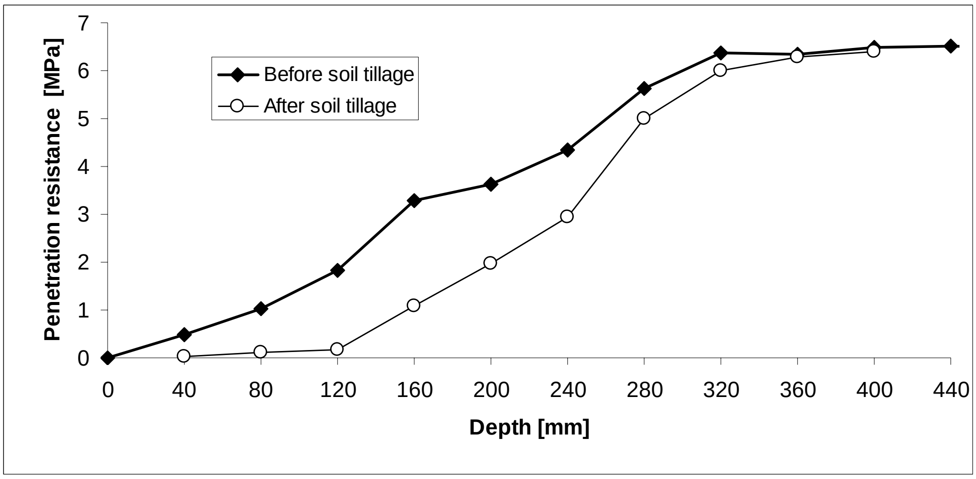

Fig. 2 Soil penetration resistance before and after soil tillage

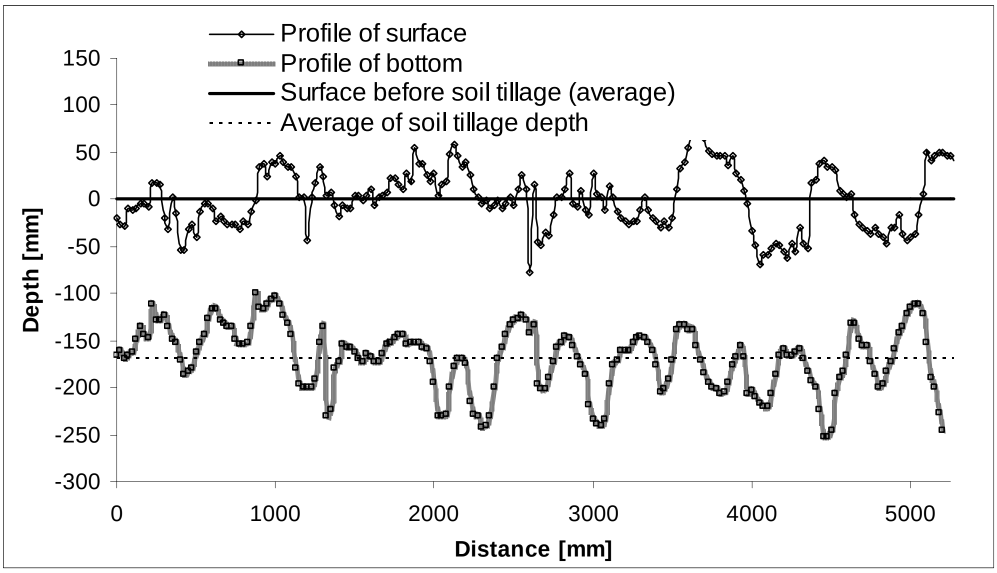

Fig. 3 Demonstration of surface profile and bottom of soil tilled layer for Variant A (250 mm)

The measured tillage depths are presented in table 2. Unlike the set up depths the measured average depths are significantly lower. From the Fig. 3 is evident that the chisel bodies with the deepest set up did not break the soil layer within the total profile width. In consequence to this fact there are created the non-tilled soil belts in the depth required. The average belt depth was by 10-30 mm lesser that the required set up depth. This conclusion is valid for the belts with the deepest loosening.

According to the equation [1] presented in this methodology the soil surface roughness was computed. Its value for Variant C was influenced by tillage small depth. The tilled soil layer has not been sufficient enough to allow the discs and bar harrows to level the surface. This has caused the unlevelled ditches behind the chisel bodies standards influencing the soil surface roughness value.

At depths of 250, 200 and 150 mm the instantaneous values of diesel consumption and working speeds (tab. 3) were recorded in interval of 5 s on stacked section in length of 150 m. For each depth on individual bed within 4 travels of tiller in both directions the area of 138 m x 14 m was tilled. During the measurement the machine construction working width of 4 m has not been maintained. In all the variants the working widths overlapped and real average working width of 3.6 m was reached. At depth of 250 mm the tractor CASE 7250 has operated with the 8th gear, in variants with lesser depth then with the 9th gear. This corresponds with the speed reached. The diesel unit consumption was processed statistically (Fig. 4). At depth of 250 mm the consumption was 12.58 $l.ha^{-1}$ and the highest variability reached. When expressed by the coefficient of variation the variability was 26 % (tab. 3), i.e. by one third more than at the least depth of 150 mm. Even though the loosening blades do not break the compacted soil layer at depth of 150 mm the diesel unit consumption per the loosened volume is by two thirds higher as compared with depth of 250 mm.

Table 2 Measured and computed values of soil tillage depth

Variant	Tillage set up depth	Measured tillage depth		Soil surface roughness
		Average	Highest	
	[mm]	[mm]	[mm]	[mm]
A	250	169	242	119.6
B	200	103	168	105.5
C	150	59	127	122.4

Table 3 Results of diesel consumption recording

Plot	Set up depth	Tillage average depth	Number of records	Average speed	Diesel consumption per 1 bed	Diesel unit consumption	Diesel unit consumption variability	Diesel unit consumption
	[mm]	[mm]		[$km.h^{-1}$]	[l]	[$l.ha^{-1}$]	[%]	[$l.ha^{-1}$]
A	250	169	54	7.2	2.404	12.58	26	0.0074
B	200	103	45	8.8	1.826	9.27	20	0.0090
C	150	59	43	9.1	1.431	7.31	18	0.0124

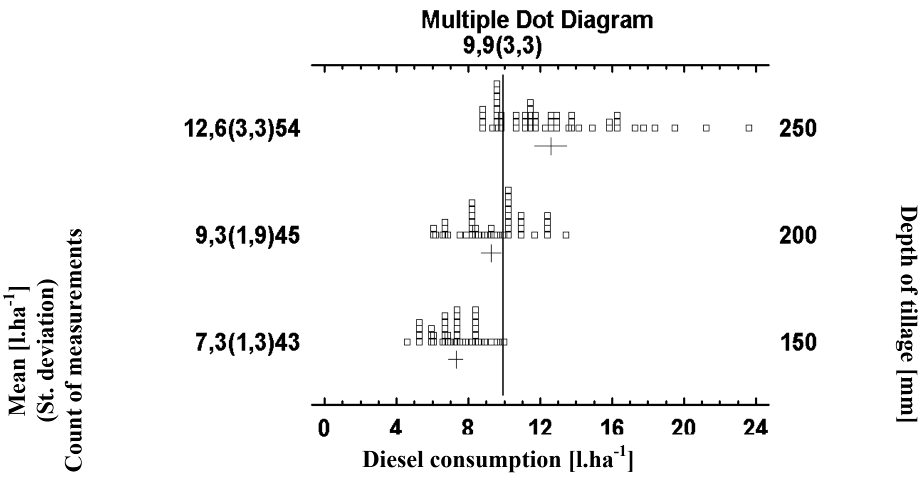

Fig. 4 Summary statistics of diesel consumption on depth of soil tillage

Conclusions

When evaluating the combined tiller work quality and energy consumption for the compacted soil layer breaking in the tillage process with zero ploughing the information was acquired usable for procedures suggestion with marks of technological compaction. The found soil compacted layer in depth of 160 mm was broken and tilled only at the set up depth of 250 mm, variant A. When evaluating the soil tiller depth and soil bottom tilled layer the difference between the set up and average soil tiller depth was found out-the reason is the bottom racking. The found average tillage depth was lower by 81-97 mm in comparison with the chisels set up depth. Even at the bigger depth the compacted layer was broken only within the narrow area of the chisel body.

Further the diesel consumption dependence on the set up soil tillage depth was proved. At the variant with the deepest chisels adjustment also the highest diesel average consumption of 12.6 $l.ha^{-1}$ was measured. The performed measurements have shown also necessity to keep the tillage depth as required.

The results were obtained by solution of the research programme MZE 0002703101 and research project 1G57042.

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INFLUENCE OF LOCAL CLIMATIC CONDITIONS ON THE EVAPORATIVE SYSTEM DESIGN IN STABLES

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Paper describes procedures during designing of evaporative cooling system for inner air cooling in stables under different climatic condition. There are described an effect of different device types and recommendation for its operation.

Two types of equipment are used in agriculture for evaporative cooling: pressure nozzles and evaporative panels. The sufficient 80 % adiabatic efficiency can be expected in the equipment with spray nozzles at the 5 MPa water pressure before the nozzle and with the properly installed standard wetted surface 100 mm thick, over which air flows at a rate of 1 m/sec.

When deciding the installation of the cooling equipment, it is important to take into account local climatic conditions. In the current and future period, it is sufficient to design equipment that is able to evaporate about (5 ÷ 6) grams water into each cubic meter of the ventilation air. On the basis of this value and the given volume of the ventilation air in the stable, it is possible to determine the necessary number of nozzles or, as the case may be, the volume of the evaporative panel.

Introduction

The use of suitably designed evaporative cooling is one of the methods how to reduce the consequences of heat stress on animals kept in stables during the summer months. Two types of equipment are used in agriculture for this purpose. Pressure nozzles, which spray water directly into ventilation air, and evaporative panels, i.e. walls with a large surface wetted with water running down, through which air is sucked into the stable.
The adiabatic efficiency of the pressure nozzles η_{ad} (-), defined as the ratio of the achieved cooling to the maximally possible cooling, depends on water pressure p (Pa) before the nozzle according to the equation (Bottcher et al., 1991)

$$\eta_{ad} = 0.124 + 1.35 \cdot 10^{-7} \cdot p \quad . \tag{1}$$

Theoretically, 100 % efficiency can thus be achieved at a water pressure of 6.5 MPa. Air cannot be cooled more by evaporation because its 100% water vapour saturation has been achieved. The adiabatic efficiency of the evaporative panels is in the range from 60 % to 90 %. It depends primarily on the filling material used, thickness of the wetted layer and the flow rate of treated air (Liao and Chiu, 2002). The dependence of efficiency η_{ad} (-) on the flow rate v (m/s) is described by the equation (corrugated cellulose)

$$\eta_{ad} = 86.62 - 20.787 \cdot v + 2.755 \cdot v^2 \tag{2}$$

or (wood wool)

$$\eta_{ad} = 76.055 + 2.909 \cdot v - 17.414 \cdot v^2 \tag{3}$$

(Trumbull et al., 1986). The optimum PAD thickness is (50 ÷ 100) mm.

When deciding the installation of the cooling equipment, it is important to take into account local climatic conditions. These conditions can be assessed by means of long term detailed meteorological data. The measured and observed values of basic meteorological factors during 1961 ÷ 2000 on the territory of the Czech Republic are available in the literature, e.g. (Květoň, 2001) or directly in climatic stations. Apart from humidity, the maximum and average air temperature in a given region is primarily important for designing the evaporative cooling. For example, in stables where poultry is kept, Shane (1997) recommends using evaporative cooling if a temperature of 35 ºC occurs in a given place every year. Growing and finishing pigs belong to animals even more sensitive to increased temperature and in this case, it is therefore possible to assume a limit for the efficient use of the evaporative cooling by (1 ÷ 2) K lower.

The future evolution of climate is estimated by means of mathematical models. The future amount of the CO_2 emissions cannot be determined accurately; neither can the climate sensitivity be determined to the increased concentration of greenhouse gases. For this reason, several different groups of emission scenarios SRES (Special Report on Emission Scenarios) have been set up, where evolution alternatives are included leading to the compensation of differences between rich and poor countries and the evolution is oriented to a very heterogeneous world. In the world centres for climate modelling, several global climatic models have been created, by means of which the climate changes and their impacts have been estimated. The outputs from these models are freely available on the following address: http://ipcc-ddc.cru.uea.ac.uk . The HadCM2 (Hadley Centre for Climate Prediction and Research) model from Great Britain meets best the conditions of the Czech Republic.

Although there are uncertainties in regional estimations of the future warming and considerable differences between individual models, their conclusions agree that the increase of the summer temperature above the continents of mild latitudes will exceed the increase of the global annual average air temperature. The probability of the occurrence and increased frequency of temperature extremes significantly increases even if the average temperature values increase mildly (Brázdil et al., 1995). These facts show on the growing importance of the evaporative air cooling also in stables in mild geographical latitudes.

The primary goal of this contribution is to assess the effect of climatic conditions on the design of equipment for evaporative cooling in a given region.

Materials

The current climatic conditions can be determined on the basis of meteorological elements in selected climatic stations. In the calculations, data on the average daily temperature were used that were determined from the values measured at a certain time (at 7:00 a.m., 2:00 p.m. and 9:00 p.m.) and the maximum daily air temperature that was determined according to the extreme thermometer in the summer months (June, July, August) from 1961 until 1990. Stations were chosen with respect to their uniform distribution and continuity of measurements, if possible at the same place. The accessibility and form of the provided data is also important. For making it possible to generalize the results obtained in a specific place to other regions with analogous climate, the average temperature in the summer months for the entire period 1961 ÷ 1990 was chosen as the basic parameter characterizing the climatic conditions of a given place. The data from the following 27 stations were available for the calculation: Brno - Tuřany (average summer temperature 17.9ºC), Olomouc - Slavonín (17.9 ºC), Žatec (17.9 ºC), Kuchařovice (17.7 ºC), Semčice (17.7 ºC), Hradec Králové - Nový Hradec Králové (17.5 ºC), Holešov (17.4 ºC), Doksany (17.4 ºC), Mošnov (17.1 ºC), Klatovy (16.8 ºC), Tábor (16.6 ºC), Valašské Meziříčí (16.5 ºC), Třeboň (16.5 ºC), Kralovice (16.4 ºC), Ondřejov (16.2 ºC), Velké Meziříčí (16.2 ºC), Havlíčkův Brod (16.1 ºC), Husinec (16.0 ºC), Město Albrechtice Žáry (15.9 ºC), Ústí nad Orlicí (15.9 ºC), Kostelní Myslová (15.8 ºC), Cheb (15.8 ºC), Liberec (15.6 ºC), Přimda (14.5 ºC), Červená (14.4 ºC), Svratouch (14.4 ºC), Churáňov (12.2 ºC).

For the comparison of the results for the current and future conditions, it was necessary to create the corresponding series of the expected future maximum daily temperature during the equally long period. The temperature increments were added to the values obtained from individual stations for the optimist (June +0.7 K, July +0.8 K, August +1.2 K) and pessimistic (June +1.8 K, July +2.3 K, August +3.2 K) evolution alternative (Kalvová et al., 2002).

From the everyday maximum temperature, the number of days is determined in the summer months, when the determined value of the maximum temperature is exceeded. Furthermore, it is possible to determine the temperature maximum that occurs every year in a given locality. When designing the evaporative equipment, the maximum amount of water ρ_p (kg/m^3) that the equipment can evaporate into the ventilation air must be considered as an important factor. This quantity can be calculated from the relation

$$\rho_p = (x_2 - x_1)\cdot\rho_{sv} \quad . \tag{4}$$

Specific humidity x_1 (kg/kg), corresponding to the maximum air temperature t_1 (ºC) in the given place during a period of thirty years, can be calculated from the relation (Chyský and Hemzal, 1993)

$$x_1 = 5.8\cdot(1 + \mathrm{tgh}(0.05\cdot(t_1 - 10)))\cdot 10^{-3} \quad .(5)$$

Dry air density ρ_{sv} (kg/m^3) is given by the equation of state

$$\rho_{sv} = \frac{p_{sv}}{r_{sv} \cdot T_{sv}} \quad . \tag{6}$$

The relation for the calculation of the dry air pressure p_{sv} (Pa) can be obtained from the basic relations of thermodynamics in form

$$p_{sv} = p_{vv} \cdot (1 - \frac{x_1 \cdot r_p}{r_{sv} + x_1 \cdot r_p}) \quad , \tag{7}$$

where 98 000 Pa, i.e. the average value in the Czech Republic (Chyský and Hemzal, 1993), is substituted for the humid air pressure p_{vv}; $r_{sv} = 287$ J·kg^{-1}·K^{-1} and $r_p = 461$ J·kg^{-1}·K^{-1} are the values of the specific gas constant of dry air and of vapours respectively. Temperature T_{sv} (K) of dry air is given by the relation $T_{sv} = t_1 + 273.15$. Under the assumption of the same enthalpy of air in state 1 and 2, the specific humidity of air x_2 (kg/kg) after cooling can be calculated from the relation

$$x_2 = \frac{c_{psv} \cdot \eta_{ad} \cdot (t_1 - t_{ad}) + x_1 \cdot (l_{23} + c_{pp} \cdot t_1)}{l_{23} + c_{pp} \cdot [t_1 - \eta_{ad} \cdot (t_1 - t_{ad})]}, \quad (8)$$

where c_{psv} = 1 004 J·kg^{-1}·K^{-1} and c_{pp} = 1 884 J·kg^{-1}·K^{-1} are the specific heat capacities of dry air and of vapours respectively; l_{23} = 2 499·10^3 J/kg is the specific heat of the water evaporation at 0 ºC, η_{ad} (-) is the adiabatic efficiency of the cooling equipment and t_{ad} (ºC) is the temperature of the limit adiabatic cooling at 100 % relative humidity that can be determined for air state 1 given by parameters t_1 and x_1 from the Mollier diagram; instead of it, the corresponding wet bulb temperature can be substituted with sufficient accuracy.

Results and discussion

In Fig. 1, the annual temperature maximum rounded down to an integer is displayed. In the given place with the indicated average temperature in the summer months, this temperature was observed on the average at least once during each year of the thirty year period. Should the limit be determined for the efficient use of the evaporative cooling in the stable for growing and finishing pigs at an annual temperature maximum above 33 ºC, it is suitable to install the equipment in the current period in places with the average summer temperature above 16.5 ºC. However, around 2050, this would already be in places where the average temperature is now above 15.5 ºC in the summer months. Thanks to knowledge of the future values, it is possible to find out what is called a space analogue, i.e. a place where a similar situation occurs at the present time and will be there in the future.

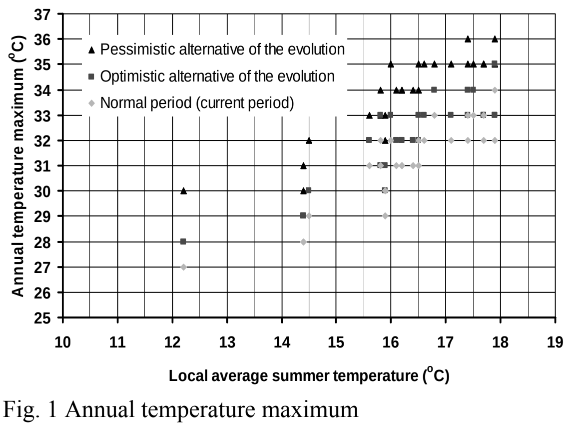

Fig. 1 Annual temperature maximum

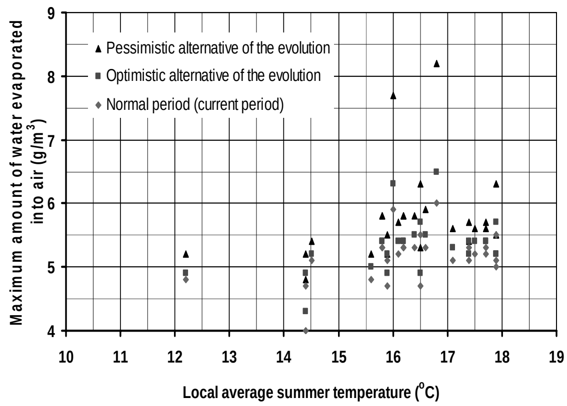

Fig. 2 Maximum amount of water evaporated into air

In Fig. 2, the calculated amount of water is indicated that must be evaporated into the ventilation air at the extremely high temperature and the chosen adiabatic efficiency of 80 %. This value does not depend too much on the average summer temperature. It is obvious that in the current and future period, it is sufficient to design equipment that is able to evaporate about (5 ÷ 6) grams water into each cubic meter of the ventilation air. On the basis of this value and the given volume of the ventilation air in the stable, it is possible to determine the necessary number of nozzles or, as the case may be, the volume of the evaporative panel. The 80 % adiabatic efficiency can be expected in the equipment with spray nozzles at the 5 MPa water pressure before the nozzle and with the properly installed standard wetted surface 100 mm thick, over which air flows at a rate of 1 m/sec (Bottcher et al., 1991; Liao and Chiu, 2002; Trumbull et al., 1986).

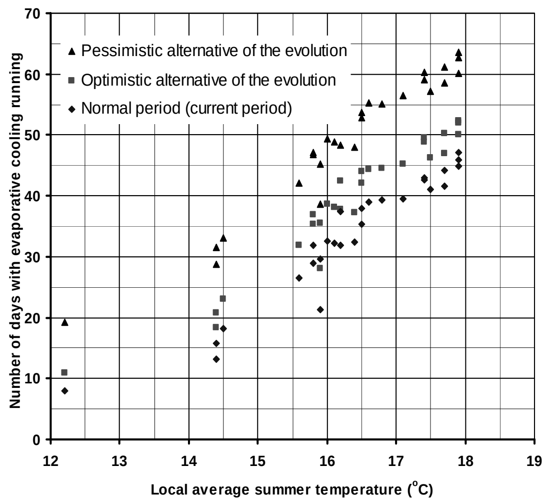

Fig. 3 Number of days with evaporative cooling running

In Fig. 3, the number of days is indicated in the summer season when the equipment would have been in operation under the assumption that it was put into operation whenever temperature exceeded 24 ºC.

Conclusions

The paper describes how the effect of local climatic conditions should be taken into account when designing efficient cooling of air in stables. The number of places where it will be suitable to install evaporative cooling will increase with the increasing temperature in the summer months. Independently of the local conditions, the planned evaporative equipment should be able to evaporate about (5 ÷ 6) grams water into each cubic meter of ventilation air in the current and future period. In the time when cooling is used although air does not reach the extreme conditions, it should be possible to regulate the amount of evaporated water, for example, by using a variable number of pipe branches with nozzles, independently controlled units, mobile equipment, etc.

Sometimes it is possible to encounter an evaporative cooling unit that is unsuitably designed and its effect is by several Kelvin worse than expected. The most frequent cause is a small amount of water that the equipment can evaporate. The efficiency of the evaporative panels exposed to sunshine is decreased to mere 15 % (Timmons and Baughman, 1984).

Simultaneously with the evaporative cooling, other important means should be used for increasing the comfort of animals, such as shading the buildings, increasing the airflow rate around animals and directing the flow of ventilation air directly to the zone of animals.

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PRINCIPLES AND EXPERIENCE OF HEAT STRESS REDUCTION IN BUILDINGS FOR HOUSING OF ANIMALS

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Reduction of heat stress in buildings for housing of animals is current programme in farm animal breeding in conditions of continental climate at present. The whole process is often speeded up by variations in weather to extreme temperature conditions that cannot be anticipated currently and predict their time course. The process has important economic dependences that depend on the rate of decline of production parameters and influence of climate change on reproduction traits and health of bred animals. In contrast to it are costs connected with improvement of technological and construction parameters as well as operation parameters. Complex of costs for modification technologies condition the requisite standard of parameters expressed by microclimate elements temperature and relative air humidity, air movement speed, its cooling values.

Increased demands for microclimatic elements – microclimate is not possible in principle achieve only with hitherto used ventilation technique. These techniques respect classical principles of ventilation and broadly used processes for clean air in stable and standard modification of outer climate, air exchange, and they respect basic demands for microclimate. With modern techniques are demands made on decrease of heat stress, prevention of heat stress and its consequences. For the mentioned processes it is necessary to respect the new drawn up criteria for temperature and humidity parameters, air movement, ventilation capacity, functional balance of the given element in the breeding room, its sections. Specific problems are with requirements for double environment, and it is hard to realize the present reduction criteria.

It is necessary to propose economically available techniques of heat reduction together with construction-technical parameters for the selected farm animal categories and for the given microclimatic zone, parameters of outer climate and for summer and winter periods. It means respecting the creation of inner microclimate at outer temperatures within the span from -20÷(25^{0}C) in winter period to 30 au to 35^{0}C in summer period. Total differentiation of outer air temperatures is 50 up to 60 K, which is demanding for construction-technical solution of breeding environment and apparatus outfit for its modification if we want to achieve optimum temperature-moisture regime in the given farm for different animal species, their categories and season. Results of analyses of microclimate and functions of reduction techniques used in the Slovak Republic in buildings for large-scale production – stables for cows, pigs and poultry – fattening of broiler chickens in summer period - will be presented.

Key words: Animals Housing, Building, Heat Reduction

Introduction

Process of heat stress reduction in buildings for housing of animals has a number of dimensions within the optimisation of breeding environment. It is aimed at reduction of the influence of increased and high air temperatures on parameters of efficiency, reproduction traits and state of health. Prevention of stress from heat, hyperthermy, is the matter in question. Elimination of death that was observed often also in our conditions; it was documented mainly in flocks of poultry broilers – in fattening of chickens in conditions of large-scale production. It was caused mainly by non-standard microclimatic conditions that arose mainly towards the end of fattening period. In that period cumulate factors of over occupation of the building and high weight of chickens and too high density in the area. In such conditions was insufficient heat removal from organism into the surroundings, and from the area of housing into outer surroundings. It is caused also by shortcomings in construction lay-out, in the system of ventilation.

As far as this resulting state is concerned it is necessary to say that some construction and technological solutions “standard conditions” are not able to modify the microclimate according to the new defined criteria for individual species and categories of animals. Whole process must fit to dimensions of buildings, their heat insulating

properties, ventilation intensity and technique of heat reduction at starting climatic change.
Mainly in conditions of interactivity of often-occurring temperature extremes arise states that are subjects of demands for heat reduction by technical methods and solutions that were non-traditional in animal husbandry up till now.

Climatic conditions

Initial climatic conditions in continental climatic zone determine basic parameters of the whole process for summer period, it is 25 – 30 – 35°C. Length of season with summer and tropical days is variable, and it is not possible to predict and define it exactly, which is mainly an economic problem at assessment of returnability of investments. However, it is necessary to keep in mind that the influence of higher temperatures on production, and whole mechanism of negative influences in animal husbandry makes an impact at lower temperatures already and therefore a modification – reduction of heat stress must be shifted into the mentioned sphere, as a matter of fact in the whole range of definition temperature for summer days and nights, and separately for tropical days and nights. However, criteria are practically defined for individual species and categories of animals according to the level of production.

Construction lay out of the building

Heat-insulating properties, thermal resistance are determined for buildings and their basic construction elements – roof cladding and external cladding, operating mode to provide heat comfort.

Demands for thermal resistance in buildings for housing of animals R / m^2.K/W/

	Unheated building	Heated building
Roof construction	2.816	4.2246
External wall	1.584 - 2.112	2.288

As described by DEFRA study thermal resistance of 2.5 /m^2.K/W/ or 2.9 /m^2.K/W for roof are requested.

We evaluated the situation in our conditions and we found out that the mentioned criteria were not always respected. Therefore arise non-standard states of microclimate that must be reduced otherwise occur consequences according to air temperatures, at least with non-standard extreme course, with fluctuations of air temperatures.

For operation in building	Unheated building	Heated building
Roof construction	76,92%	51,27%
External wall	47,3 % - 35,46 %	32,74%

Basic modificatory function of ventilation system

It is given by principles for definition and realization of variable ventilation capacity with highly differentiated capacity: max in summer and min in winter with continual regulation or at least with gradual regulation. From the given point of view it is very topical to provide so called minimum ventilation in winter period, and increase the required capacity during transition functional periods. Minimum ventilation, ventilation capacity provided technically, should continue with continuous rise on the basis of course of regulating variable, which is air temperature as a rule.

Airflow – factor of ventilation system

With repeated solutions it is desired to pay system attention also to the development verification of the creation of convenient circulation conditions. Visualization of airflow and its value analysis can contribute to verification of fulfilment of intentions in practical conditions in buildings. Further at assessment of secondary function of air movement within the ventilated area, technological limitation of area, e.g. in a cage etc.

Role of airflow in a building

Air that flows shall provide steadily and particularly the transport:
- of oxygen necessary for breathing from outside into the room, and the used-up CO_2 transport into the outer environment
- of released heat, water vapour and harmful gases remove from organism in the first place, to remove them from the room
- of residual heat and amount of substances through the room so that they keep together with other viewpoints requisite conditions of microclimate (temperature, relative air humidity, concentration of harmful gases) in the zone where they stay or in breathing zone.

Heat and substance load must be transported without apparent draught. Draught is characteristic by the fact that air velocity within the zone of stay fluctuates at recommended temperature values above the optimum span according to concerned standardized values or exceeding maximum table prescriptive values. Therefore more attention must be paid to air velocity within the zone of stay as well as direction of flowing air to appointed parts of body.

Reduction of heat stress in buildings for housing of animals

Hitherto experience in the field of heat stress reduction by heat stress reduction in buildings for housing of farm animals in our country have still the tendency to look for economically reasonable and effective solutions.
Solutions used in practice within herds often lack complex realization of the basic intention to reduce

heat stress. Basic tendencies in our climatic conditions are conditional on possibilities of investment stimulations for basic adjustment – possible modifications mainly under extreme microclimatic conditions.

Complex technical solutions are as a rule not realized. The solution has a number of variants that have differentiated extent of reduction given by differently solved elements in construction-technological solution in given rearing system and its provision from the given aspects.

Analysis of systems in practice

Practical analysis shows possibilities, possible weak points in systems used in our climatically difficult conditions in the course of differentiated periods.

Great differences and variability in course of climatic elements and difficulty of exact definition of the expected occurrence, possibilities of their prognostic determination in advance are the main economical problem for planning the return ability and effective utilization of equipment that is more expensive.

Their exploitative long lasting utilization with simultaneous prevention of losses in production, reproduction and prevention of death losses in individual phases of production cycle create basic stimulus of motivation for application of modification techniques by optimisation of technological-construction solutions in the whole complex of problems with heat stress reduction.

Experimental solutions are so to say subject of interest of specialist public but mainly of modern practice. It is oriented at present in co-operation with main tendencies and intents at decrease of production risks and improvement of effective processes at decreasing heat stress in buildings for housing of farm animals, at available techniques within investment possibilities.

Appointment of criteria

It is necessary to re-evaluate the measures for reduction of heat stress with criteria for individual animal species. Situation is complicated mainly by high occurrence of extreme fluctuations with increase of daily air temperatures over 30^{o}C – partially even over 35^{o}C, which are characteristic for tropical days and nights. To the mentioned conditions of continental microclimate and its fluctuations must be directed also reduction measures in practical conditions of individual buildings.

In practice are demanded real breeders' measures to reduce heat stress in herds of dairy cows to decrease the influence on milk efficiency.

In pig breeding are deteriorated parameters of reproduction, growth intensity serious problems at temperature extremes.

In poultry breeding – broilers in fattening prevention of mortality according to time relation of course and stage of batch as the demands for the course of temperatures are markedly changed according to the age of chickens within the span 10 – 15 K. Further is in question the quality of egg production in layers breeding.

In present practice are defined demands in connection with intensive breeding of rabbits in the sphere of growth intensity, production parameters.

Report by CIGR (International Commission of Agricultural Engineering) proposes non-traditional criteria for our conditions that must be kept if the mentioned negative phenomena and consequences for individual animal species are to be stopped, especially with summer temperature extremes.

To determine criteria for heat load reduction in buildings for housing of animals the basic meteorological – microclimatic element of air temperature is used. This is manifested by extremely above-average values in the time horizon of the last years. In some years it manifests itself very negatively and it has its expression characteristic in early onset of increased and high air temperatures during the spring months already. In this way increases number of days in year with negative impact on physiological functions of organisms of raised animals, and their time course with extreme tropical days and nights with marked impact on amount of production – milk, gains in fattening, egg production and quality of production.

High temperature has negative impact on reproduction parameters – e.g. fertility of cocks, mortality in poultry – broiler – flocks if critical moments are not respected, upper temperature conditions that can still be tolerated in standard operation conditions by individual species and categories of farm animals.

In our climatic zone – continental climate becomes the mentioned – extreme course of weather more and more markedly and frequently and therefore it is inevitable to inquire into counter measures that will enable us to modify effectively the mentioned negative traits.

Research can help in the process of reduction by defining the new criteria that will be more precise, they will control possible processes and enable the agricultural – breeding practice to provide effective reduction, modification in our conditions of continental climate, mainly in frequent extreme conditions of temperature.

It is necessary to mention the fact that they are not given exactly in form of directions or conditions, critical temperature and other microclimatic parameters, relative air humidity and air flow velocity mainly in the space where animals stay that are defined in another form, and it is necessary to keep them unambiguously if we want avoid negative consequences of non-standard microclimatic conditions.

Existing directions or rules and regulations define as a rule optimum requisite parameters of air temperature, partially humidity regime, objectively in thermonuclear zone. They do not determine broader zone from the aspect of ability of organisms to adapt themselves within outside - the thermo neutral zone. Namely in such way which would avoid negative phenomena, mainly decrease of production, if they are respected. If the mentioned broader zone is exceeded there arise often non-standard conditions which cannot be compensated by animals without decreased intake of feeds, consequently decreased production as well as death losses as we partially noticed in poultry breeding, broiler fattening of deterioration of reproductive parameters.

In this state participate a number of problems in construction layout, changed purpose of utilization, thermal insulation properties, ventilation systems. The main disadvantage with high intensity of animal breeding is also the fact that the buildings are not able to function properly; they are neither constructional nor technically dimensioned, and mainly not equipped to decrease effectively the risk factors of non-standard microclimate in extreme situations that occur repeatedly in our climatic zone during the last years. These situations are defined by following and repeated findings e.g. by Sottnik et al. (1983). There were found very low cooling values as a rule – cooling values on the level approx 50 $W.m^{-2}$ and less. Even under specific conditions were the cooling values not measurable, i.e. under given and so determined microclimatic conditions (if they were 0 $W.m^{-2}$) they are absolutely unfit for decrease of heat load on organism. The already mentioned shortcomings become fully evident on animals (Sottnik et al. 1998) in such surrounding.

Here is in question the economy of the whole branch or section of farm animal husbandry, return of the investments that are very high already, lasting economic potential of the given branch, ability to produce continually without negative impacts that make it difficult to obtain extra investments for modification equipment and operation costs for higher consumption of energy for their operation.

Situation is complicated by marked difference between temperatures in summer and in winter (up to 50 – 60 K t.j –20 (-25)^{o}C in winter and 30^{o}C +35^{o}C in summer period). These are conditions that must be calculated in total consideration of possible states of outer air. For the mentioned and limit states of air must be provided balances at compensation and modification for the winter as well as summer periods.

Initial criteria

In dairy cows breeding is the basis for settlement of the level of heat effect 25 ^{o} C. For cows with good level – amount of production begins significantly decrease from the temperature 25^o C and higher, and Rv 50 %.

For the control of the process are proposed following indexes:

THI Thermo Humidity Index, out of it is defined DI – Discomfort Index

THI = 0.6 t_{db} + 0.4 t_{wb} – as described by R.S. Gates et al. (1995), heat-humidity index – THI = 0.6 t_s + 0.4 t_m

DI – Discomfort Index proposed by GARGILL and STEWARD is calculated as follows: THI = 0.72 (t_{db} + t_{wb}) + 40.6

Criteria for discomfort DI are proposed for individual farm animal species as follows:

In cattle breeding – THI – 75 allows – enables still max milk production, value 80 causes 20 % decrease of production, and value 90 causes production decrease by 40 – 45 %. Analogical values are derived also for fattening cattle.

Pig breeding – we have only little information in this sphere. From information about pig breeding in Australia during typical summer conditions follows that at the temperature over 30^o C can be reduced fertility, feed intake and feed utilization efficiency. Sprinkle equipment can decrease the influence of high air temperatures. Pigs are sprinkled until they are completely wet; they are cooled by evaporation, water absorbs their body warmth.

In Iowa they settled heat-humidity stress index for growing up to end categories of pigs, in individual sections are defined zones of vigilance – danger up to urgency.

Banhazi T, et al. (PIN March 2001) showed in conditions of Australia unambiguous effect on gains in pig breeding and lower feed consumption if the building was equipped by sprinkle equipment – adiabatic cooling of air. The authors reported gains higher by 11.16 %, feed consumption was lower by 5.77 %. Feed conversion was more favourable in the group treated by sprinkle system by 4.53 %.

In poultry breeding it is difficult to find rational way out from the state of non-standard microclimatic surrounding in our conditions. Simmons et al. (1997) studied dependence of heat liberation in broilers at variable velocity of air movement from 1 to 3.05 $m.s^{-1}$ (with differences by 0.5 $m.s^{-1}$) and air temperatures 29^o C, 32^o C and 35^o C. The results show that with higher velocity of movement grows liberation of noticeable warmth from tested broilers and the amount of liberated latent warmth decreases at the same time. Sum of both (total liberated warmth) shows the tendency towards constant increase with increasing velocity of air movement.

Drury 1966, Drury and Siegel 1966 (bibl.ref. Simmons et al., 1997) mentioned the significance of air movement; they laid basis for the statement that broilers feel well in the consequence of created cooling – wind factor. The description is derived from human sphere and experience that the increase of evaporative cooling of skin is caused by wind. But feathers cover a chicken and it cannot sweat. Heat is liberated from the chicken by passive diffusion of water by skin. From results of experiments performed by Simmons et al. 1997 in ventilation – breeding tunnel with broilers follows:
- liberation of noticeable warmth rises with rise of air movement velocity and it decreases with increase of surrounding temperature
- liberation of latent warmth decreases with rise of air movement velocity, and it rises with rise of surrounding temperature. With nominal velocity of air movement approx 2 $m.s^{-1}$ remain total heat losses relatively constant also with increasing temperature.

Adiabatic – evaporation cooling

During dry weather with extremely hot summer microclimate is recommended the evaporation cooling that is created by spraying fine mist (aerosol) into the area. Today exist already functional humidifiers of air used in glasshouse systems. In fattening of gallinaceous fowl they can be used not only as a means for decrease of temperature but also for decrease of respiratory diseases, and the result is better economical effect (Albright, 1990, 1994). However, it is doubtful to which extent it is possible to provide creation of really fine mist and in adequate amount; inconvenient application could cause more harm than use. Temperature decreases by evaporation of water aerosol on the basis of psychrometric state of air. It is a quite effective system enforceable potentially in dry and hot weather during days with very low relative air humidity. The difference (t_s – t_m) between dry and wet temperature of outer air is the definition factor, so called depression of wet temperature.

Systems with cooling equipment or their parts in supply panels, flaps etc., are broadened. Experience in practice show there was obtained a temperature reduction of approx 5 K, measured at air inlet in flaps.

Technique of reduction based on air movement

One of the possible processes in reduction of heat stress in buildings is the technique of reduction by increased air movement that is adequate to air temperature. During the last years is this method used also in ventilation systems to raise their efficiency. In comparison with our conditions there are applied rather high values of ventilation capacity and airflow.

Also buildings with natural ventilation are equipped with supplementary sliding ventilation – fans for increased air movement in building up to the level 3 $m.s^{-1}$. These possibilities are tested in practice also in our conditions. The principle of tunnel ventilation is based on this technique also.

Application in practice is highly topical in breeding of cattle, high-yielding cows, and poultry, partially also in pig breeding. Necessary is the combination with the technique of reduction on the basis of adiabatic – evaporation cooling of air.

Conclusion

Analysis of evaluated systems for reduction of heat stress showed that it is necessary to improve the standard function and conditions for operation of equipment. To respect basic criteria and functional preconditions of the whole process of heat reduction with selected technique, namely:
- regulation of the whole process according to settled criteria, temperature or relative air humidity
- function of system considering the technological system – water supply under pressure for its evaporation ability, planned performance – function of basic elements – atomising – aerosol jets used in the equipment
- be engaged in the question of quality of the supplied water – its filtration if necessary for continuous functional process – technological process in sprinkle elements, aerosol jets and the like
- to set service parameters and treatment of reduction technique for this request with the intent to put it into permanent function in time of required reduction of excessive heat load

Summary evaluation of techniques

Reduction of heat load is given by their functional preconditions and extent of their application within the given building, facilities, functional part – alley for movement, feeding place, housing section and their connection.

Reduction effects have their physical-technical and technological-constructional possibilities and they are given by thermodynamics of moist air in the part of adiabatic systems of humidification and cooling of supplied air.

Individual parts of the equipment are to different extent adjusted in order to be able to take into account the whole process of reduction at the most. It is given by the quality of cooling medium. Spray is less effective than high-pressure aerosol. System PAD is given by the size of area of moistened insert and its connection with other elements.

More active are systems functionally connected to ventilation units that have both functional

connections joined – moistened – cooled air has noticeable and significantly increased cooling effect if it is dynamically shifted – in configuration with ventilation unit. More effective is direct entry through the systems of PAD inserts into the production building; the size of area is on the other hand limited by reduction of temperature stability in winter.
The analysed systems and elements of heat load reduction participate differentiated in the whole process of heat content reduction of the building.

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Tested and Recommended Techniques of the Heat Reduction in Stables
Outside food passage with sprinkler cooling
Systems of the supplemental cooling fans
Supplemental cooling fans - sprinkler fans
PAD Cooling System – Air Inlet through Corridor
High pressure – fogging cooling systems
Tunnel ventilation system
Cooling Unit with Ceramics– Brick PAD

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THE RURAL DEVELOPMENT SUPPORT IN TAPANULI UTARA REGION

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There are lots of differences in agricultural systems between an advanced countries and developing countries. These differences are result from historical progress, economical and a political system, human's potential and utilization of scientific knowledge. The agriculture in developing countries is going through all spheres of live. The agriculture has a lot of functions, it is not only a source of food and basic raw materials but a source of employment and in some case a single source of incomes for rural population, too. In long term conditions is it important factor of social stability in rural area. In this project at University of Sisingamangaraja XII was founded a sample plot of corn with variants of fertilizing, it was displayed possibility of using machinery on the field and a lot of lectures about safety agriculture has been done. Actually was displayed advantages of mechanization and intensification of large-scale crop production.

Key words: Support; developing countries; agriculture.

Introduction

The field economy of advanced countries and developing countries is different not only by their dispositions (formed by long-term historical progress, economical and political systems, human's potential, utilization of scientific knowledge, traditions and conventions), but by their goals and economic influence too. Ambition of the developing countries is self-sufficiency effort in food production, whereas the advanced countries support reduction of agricultural production by big amount of money. The agricultural overproduction of advanced countries disputes a pressure on increasing worldwide agricultural production with excessive exploitation of natural resources by the developing countries.

Fig.1 – The central building of University Sisingamangaraja XII in Silangit

This paradox is more important, because the nutrition problems have approx. 2/3 of population, but problems with overproduction have only 15 % of population. Food-aid program can't be permanent solution of this problem. The sufficient foodstuff production is a global problem.

The main objective of the project funded by Ministry of Agriculture of Czech Republic is foundation of information centre for local farmers at University of Sisingamangaraja XII in Tapanuli Utara region on Sumatra Island in Indonesia. The fields of consulting service are the plant nutrition and the plant protection, utilization of agricultural mechanization and fertility improving treatment.

Fig.2 – Teaching at Agricultural faculty

Material and methods

During stay of the pedagogues on the university was founded a sample plot. The most of agricultural operation on this sample plot was doing by mechanization purchased from the grant. Namely; small four-wheel drive farm tractor Dong-Feng with power output 25,4 kW, tractor-carried rotary tiller with horizontal rotary axis, disk plough and precise seeding machine for corn seeds. By cultivation of land was prepared condition for corn and potato growing. In this region agricultural mechanization is not extended, a most of works are doing by hands or by beast of draught, primarily by the water buffalo (*Bubalus bubalis*). Exceptions forms only rice fields, there is possible to see a one-axle tractors. They are used for basic soil cultivation for rice planting by the "wet" technique.

Fig.3 – The opening ceremony of practical courses

The first part of work was a transfer of knowledge to the students by the lectures and the practical courses, at the university or directly on the sample plot. The second part was making the tutorials with consultation for farmers at farms in neighborhood of Siborongborong and Tarutung. The chosen group of the students and farmers was trained by using purchased machines to effective work on the field. Besides tractor driving courses was put the accent on positive effect of machine's condition maintenance. It was necessary task from the point of view of the technical condition of all local machines and devices.

It's imperative to know that the agriculture is going through all spheres of live in the developing countries. The agriculture has plenty of functions there; a source of food, a source of basic raw materials, a source of employment, and in some case a single source of incomes for rural population. In this case it is important factor of social order stability. In some conditions the crops sale revenue can be a motor of economic development. At the same time the agricultural production is responsible for landscape design and conservation, accordingly besides an economic function the agriculture has an environmental function. Therefore the contents of the lectures for students were geared towards correct application of mineral fertilizers and pesticides. It was very important theme, because the local farmers don't use the mineral fertilizers and the pesticides well-balanced and frequently occurs to purposeless application of them, due to ignorance of rudimentary knowledge about mold diseases and their symptoms or only due to e.g. greensickness by deficiency in specific chemical element in soil conditions.

Fig.4 – Sowing of corn

The main crops in this region are rice, corn, vegetables (first of all carrot, onion, garlic and potatoes), fruits (mandarins, bananas, granadillas, tamarillos) and a special class crops grown on a plantations – pineapple, coffee, oil palm and rubber tree. Especially the plantation system of agriculture would not arise without demand of these products by the advanced counties. The environmental falls of the plantation system of agriculture is a part of the most important questions about the agricultural transformation.

Fig.5 – The field work consultation

Results and discussion

In the context of our activity at University of Sisingamangaraja XII was founded the corn growth by mechanization on the sample plot. The students and farmers were informed about cultivation machines principles, lay out a field, and crop protection. At the same time was laid stress on foodstuffs safety, especially on safe application of pesticides and principles of correct mineral fertilizing, in particular divided fertilizer dose application. The group of students of Agricultural faculty was trained to using tractor and tractor's implements. Then the student texts about soil cultivation, corn growing and using mechanization of crop production was hand over to the college library.

Fig.6 – The oil palm plantation alongside Sumatran arterial road

Conclusions

Process increasing capacity of agricultural production generates necessity for appropriate post harvest cultivation (mainly capital intensive), storing and expedition. Most of the developing countries are not able to pay these additional expenses associated with modernization. The expenses are higher, because there are not developed infrastructures in developing countries.


Fig.7– The rubber tree plantation
(in the foreground newly planted trees; in the background full-grown trees)

Desired modernization of agricultural sector in developing countries and consequent growth in agricultural production should not ignore imperative environmental requirements. When the agricultural production can not provide agricultural products and foodstuff by actual technologies, demand-pull on excessive exploitation of natural resources and living environment degradation is growing. This subject is very touchy, primarily in developing countries, because it is very difficult give preference to nature preservation over sufficient agricultural production.

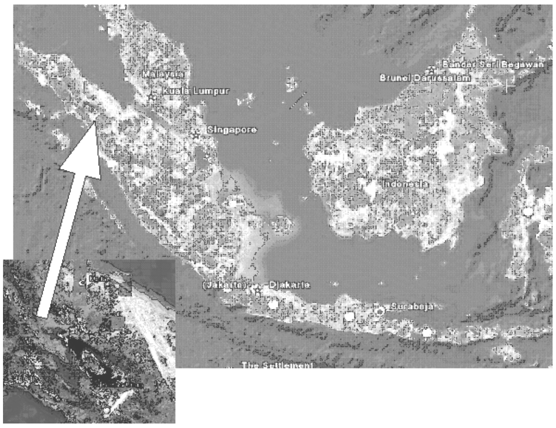

Fig.8 – Location of Tapanuli Utara region in Indonesia archipelago

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DESIGN AND REALISATION OF TESTING DEVICE FOR LABORATORY TESTS OF HYDROSTATIC PUMPS

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In this paper a design of testing device for life time tests of hydrostatic pump type UD 25 is presented. The designed testing device serves for laboratory verification of influence of biodegradable oils on lifetime of hydrostatic pumps. The designed testing device was built and tried out. On the basic of achieved results of trials we can say that testing device is suitable for life time tests of hydrostatic pumps.

Key words: testing device, lifetime tests, biodegradable oils and hydrostatic pumps.

1 Introduction

The Hydraulic devices have a wide application in powerful mechanisms of earth machines, road and construction machines, in agriculture and forest machines as well as in many other areas. Together with increasing demands on quality these machines and devices increased demands hang over on hydraulic components and systems, too. The development of modern hydraulic components is aimed at an increase of transferred power, decrease of energy severity, minimization of environmental pollution and increase of technical lifetime and machine reliability. It is very difficult to realize some tests direct on machine. The tests of hydrostatic components are advantageous to solve on special testing devices in the laboratory conditions which are steady getting bigger weight. As outline above, the measurement of parameters of hydrostatic components and devices is needed to realize in the laboratory conditions.

Within the solution of grand project VEGA MŠ SR "The research of improvement of ecological aspects of operation for mobile and stabile machines in agriculture" N° 1/3483/06 was accomplished a suggestion of a developed testing device for laboratory tests of hydrostatic pump with open the circuit.

2 Material and Method

2.1 Requests for Testing Devices

The testing device must be designed so that the running of the test corresponds with a valid standard STN 11 9287 "Hydrostatic gear pumps and hydro-motors" in which the dynamic loading of the hydrostatic converters (for pressure p_n = 16, 20 and 25 MPa art. 4), realized by selected characteristic of working pressure or the cyclic characteristic of pressure is defined.

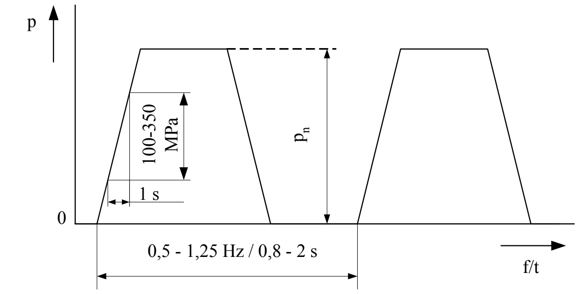

Figure 1 The time characteristic of cyclic pressure loading according to standard STN 11 9287

The determination of requirements for the testing stand goes out from parameters of hypothetic tested converters and from listed standard in witch requirements for reliability are stated as follows: "Technical lifetime must be minimum 10^6 cycles under cyclic pressure loading from zero to the nominal pressure within frequency 0.5 – 1.25 Hz during acceleration of increasing pressure 100 – 350 MPa . s^{-1} and in nominal parameters. It this case decreasing of the flow rate efficiency may be maximum 20 percentages". The time characteristic of cyclic pressure loading according to standard STN 11 9287 is shown in Figure 1. The testing device must be designed with regard to the working parameters of the tested hydrostatic converter and tested hydraulic fluid. The designed testing device will be used for the test of hydrostatic pump type UD 25.

2.2 Parameters of Hydrostatic Pump UD 25

The hydrostatic pump type UD 25 is one-direction hydraulic gear pump made by the company: Jihostroj Aero Technology and Hydraulics, Figure 2.

Figure 2 Hydrostatic pump type UD 25

This gear pump is equipped with the hydraulic balancing of axial clearance, which is done by sealing in the end face bearings. It has the application in smaller and medium agriculture and construction machines. The basic parameters of the hydrostatic pump type UD 25 are in table 1.

The testing device will be intended for detection of the influence of biodegradable hydraulic fluids on lifetime of hydrostatic pumps (gear pumps). The lifetime of hydrostatic pumps is evaluated on the ground of change of working properties according to a flow rate characteristic $Q = f(p)_n$ (STN 11 9287). The influence of hydraulic fluid on the lifetime of the hydrostatic pump than will be evaluated on the ground of the comparison of flow rate characteristics measured before and after lifetime test.

The testing device will consist of two testing stands:

1. the testing stand for realization of the laboratory lifetime test of hydrostatic pump,
2. the testing stand for measurement of characteristics of the hydrostatic pump.

3 Result and Discussion

3.1 The Suggestion of Test Stand for Realization of Laboratory Lifetime Tests

The scheme of designed testing stand is illustrated in Figure 3. This device allows to test lifetime of gear pumps according to standard STN 11 9287.

Table 1 Parameters of hydrostatic pump UD 25

Parameter		Unit	Value
Rotation speed	Nominal	min^{-1}	1500
	Maximum		3000
	Minimum		500
Pressure on the inlet	Maximal	MPa	0,05
	Minimum		0,03
Pressure on the outlet	Nominal	MPa	20
	Max. continuous		23
Nominal volume (geometrical volume) V_G		cm^3	25
Nominal outlet flow rate		$dm^3.min^{-1}$	35,1
Kinematic oil viscosity	At continuous operation	$mm^2.s^{-1}$	20 – 100
	Maximum		1200
	Minimum		10
Oil Temperature	Maximum	° C	80
	Minimum		– 20
Mounting position		-	Arbitrary
Power demand (nominal)		kW	14,2

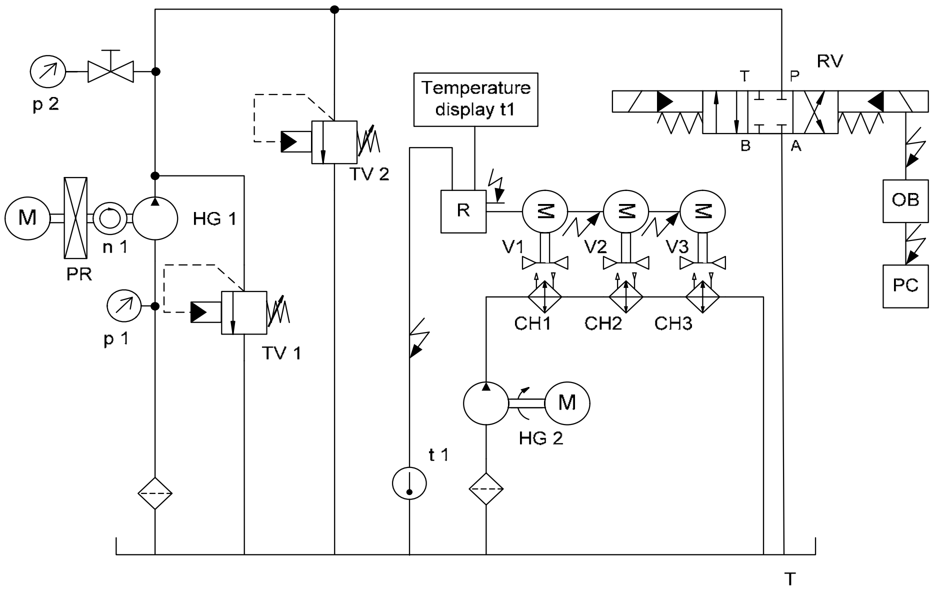

Figure 3 The test stand for realization of laboratory lifetime test of hydrostatic pump

The hydrostatic pump UD 25 is marked in scheme by symbol **HG 1**. The hydrostatic pump **HG 1** is driven by the electric motor **M.** The gear box **PR** is placed between the electric motor and the hydrostatic pump to rotation speed change of the hydrostatic pump. The adjustment of pressure gradient in the circuit is accomplished by the pressure valve **TV 2**. The pressure valve **TV 1** is as a safety-valve. By reason of designation of the pressure gradient in circuit the pressure is measured by two manometers of which one is placed in the suction pipe **p1** and second one in the pressure pipe **p 2**. The cyclic pressure loading is accomplished by the electro-hydraulically operated distributor **RV**. The distributor **RV** is connected to the output pipe of the hydrostatic pump **HG 1**. The change of flow direction is realized by the position change of the distributor **RV.** When distributor is in the basic position the fluid passes through the pressure valve **TV 2.** When distributor is in the left position the fluid passes in the tank. Thereby, the pressure loading conditions in the outlet of the hydrostatic pump **HG 1** are changed. The constant oil temperature during the test is controlled by three coolers **CH 1**, **CH 2**, **CH 3** and their ventilators are switched automatically according to an actual temperature. The control block **OB** supplies electromagnets of the distributor **RV** and its position depends on the supplier voltage. A wiper-speed switch is placed in the control block **OB** and it creates time-dependent characteristic of supply voltage of distributor electromagnet. This time dependent characteristic of the supply voltage corresponds with the pressure loading characteristic according STN 11 9287, Figure 1.

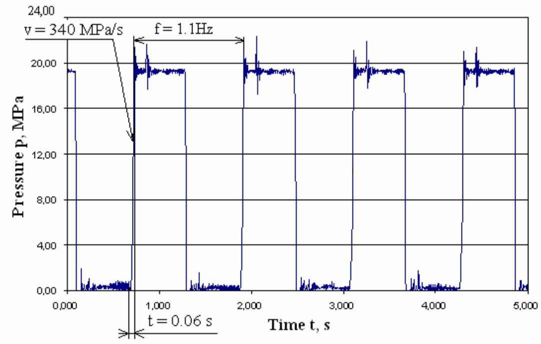

Figure 4 Time-dependent characteristic of pressure loading

Figure 4 shows the time-dependent characteristic of the pressure loading, which was measured by the test stand, Figure 3. The verification of function of the test stand was realized by the measurement of the characteristic mentioned above.

3.2 The Suggestion of Test Stand for Measurement of Characteristics of Hydrostatic Pump UD 25

The suggested test stand (Figure 5) is intended for a measurement of characteristics of the hydrostatic pump UD 25 which is marked as **HG 2**.

Characteristics, which are possible to measure by these test stands, are as follow:

- $Q = f(p)_n$ the dependence of a flow rate on a pressure during a constant rotation speeds,
- $Q = f(n)_p$ the dependence of a flow rate on a rotation speeds during a constants pressure.

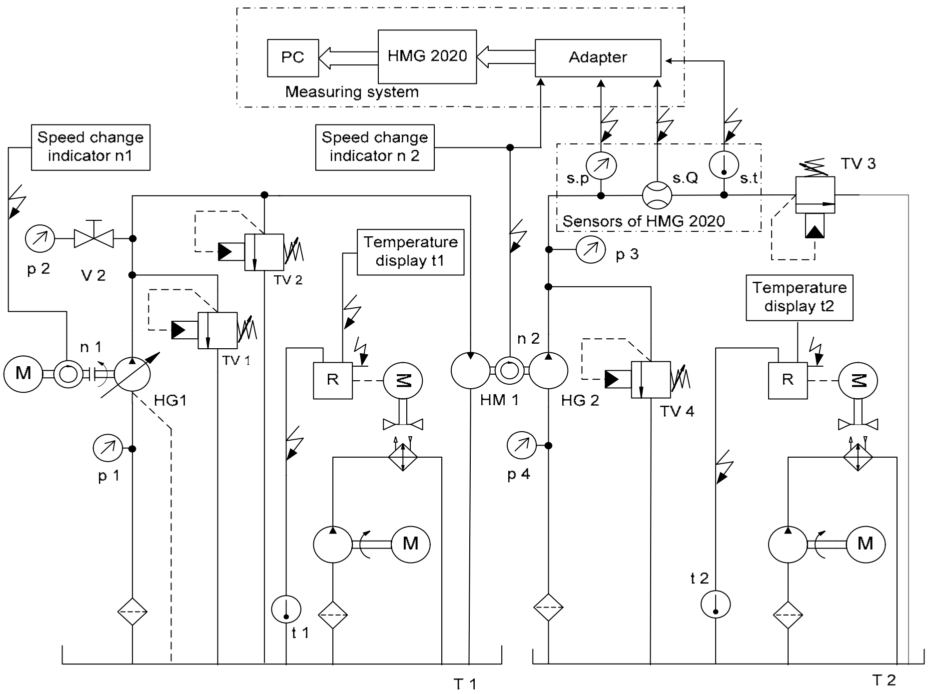

Figure 5 Test stand for measurement of characteristics of hydrostatic pump

The test stand consists of two hydraulic circuits. The hydraulic circuit, which uses the tank **T 1**, serves for a drive of the measured hydrostatic pump **HG 2** supplied by the tank **T 2**. The outlet pipe from the regulation axial piston hydrostatic pump **HG 1** is direct connected to the inlet pipe of hydrostatic motor **HM 1**. The pressure valve **TV 2** serves for adjustment pressure into the circuit. The pressure valve **TV 1** is used as a safety valve.

The tested hydrostatic pump **HG 2** is connected to the circuit with the tank **T 2**. Also the pressure valve **TV 4** is used in this circuit as a safety valve. The pressure valve **TV 3** is dedicated either for adjustment various values of pressure (from zero to nominal value) by which flow rate for characteristic $Q = f(p)_n$ is measured or for adjustment only one value of pressure for the measurement of characteristic $Q = f(n)_p$. Both hydraulic circuits have the independent cooling circuits of fluid.

The measuring system consists of the adapter, measuring device Hydac HMG 2020 and computer for the evaluation of measured values. It is possible to record simultaneously four analog signals (with input voltage from 0 to10 V or current input from 4 to 20 mA with possibility of switching) and one a frequency signal from 0.3 Hz to 30 kHz by means of measuring device HMG 2020. The analog signals were obtained from the sensors of pressure **s.p**, flow rate **s.Q** and temperature **s.t** by means of adapter. The frequency input was used for the record of rotation speed **n 2**. The measuring device was connected to notebook and by which all process of measurement was controlled.

Before the measurement of characteristic $Q = f(p)_n$ the nominal value of rotation speed **n 2** (the measured hydrostatic pump **HG 2**) must be adjusted by change of flow rate of hydrostatic pump **HG 1**. Output power of driving circuit must ensure the power demands of measured hydrostatic pump **HG 2**. Therefore, it is needed to adjust a value of the pressure **p 2** by pressure valve **TV 2** so that input power given by the multiple of pressure and flow rate to be above the output power of measured hydrostatic pump **HG 2**. The characteristic $Q = f(p)_n$ is measured by gradual increasing pressure until nominal pressure value of measured hydrostatic pump **HG 2** by virtue of the pressure valve **TV 3**. On the basis of data recorded in measuring system it is possible to make flow rate characteristic $Q = f(p)_n$.

The characteristic $Q = f(n)_p$ is measured under constant pressure by continual change of rotation speed. The continual change of rotation speed of the measured hydrostatic pump **HG 2** is achieved by change of flow rate of the hydrostatic pump **HG 1**.

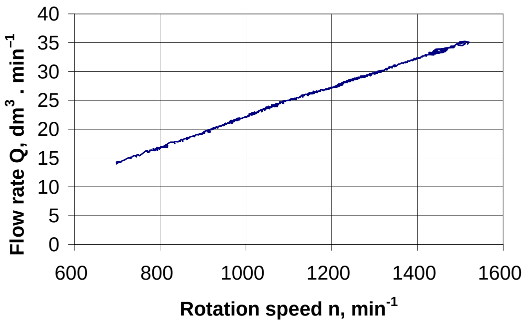

Figure 6 Flow rate characteristic $Q = f(n)_p$ of hydrostatic pump UD 25 during $p_n = 20$ MPa.

Figure 6 shows the flow rate characteristic $Q = f(p)_n$ of the hydrostatic pump UD 25 measured by means of designed test stand according to scheme in Figure 5. The measured values of flow rate and pressure were recorded by device HMG 2020 in the time intervals 0.5 s. The result of measured values provides a detail view about the flow rate of hydrostatic pump for any rotation speed values.

4 Conclusion

It was needed to suggest two test stands for the measurement of the hydrostatic pump. The lifetime test of the hydrostatic pump is realized by one stand (the test stand for realization of laboratory lifetime test of hydrostatic pump, Figure 3) and the second one serves for the evaluation of results of test (the test stand for measurement of characteristics of hydrostatic pump, Figure 5). The test stand for the realization of laboratory lifetime tests was designed so that the time characteristic of cyclic pressure loading corresponds with the valid standard, Figure1. The time characteristic of cyclic pressure loading was measured by test stand (Figure 4) when its design was finished. On the basis of comparison of measured values Figure 4 (the frequency of pressure increasing is f = 1.1 Hz, velocity of pressure increasing is v = 340 MPa . s^{-1}) with the interval of values according to standard Figure 1 (the frequency of pressure increasing f = 0.5 Hz – 1.25 Hz, velocity of pressure increasing v = 100 MPa . s^{-1} – 350 MPa . s^{-1}) it is possible to state that the test stand is suitable for the lifetime test of hydrostatic pump.

The test stand for the measurement of characteristic (Figure 5) is designed so that it enables the adjustment of a wide range of working parameters. The flow rate characteristic shown in Figure 6 is result of the measurement realized by using of test stand mentioned above. Figure 6 shows dependence the flow rate change versus pressure of a new hydrostatic pump. This characteristic will be used for the comparison with the characteristic measured after realization of lifetime test by the test stand, Figure 3. The influence of ecological hydraulic fluid on lifetime of the hydrostatic pump UD 25 will stated by comparison with the characteristics mentioned above.

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ADVISORY SYSTEM SUPPORTING THE DECISION-MAKING ON THE LEVEL OF RURAL REGIONS AND FARMS

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From the evaluation of current state and trends in area of information base and information services for the rural areas it follows that the level in a sphere of evidentiary or identification information is good. The deficiencies are reflected mainly at providing information for decision-making purpose and in special case also for their pre-elaboration so that the final decision is close to optimal state. It is therefore requisite to focus on such systems which will extend the decision-making support on level of rural regions. The information base should correspond with so defined requirements too. There is presented an advisory information system for decision-making support on level of rural regions with close attachment to multifunctional role of agriculture using the Internet technology in the report.

Key words: Internet, advisory system, decision-making support, rural regions, rural settlements development

Introduction

Rural regions are areas with very low density of population that, however, live in large number of spatially spread small settlements. These territories cover significant part of states not only in Europe but on all other continents. This area represents more than 90% of extent in European Union with half of the population living in. If we use a criterion of OECD method for the determination of countryside then the qualified area represents 75,1% of the Czech Republic extent where are 79,3 % municipalities spread but with only 22,6 % of population living in. This situation brings many advantages but disadvantages too. Certain "information barriers" could be included among the existing and continuing disadvantages for the small regions which are plenty of professionally and legally complicated decision information mainly in written form and which are not adjusted and classified so that they comply with the need of users of rural regions.

Methods

The methods should correspond with the defined requirement for advisory information system. It is mainly information base definition that is a basis for application of methods used at information strategy creation, draft making and system implementation.

The information base could be classified on basis of primary information and met information.
In this case we will take as the primary information base the summary of information

Table 1: The structure of municipalities of the Czech Republic according to the territorial structure in 1.1.2005

Size of municipalities by number of inhabitants	Number of municipalities			Number of inhabitants in ths.		
	Total	Towns		Total	In villages	
		Number	%		Number	%
< 999	4972	2	0,4	1761	1760	58,9
1000 – 1999	652	56	10,6	904	814	27,2
2000 – 2999	198	81	15,4	484	275	9,2
3000 – 3999	101	74	14,0	347	93	3,1
4000 – 4999	64	53	10,1	287	47	1,6
5000 <	261	261	49,5	6447	-	-
Total	6248	627	100,0	10230	2989	100,0

Source: Census 2001

published on WWW servers accessible from Internet. This information could be classified under different views. It will be appropriate to use classification according to the content categories for the purpose of this information system creation, i.e.:

A. Information of identification character

1. Information on specific institution or on a region – reason and method of founding of the institution, or better its role, statement of policy, resort strategy, description of organisational structure, dislocation and topology, business hours etc., annual report, budget, management, list of organisations that the main one founds; information on culture, transport, school system, health service, environment.
2. Legislation – overview of most important and latest acts, resolutions or public notices.
3. Recent news – press releases for journalists, public relations.
4. Official statement – tenders, public tenders, and programmes called, organised, funded by the organisation, grant and subsidy proceedings etc.
5. Information of feedback from the information receivers (summary of frequent questions, contacts, most often problems etc.) and on organisation efficiency.
6. Data sources – data for download important for further use (i.e. maps, territorial plans etc.).

B. Information of decision-making character

7. Support for solution of main life situation of citizens – a place, a deadline and a method whom to approach with application, a complaint, an appeal, a description of the procedures and rules which the individual or legal entity has to comply with at different public proceedings, a title of adequate form and place where to get it, a procedure to by complied with by the institution whilst sorting these thing out, evaluation criteria and binding deadlines etc.

Instruction for main decision situations on the level of regional and local administration in area of management and marketing, municipality position, economic management and financing, subsidies, region development and administration, environment protection, territorial planning and building procedures etc and directions provisions (standards of numeric etalons) for data support of decision situations solution on a level of rural regions (i.e. prices, limits, rates etc.).

From the overview and the fig. 2 it follows that the advisory information system must extend complexly both the primary information base and met information base. It is important to focus on 3 aspects:

8. To extend necessarily the category of the content of primary information base by information such: „a support of the professional advisory during decision making on a level of rural regions“.
9. To respect necessarily the rules for creation of met information during solving the information system as described in the above section. The important met information is those that allow creation of effective filtration tools for the system and dynamic information representation of various characters (from the instructions for the decision situation solutions to a presentation of norms and directions of different type).
10. It is required to draft the technology architecture as three- tiered, i.e. on basis of Internet technology.
11.

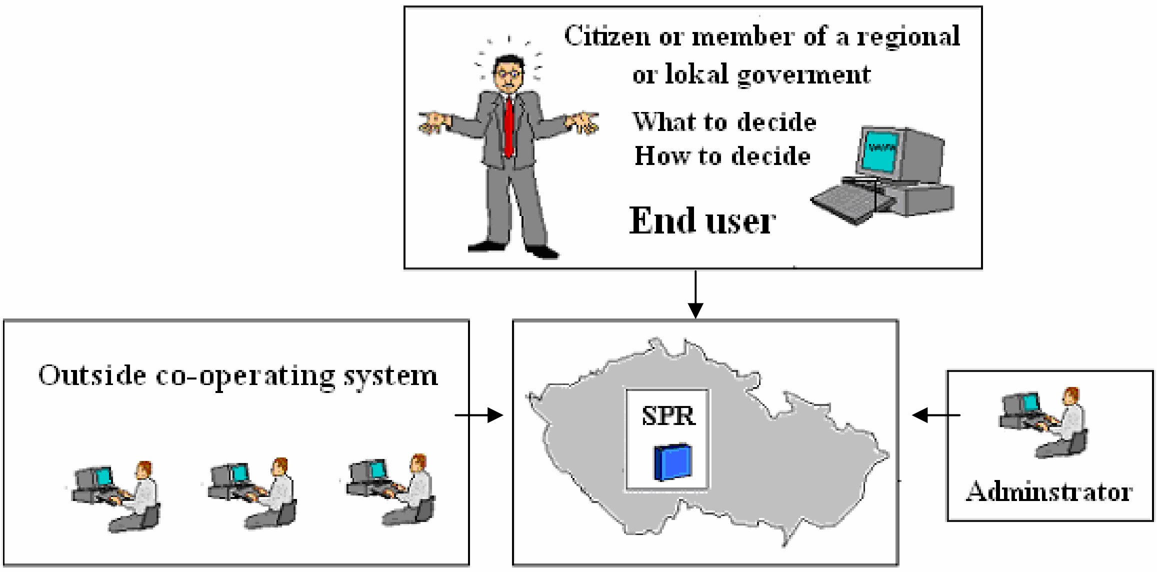

Fig. 2 Context diagram and model of a case for advisory system („SPR“) use

Results

Acquisition of indicators needed for decision-making on the level of rural regions

In total 11 websites were analysed for a purpose of information needs of an analysis in monitored segment. The classification criteria under the category of the content set on used methods were applied by the solvers on all above mentioned web sites. From the analysis it follows that there is a good level of providing the evidentiary and identification information. The imperfections are reflected mainly in information supplying for decision-making needs and in some cases also for their pre-elaboration so that the final decision is close to optimal state. It is therefore desirable to concentrate on such systems that will extend the support of decision making on a level of rural regions or better regional and local administrations via the professional advisory.

The websites evaluated: 1 – Portal of Czech public administration; 2- Electronic portal of local self-administrations; 3 – Electronic amiable administration; 4 - SW to support agendas elaborated on the level of villages and towns; 5 – Towns and villages online; 6 – Villages and towns association; 7 – Websites of Central Bohemia region; 8 – Websites of Benešov municipal authority; 9 - Websites of Rakovník municipal authority; 10 – Websites of voluntary association of villages in micro region Želivka (also Čechtice villages); 11 – Websites of Líšov municipality authority.

The structure of most frequent decision-making situation was surveyed partly with the mayors of chosen municipalities and partly by field research. Individual decision-making situations could be divided in the idea of the authors into fields and groups, better the tables that make "the structure of the tree-searcher" of advisory information system „SPR". They are the **fields** and groups-tables in line with table. 2:

Tab. 1: Results of evaluation of chosen websites

Order numb.	Evaluation criterion	Numbers for of evaluated websites											Points	Order
		1	2	3	4	5	6	7	8	9	10	11		
A. Information of identification character														
1	Information on the organisation, region or system	●	○	●	●	●	●	●	●	●	●	●	10,5	**1**
2	Legislation	●	N	○	●	N	●	●	●	●	N	N	6,5	**3**
3	Recent news	●	○	○	●	N	●	●	●	●	●	●	9,0	**2**
4	Official board	N	N	N	N	N	N	●	●	●	●	○	4,5	**4**
5	Information on feedback	N	N	○	N	N	N	○	N	N	○	N	1,5	**8**
6	Data sources	●	●	N	N	N	●	○	N	N	N	N	3,5	**6**
B. Information of decision-making character														
7	Support of solution of life situations of citizens	●	N	●	○	N	N	○	N	○	○	N	4,0	**5**
8	Instructions for solving the decision-making situations	○	N	○	○	N	○	N	N	N	N	N	2,0	**7**

● - is well ensured (1)
○ - is partially ensured (0,5)
N - in not ensured (0)

Tab. 2 Structure of the tree-searcher

1. Municipality position
1.1. Municipality and its position in public administration structure
1.2. Regional administration, rights and obligations
1.3 Administrative procedures, relationship of the citizen to a building law and to environment
1.4. Principles for employees conduct and actions at public administration
1.5. Citizenships and permanent residence, foreigners, asylum seekers, national minorities
2. Project management and marketing of municipalities
2.1. Project management problems
2.2. Project management methods
2.3. Practices of good project management
2.4. Risk management
2.5. Management in public administration
2.6. Quality management for the municipalities
2.7. Marketing for the municipalities
3. Economic management and financing of municipalities
3.1. Principles for proper economic management of municipalities, audit

3.3. Fundamental documents for finance management for the municipalities
3.4. Budgetary sources for financing of municipalities
3.5. Off-budgetary sources for financing of municipalities
3.6. Other forms of financing of municipalities
3.7. Methods of acquisition and use of subsidies for the municipalities
3.8. Programs, directives and measures within the EU funds
3.9. Programs, directives and measures within the CZ funds
3.10. Subsidies and aids related to rural development
3.11. Sale of the state land
4. Municipality development
4.1. Strategic plan, investment and economical development
4.2. Local plan and building proceeding
4.3. Strategy of integrated micro-region development
4.4. Landscaping
5. Municipality administration
5.5. Public notices and provisions
5.6. Municipal fees
5.7. Service to citizens
5.8. Housing policy
5.9. School system, culture and sport in the municipality
5.10. Social and health policy in the municipality
5.11. Security and order in the municipality
5.12. Local transport and communication
5.13. Games, clubs, markets, public gatherings, alternative punishments
5.14. Notary minimum
5.15. HR management, Labour Code, registry office
5.16. Communication with public
6. Civil issues
6.1. Citizens coexistence
6.2. Offences
6.3. Domestic animals
7. Environment
7.1. Water in landscape, water-protection measures
7.2. Water management
7.3. Waste management
7.4. Landscape maintenance of municipalities
7.5. Municipal forests
7.6. Protection of vegetation and agricultural land fund
7.7. State nature preservation - NATURA 2000
7.8. CHKO (protected landscape) in relation to the municipalities
7.9. IPPC directive in relation to the municipalities
7.10. Air protection against pollution
7.11. Parameters for classification of land owned by municipalities into LFA
7.12. Animal cruelty protection
8. Information support of decision-making
8.1. Orientation prices of selected services for the municipalities
8.2. Orientation prices of basic constructional material
8.3. Parameters of buildings
8.4. Values of air quality standards of polluting materials
8.5. Main indicators of potable water and their limits
8.6. Minimal annual number of samplings and scope of potable samples analysis
8.7. Indicators for water quality for swimming
8.8. Quality requirements for water sources for artificial lido
8.9. Requirements for quality of water sources for artificial lido
8.10. Establishment of intensity of water recirculation
8.11. Permissible level of noise
8.12. ÚHDP summary and land changes options
8.13. Summary of wood and bushes suitable to be planted in free landscape
8.14. Requirements for welfare of farm animals
8.15. Renewable an power engineering of rural areas
8.16. Volume weights of products and material
8.17. Measure units

9. Data sources – documents for download	
9.1. Documents for download	
9.2. Prices, costs, rates (material and service prices)	
9.3. Parameters, contents, boundary values (construction sites, land and landscaping, water, air, noise)	
9.4. Completing information (welfare, woods, volume weights, measure units)	
9.5. Programs, directives, measurements, subsidies and aids	
9.6. Quality management for the municipalities	
9.7. Marketing for the municipalities	

Tab. 2 Structure of links

1. Portals
2. Registers
3. Unions, associations, companies, political parties
4. Ministries, state administration authorities, reforms
5. Institutions, agencies, schools, education
6. Ethics at public administration
7. Programs of subsidies for the Czech republic
8. EU structural funds
9. Laws, public notices and provisions related to municipalities issues
10. Supplier area for municipal use

Tab. 3 Structure of output information for resolving the decision situations

Order numb.	Description	Note
1	Classification by subject	C
2	Classification by group of decision-making situations	C
3	Denomination of decision-making situation or question	C
4	Instruction for resolution of decision situation or answer to a question	C
5	Information connection as reference to data source or legal norm (law or provision)	C
6	Responsibility for solution	F
7	Deadlines for solutions	F
8	Formal particulars	F
9	Remedies	F
10	Note	C
11	Source and elaborator	C

Legend to the table:
C – Compulsory output at each DS
F – Facultative output at DS which is requires by the character

A set of records describing either decision situations or normative indicators belongs to each defined group.

Output information has for the solutions of decision situations a structure as in the tab. 3.

Only relevant data items were chosen with regards to a character of the system that is designed mainly for advisory and the structure of information provided is very heterogenic (from standard decision situations over decision situations from environment area, application of ISO standards in public administration, use of subsidies) and with regard to comprehensibility.
Output information from the area of data sources are very different and cover mainly the area of information support of decision-making as: price, rate, limits, parameters etc.

Data architecture

Information base important for project resolution will be created by a primary information base and met information base. These two bases will be mutually interconnected so it is possible to assign the characteristic to each data component or record in base of primary information. These characteristics must first of all respect the requirements for filtration and presentation of data.

Primary information base

Primary information base is logically created by two sectors: 1. decision situations sectors; 2. data sources sectors.

Decision situations sector (farther only **DS sectors**) is determined for data immediately related to solutions of decision situation. They are information as:

Decision situation → Manual for solution of decision situation → Reference to data source (if it exists)

Data sources sector (farther only **DS sector**) is determined for data sources that support the solution decision situations from DS sector. They are in part text or digital data as: parameters, contents, boundary values, prices, rates, costs and completing information and partly data sources – documents for download or links to official documents, laws and provisions.

A relational record-orientated E-R model of data placement is applied to both data sectors.

DS sector:

There is detached a type of entity from the DS sector that describes a solution of one decision situation in each data component unit. Apart from the data components designed for solution description the interconnecting components on met information base allowing assigning the characteristics either to the entity as a whole or to individual components is included.

The entity itself is identified trough assignment into "a structure of the tree- searcher", i.e. though a field, group of tables and a table a within a table through a group of records and a record. The table has a title and a legend.

DR sector:

DR sector is classified so that during the presentation to the users a specific set of database records creates a table with required information to support the decision-making (i.e. „Orientation prices of services for the municipalities"). The table or the group of records belonging to the table also have a title and a legend. The other data sources are party document for download and in part data sources as laws, notice, provisions, development programs and subsidy rules that are solved through the links to relevant websites (e.i.www.portal.gov.cz, www.mze.cz, www.mmr.cz, www.struturalni-fondy.cz, www.env.cz etc.) that includes required information. The information is thereby ensured u-to-date.

Met information base

There are incorporated the relevant information into the working database that characterises:

- Tree- searcher – is divided into fields and groups of tables inherent to the field
- Within the tables or on a level of decision situations is the identification of data components done by names;
- Key words = short names concisely characterising the tables;
- Identification of connection to data sources and links.

Functional architecture

The functional architecture follows from action model (see fig. 2) and could be explained using fig. 3 that schematically represents the sectors of system websites.

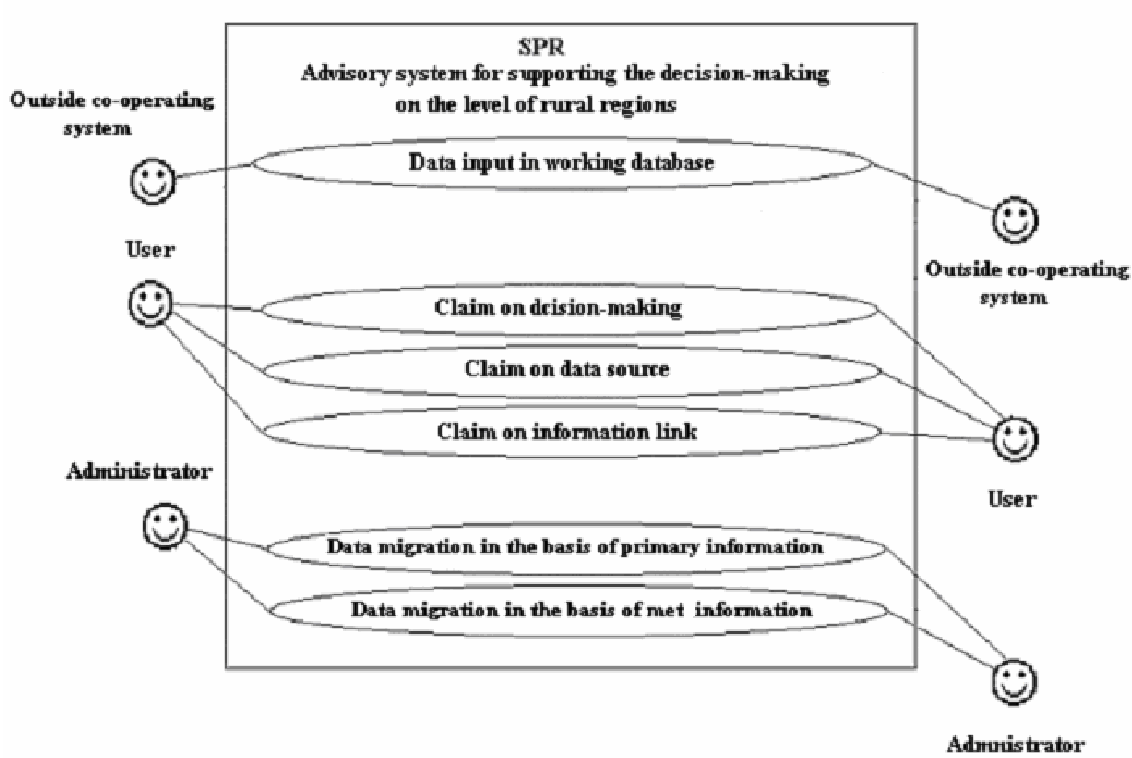

Fig. 2 Schematic representation of action model

The functionality of the system (fig. 3) is based on a selection of a set of decision situations (DS) and relevant data sources (DS) put in tables and consequent DS presentation of solution of given DS and adequate DS. It is possible to choose the set of decision situations (a table) in two ways: 1. by a searcher according to full text or key words; 2. by the tree- searcher.

The filtration tools select the relevant tables according to taxative selection of a key word or specification of continuous text and show their list.

The tree-searcher allows systematic representation of the tables. If the tables have the filtration of record structure permitted (mainly DS) a consequent representation of individual record is allowed (decision situations) or in each such table is the data component "Naming of decision situation or a question" in a form of hypertext link to record representation. Complete information will occur on one decision situation as in tab. 3 in this case. The tables from DS sector do not have permitted record structure.

A title and a legend with presenting the authors and literary sources are part of each table. If it is a DS table then it includes "an order number" in its simplified structure as well as "naming of decision situation or a question" and "Manual for solution of decision situation or answer to a question".

Part of a decision situation record is "the information link" in a form of a link to law, notice, provision, development programs and subsidy rules.

There is showed an example of graphic solution of interface for end user (search via tree-searcher) in the tab. 4. Other components of the functionality of "SPR" advisory information system could be found on website http://mmrapp.kapos.cz .

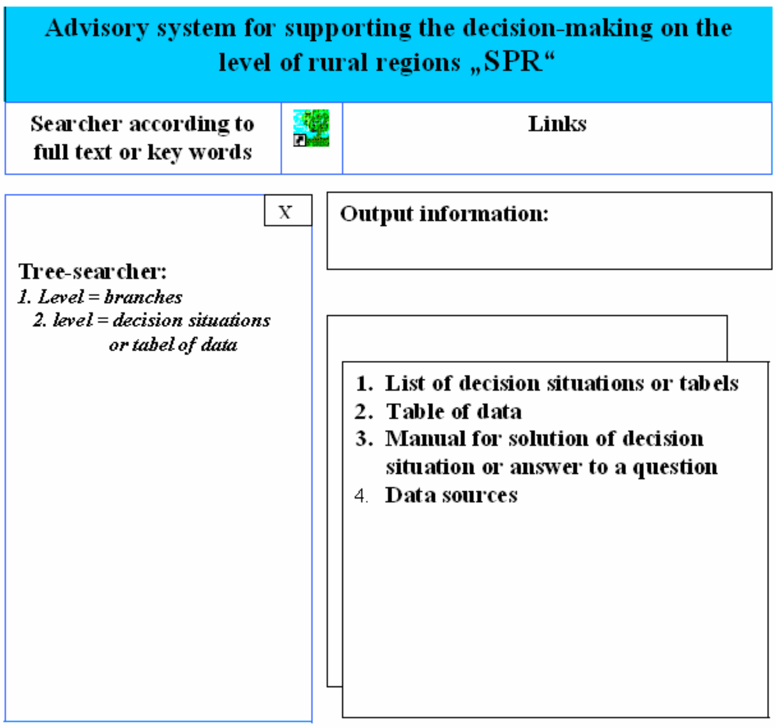

Fig. 3 Schematic representation of sectors of SPR system website

Fig. 4 Graphic solution of interface for the end user (search via tree- searcher)

Technological architecture

SW and HW is based oh the tree-layer architecture. MS Windows 98 and upwards in combination with Internet browser is respected at the end users.

Linux, PostgreSQL, JSP+servlet technologies are used on a level of information providers.

Conclusion

As expected solution of information system it is possible to obtain on a level of end users and mainly by the workers of regional and local administrations the right and practically usable data for achievement of competitive advantage and qualified decision-making in above mentioned areas. The identification advisory system is basically used to improve decision-making of regional and local administrations whereby it helps to improve their situation.

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STRUCTURE OF EXPERT SYSTEM FOR PRODUCERS OF BEEF CATTLE – SUPPLY OF FODDER

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The paper deals with the new method for multi-dimensional optimization of selecting the machines and devices for supplying the fodder for cattle. The method consists in working out the website on tractors, machines, and devices for preparation and supplying the fodder for cattle. The essence of the method is based on creating hyperlinks between windows and database on tractors, machines, and devices. Selection of given values of purpose function will result in a list of machines and devices corresponded to those values. The method is going to complete the lack of present methods for selecting the machines and devices for fodder supply for cattle.

Keywords: beef cattle, expert system

Introduction

Up to date, selection of machines and devices for fodder supply in inventory buildings for cattle was realized by means of single or multi-dimensional purpose functions. The selection was considered from a point of view of a single or many criteria, i.e. minimization of energy inputs, minimization of labor inputs, or cost minimization. The lack of existing methods was based on the impossibility to input immeasurable criteria to purpose function such as tradition in a region, machine's look or other impressions resulting from the opportunity of seeing it.

The aim of study

The paper is the attempt to work out a new method for multi-dimensional optimization of selecting the machines and devices for fodder supply for cattle. The method consists in designing and implementing the website on tractors, machines, and devices for preparation and supplying the fodder for cattle. The essence of the method is based on the creating the hyperlinks between windows and database on tractors, machines, and devices. Selection of given values of purpose function will result in a list of machines and devices corresponded to those values. The aim of this study results from the lack of present methods for selecting the machines and devices for fodder supply for cattle.

Concept for problem solving

Meeting the needs for fast and full access to information on tractors, machines, and devices for fodder supply for cattle, the attempt to create website as a information source has been undertaken. There is no website that contains information on above subject. Difficult access to website addresses and fact that information on them are mostly commercial offers from tractor producers, indicate the need to create website that would be a list of available tractors, machines, and devices for supplying the fodder for cattle to help breeders in selecting the most proper technical means, and even whole technologies.

The access to worldwide network is no longer the privilege of narrow group of computer users. At the same time, average, conscious Internet user sees the need to possess his own website and he quits his completely passive attitude. Designing of WWW has greatly changed recently. Once, websites were created by scientists who were aimed at presenting their own achievements to the stuff of other institutes. Those publications, due to large limitations of the Internet along with poor possibilities of HTML language, were visually little interesting. They were also simple in construction. When new versions of HTML language appeared as well as network development, websites became to look better and better. At present, websites created on a base of the newest solutions are often masterpieces of Internet art.

Methods for website creation

HTML

It was invented by Tim Berners-Lee, who worked as IT expert specializing in computer networks issues in Swedish Research Institute. He wanted to create simple language of markers for scientists making possible to transfer their study results via Internet. Tim Berners-Lee based his HTML on SGML language – international standard of text designation that makes possible to present a given document on different types of devices. The concept according to which the document presentation should be separated from its structure is basis of SGML:

- *Structure* is related to various documents or document fragments (titles, sections, headers, lists);
- *Presentation* is related to the way a given devices (computer, printer) can present particular components.

There are several important reasons, the separation of structure from presentation is principal:

- If markers define exclusively a structure, document's look may be very fast changed by the change of settings related to the presentation on a device displaying given document.
- Documents that contain exclusively markers of structural character are much cheaper and easier in maintenance.
- Document that contains exclusively markers determining the document's structure is more available for people having sight problems and other impaired persons.

At the very beginning, HTML did not differentiate structure from presentation as apparently as SGML's purists wanted.

XML 1.0

Extendable language of markers had to meet the requirements of electronic publishers. Its assumptions were to give it such elasticity to be applicable in many different applications for publishing. The point was to separate document's structure from their presentation as much as it was possible. At present, many newest programs for text edition contains XML components and even exports its documents using formants consistent with XML language.

CSS 1.0 and 2.0

Cascading Style Sheets were designed to remove formatting from HTML specification. CSS offers a mechanism that makes possible to define and change formatting with no need to change the basic code. Notion *cascading* relates to the fact that styles may interact to one another, which means that particular documents of WWW network may be formatted in different way than derived documents. Another version CSS 2.0 is based on previous one. However, it gives a designer of a website opportunity to apply larger number of attributes and properties (Pfaffenberger B., Schafer S., White C., Karow B., 2005).

HTML 4.01

It is a small correction of HTML 4.0 standard. In that version, general elements of XHTML were added and errors that have been noticed in HTML 4.0 have been removed.

XHTML 1.0

Extensible HyperText Markup Language is a successor of HTML language. XHTML was designed to be used in environments consistent with XML language, but it is also compatible with standard HTML browsers.

CSS

Internet's evolution was also associated with evolution of technologies used to create websites. Websites are displayed not only on computer's screens, but also mobile phone's displays and other mobile devices, printed on printers and read by devices, the sight impaired people use. Thus, the need to set the page formatting standards arose, which would allow for separating the document's text from its look. Such an assumption was designated by CSS (Cascading Style Sheets) inventors (Meyer E.A. , 2005).

Due to cascading worksheets, many kilobites are saved in a form of page files, and full control on its look, which can be changed through the modification of a single file containing the styles definitions. Necessary information for browser to properly format the text, are contained within style sheet being used be a browser to display particular components of a document. Due to cascading sheets, it is only necessary to change a single style sheet used by all elements of a given page to have another look of that page.

JavaScript

HTML documents may contain scripts, applets written in other languages such as Java or JavaScript. JavaScript much widens the possibilities of HTML standard, because it makes possible to create websites that dynamically change depending on activities done by a system or a user; it makes easier to organize, to process, and to achieve information from WWW. Java is quite simple script language for Internet documents. JavaScript language appeared for the first time under the name of LiveScript as a command language created by Brendan Eich. At the end of 1995, cooperation of Netscape Communications with Sun Mikrosystem led to the beginning of JavaScript based on Java open script language for the Internet. JavaScript is very closely associated with HTML and Netscape Navigator browser. There is a spectrum of tools written in that language, that make possible to operate with currently displayed document, to study the current browser's status, to open new windows, to access to history in a browser, particular form fields and other document's elements.

JavaScript is interpreted language, which means that scripts do not require compilation. To execute any script in this language, only browser interpreting JavaScript language is needed. Of course, the script must be properly associated with HTML document. JavaScript is object-oriented language, but it has limited possibilities for object programming. Due to it, object programming is available for average website designers, and opportunities to use numerous built-up objects and their methods makes work easier and faster (Siatecka J., 1999).

JavaScript is a language, that can be quite easy learnt and start to use. It is an excellent solution, when much more functionality should be added to a website. It is high-level language with wide opportunities. It allows for realizing many functions that otherwise would be made on a server. It also may read and save cookies.

Millions of websites contain JavaScript; it is the most popular script language on the network. It is still developing. New versions improved by new opportunities and more efficient tools and solutions, and modifying existing elements of the language are created every year. That language is operated by the majority of more popular browsers.

JavaScript is perfect for servicing the repeatable tasks that are associated with a given event. At present, it is the most popular language that makes communication with a user who visits WWW more efficient, and that enriches websites with new, interesting elements. The best application of JavaScript is fast modification of HTML documents that exist, creation of small and simple programs on a website. Creating interactive, multimedia applications on websites and containing various interesting and below useful elements is the most common:

- Dynamic forms with control of correctness of entered data before sending them to target server.
- Calculators and worksheets adapted to given needs, e.g. calculators recalculating units or calculating loans or mortgages.
- Interactive games, page browsers, tables, clocks, images.
- Simple help system (communicates on status within browser's window).
- Mobile text, sounds, simple animation or other multimedia elements as well as effects such as:
  - Interaction with user through warning communicates, dialogue windows and events associated with a particular action, e.g. form button click.
  - Dynamic modification of website look, e.g. setting by user the color of background, text and hyperlinks, as well as automatic selection of hello communicates depending on a date and time of website opening.
  - Possibility of analyzing or creating URL addresses on a base of data entered into the form as well as operating the history list in a browser.
  - Possibility of opening and closing new browser's windows as well as shaping of their look and content.
  - Dynamic creation of HTML document depending on user's requirements.
  - Possibility of dividing the browser's window into larger number of independent parts (frames) at remained communication among them.
  - Operating with add-ons that widen the browser's possibilities at handling with new data types.
  - More advanced mathematical calculations (Siatecka J., 1999).

PHP

The first PHP (*Personal Home Page*) was a program invented in 1994 by Rasmus Lerdorf. It was aimed at operating the author's website. At present, PHP stands for *Hypertext Pre-processor.* PHP is a script language as opposite to programming language, and is built into the HTML. It means that PHP is designed in such a way to execute operations after a specific event happens. Programming languages such as Java, C, or Perl may be used to create separate applications that need not use network. JavaScript used to operate events inside WWW browser is the most popular example of such script language. PHP is at present the most popular tool used for creating dynamic websites (PHP, Larry Ullman).

MySQL

MySQL is a very fast and reliable system for managing the relation databases. The database makes possible to efficient storing, searching, sorting, and reading data. MySQL server makes a control over an access to them to make sure many users access, guarantee fast access, and access only to confirmed users. It means that MySQL is multi-access and multi-task server. It uses SQL that is worldwide standard of question language within MySQl database. MySQL has been available to public since 1996, but its creating history reaches 1979 (Welling L. , Thomson L., 2003).

Method verification

The website is going to present information on tractors, machines, and devices for fodder supply for cattle in accordance to Catalogue of Agricultural Machines and Devices (2005). The database includes:

Fodder cars – catch machines that mix, break, and unload fodder at any place; drive is transmitted from a tractor through power receiving shaft; they are equipped in systems for double-side unloading.

Robots for fodder supply – for supplying the concentrated fodder; it automatically supplies measured portion of concentrates several times a day. The radius is about 50 cm, particular stands for fodder supply are marked by installed special magnets on a bar, reservoir is made of concentrated plastic, installed long-life batteries, dosage is based on the rotary velocity of a screw transporter, which makes possible to extremely accurate supply of a specific fodder amounts in 1-4 different portions.

Cars for fodder supply – for transport green and dry forage to their loading into the cribs and filling column and passing silos; they may be combined with a tractor or other agricultural machines such as field or self-propelled chaff-cutters, cutter-loaders, or cutters; they are equipped in floor longitudinal and transverse transporters; car may be unloaded from a side using above transporters and from a back using longitudinal transporter. They have pneumatic breaking systems. In addition, manual break serves to stop loaded car on a road of up to 16 degree inclination. Permissible speed is about 20 km/s; unloading time = 180-600 s.

Mixers for fodder preparation and supply – mixer hung on a tractor makes possible to fodder preparation at places far from electric power supply; it eliminates the need to apply additional transporting means and people for transporting of fodder produced; its power requirement is from 25 to 45 KM.

Fodder transporters – for supplying prepared fodder from a mixer, supplying broken fodder from own crusher or breaker; it may also supply grains from a prism, reservoir or crusher.

Bowl drinking toughs – it consists of cast-iron bowl, body, vent, cover, and connector; metal button mounted with the hinge to the body is inside the bowl. Water supply into the bowl is possible when animal presses the button that opens the valve. After button release, the spring is released and presses valve closing the water supply. Bowl drinking tough is adapted to be connected to water system of 100-500 kPa water pressure (Dmitrewski, 1978).

Fodder reservoirs – a set consists of three reservoirs, 1600 liter capacity each, spring connecting the input box with reservoirs of 8 meter long each, input box as well as optional spring for fodder transporter of about 5 meter long.

Software integrated in FoxServ, including Apache server for operating with MySQL system and PHP language as a specific bridge between database and HTML programming language was used to create the database. Selection of those programs was perfect not only sue to economical reasons (free software), but also interaction of software used. From a point of view of project designed, applied technologies are a perfect tool for creating the dynamic websites, their modernization and development (Siatecka 1999).

Figures 1-3 present the examples of database windows and website on devices for fodder supply for cattle.

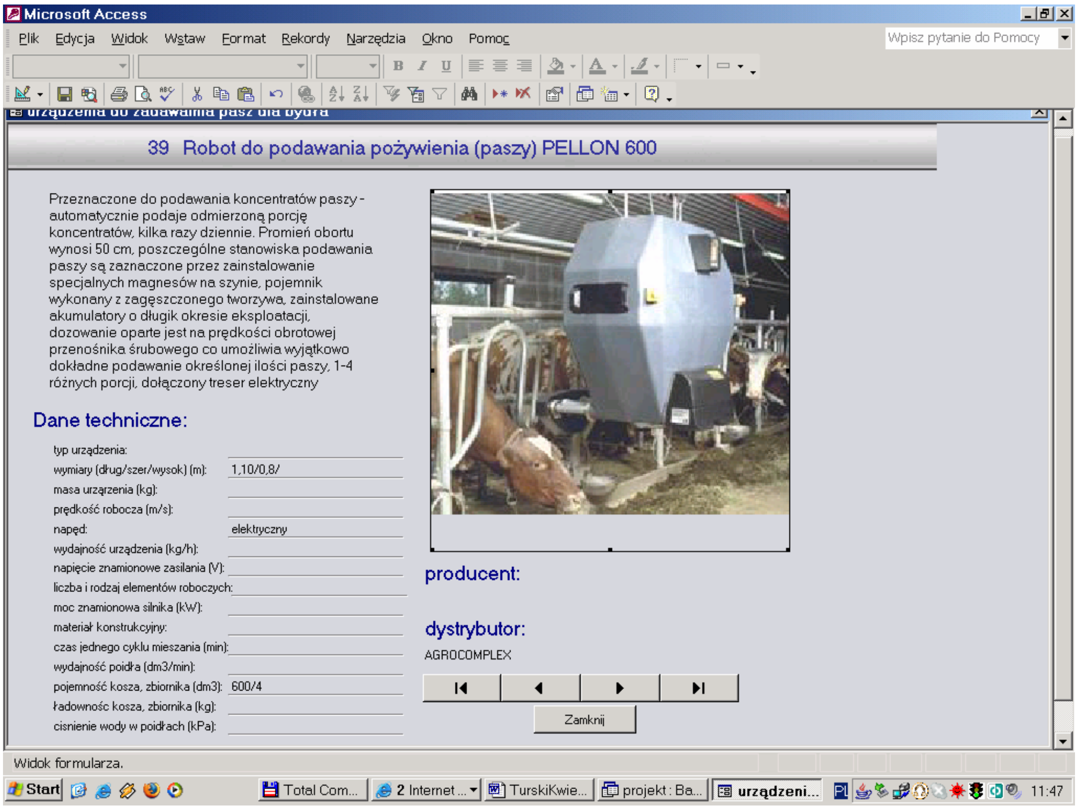

Figure 1. Fragment of database on devices for fodder supply

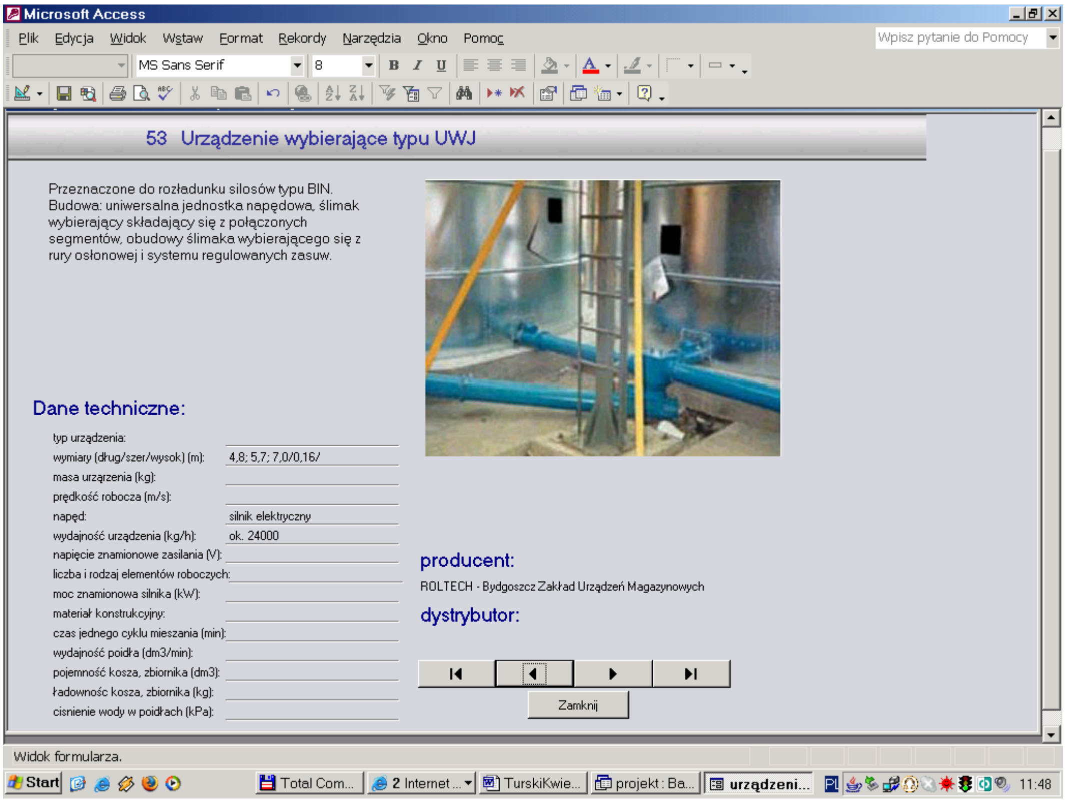

Figure 2. Fragment of database on devices for silo unloading

Figure 3. Fragment of website on devices for fodder supply

Summary

Worked out method uses appropriately created database and may be a tool useful in advisory system for cattle producers. Easily accessible and functional database is a useful instrument for collecting and updating the information as well as it makes easier to select devices for a given farm. Website designed using the database makes possible to select all types of devices that can be applied for fodder supply in a cow-house with a given width of a fodder passage. Accepted way of website programming makes possible to easy modify its content or improve by another modules for machine selection, e.g. machines for waste removal, or mechanical milking.

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STRUCTURE OF EXPERT SYSTEM FOR PRODUCERS OF BEEF CATTLE - PREPARATION OF FODDER

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The paper deals with the principles of website providing quick and full access to information on tractors, machines, and devices for fodder preparation for cattle. There is no such website that would contain data on those subjects, the access to few addresses is difficult, and information on them is most often of commercial character of agricultural machines and devices producers. There are literally no websites with a full list of available tractors, machines, and devices for preparation and supply fodder to cattle that would contain their specifications to help breeders to select proper technical means and even whole technologies.

Keywords: expert system, preparation, fodder, beef cattle.

Introduction

Internet gains more and more popularity. Number of people who have access to the web still grows. Application of Internet due to electronic mail, purchase or banking service becomes more and more common, and applications widen, which of course is positive phenomenon. Websites on various subjects are still created, and thus Internet is an enormous source of information. For many people, it is a primary tool at work and its role still grows.

World Wide Web arisen 10 years ago in CERN Laboratories in Geneva is the best known and the most popular part of the Internet. Due to it and hyperlinks, surfing through the cyberspace can be possible.

The aim of study

Meeting the needs for fast and full access to information on tractors, machines, and devices for fodder supply for cattle, the attempt to create website as a information source has been undertaken. There is no website that contains information on above subject. Difficult access to website addresses and fact that information on them are mostly commercial offers from tractor producers, indicate the need to create website that would be a list of available tractors, machines, and devices for supplying the fodder for cattle to help breeders in selecting the most proper technical means, and even whole technologies.

Concept for problem solving

Up to date, four basic methods for selecting right set and number of aggregates in a farm were used.

Coefficient method consisted in calculating the number of tractors and agricultural machines on a base of cultivated area and coefficients characterizing the requirements of a given tractor or a machine per cultivated area unit.

Indicator method represented little higher accuracy level than above one and based on cultivated area structure, which was the initial point for calculating the amount of works per year and requirements for a machine on a base of its annual efficiency. Mechanical power was calculated on a base of motorization index or a given work mechanization and annual index of mechanization means utilization.

Technological method consisted in technological cards of particular plants as the basis for calculations of requirements for agricultural machines. Cards contained the type of works, way of their doing and number of needed tractors and machines.

Another method for selecting means for mechanization of works in agriculture, bases of which were created by Zelent (1967), was based mainly on principles of linear programming. Linear programming was also used with some modifications by Wawrzyniak (1983). He created a linear model, in which year was divided into six agrotechnical periods. Those periods were not joined to one another and were shorter than permissible lengths of agrotechnical periods to ensure the reserve. The Author did not changed the work inputs for such determined periods, which was due to the fear of excessive peaks flattening, i.e. not providing sufficient number of means for work mechanization. Accepting minimum costs as the purpose criterion, the solution contained machines of a minimum efficiency that might do a given work, but number of tractors was equal to the need in a period of the highest intensity of field work. Woźniak (1984) applied similar attempt.

Marszałkowicz (1986) proposed to select machines and devices by means of marginal multi-variant optimization. It consisted in optimizing the model of linear balance conditions at non-linear purpose criterion, that production, or profit maximization, or cost minimization at a given production size could be.

Pawlak (1975) presented model method for mechanization prediction on a base of average necessary work mechanization level depending on labor resources and production size. Rychlik *et al.* (1970) discussed mathematical models worked out on a base of linear programming methods. He indicated that linear programming needs, among others, to define both form of purpose function and set of limiting conditions that describe surrounding of applied solutions.

Summing up, there is no method that uses Internet to help making a decision on selecting machines and devices for preparing and supplying fodder for cattle.

The paper presents new method for selecting the tractors, machines, and devices for fodder supplying for cattle. The method is based on a proper database and implementing it on website. Such solution would make possible to the user constant and full access to information on technologies for fodder supply. Following groups of machines are going to be found in the database:

Fodder cars – catch machines that mix, break, and unload fodder at any place; drive is transmitted from a tractor through power receiving shaft; they are equipped in systems for double-side unloading.

Robots for fodder supply – for supplying the concentrated fodder; it automatically supplies measured portion of concentrates several times a day.

Cars for fodder supply – for transport green and dry forage to their loading into the cribs and filling column and passing silos; they may be combined with a tractor or other agricultural machines such as field or self-propelled chaff-cutters, cutter-loaders, or cutters; they are equipped in floor longitudinal and transverse transporters; car may be unloaded from a side using above transporters and from a back using longitudinal transporter.

Mixers for fodder preparation and supply – mixer hung on a tractor makes possible to fodder preparation at places far from electric power supply; it eliminates the need to apply additional transporting means and people for transporting of fodder produced; its power requirement is from 25 to 45 KM.

Fodder transporters – for supplying prepared fodder from a mixer, supplying broken fodder from own crusher or breaker; it may also supply grains from a prism, reservoir or crusher.

Bowl drinking toughs – it consists of cast-iron bowl, body, vent, cover, and connector; metal button mounted with the hinge to the body is inside the bowl.

Creating modern, multifunctional, and clear websites forces designers to apply advanced technologies that considerably widen static HTML language. Fast uploading the WWW services and its efficient dynamics is a principal programmer's aspiration, because it ensures the maximum efficiency and prospering of the subject itself, website of which is devoted to.

Prior to presenting the website related to selecting machines and devices for fodder supply, FoxServer software should be installed on a computer. It contains modules required for appropriate starting the application, i.e. MySQL database server, Apache server, and PHP language interpreter. When installing, license conditions should be confirmed, and then installation is automatic on drive C. After that, program can be started by pressing icon Run FoxServ on a Desktop, and then any web browser can be opened to enter *http://localhost* instead of address. PHP MyAdmin should be opened at MySQL software logo. In a field *Creation*, enter the name of database created (*Database*), then in a window *Text File Localization*, find the file *SQL Database*, open it and confirm creating a new database. The whole folder *Work* should be transferred on drive *C:/FoxServ* to folder *WWW*. At last, start the browser and enter *http://localhost/nawożenie* instead of address. It will start the database created.

PHP technology in combination with MySQL database is perfect for creating dynamic websites and considerably widens the possibilities of static HTML language. In addition, an opportunity of easy learning the script language principles (PHP) and its numerous advanced functions is a virtue. Furthermore, FoxServ tool configures its components for working as opposite to install every server separately, where it has to be done manually. It makes significantly easier to apply that technology, namely less advanced computer users.

Method verification

There is unlimited number of information in Internet placed on thousands of servers. To get desired information, its localization is needed (URL address). It is possible only when accurate address is known. Otherwise, finding it in specialized browser systems would be more efficient (Bremer A., Sławik M. 2005). Positioning of websites in searching systems consists in actions tending to ensure high position of promoted domain under given keywords, e.g. *www.nawozenie.pl*. Indexing systems search through the WWW resources making possible to fast localization of specific information and allow for defining the searching criteria. So-called *Robot* is a basic part of a browser; it continuously searches for the Internet resources. These are the most commonly used website browsers: Altavista http://www.altavista.com, Google http://www.google.pl, Net.Sprint http://www.netsprint, Netoskop http://www.netoskop.pl (Bremer A., Sławik M. 2005). Databases in browsers are automatically created using special programs for screen scanning. Finding appropriate information on that basis is possible due to a mechanism allowing users to ask the question and list of hyperlinks meeting those criteria is a result. Designing of the source code for a website in order that indexing systems could effectively and properly register it is an important element. It should consist of website title, keywords, and website description. Website title contains 8-10 words that contribute to the fact it is better seen in searching results displayed by indexing systems in a form of reference. It sounds promising and contains general information on the project content. Keywords used in a project consist of not more than 100 characters, e.g. *mineral fertilization*, *organic fertilization*, etc. They contain words that best characterize the website content and ensure displaying by all browsers. The website description contains about 250 characters including spacing and it is very clear and compact. Main Page (Figure 6.1.1.) contains general information referring to the website subject given in such a way to encourage user for further reading. Moreover, it contains a variety of elements to interact with a user (entering buttons). Selecting the hyperlink from a vertical or horizontal menu, go to particular pages. Every page has a unique structure and more or less developed, but similar functionality as Main Page. Figure 1 and 2 present the fragment of page on selecting the tractors, machines, and devices for fodder supply. Selection can be achieved on a base of given values of volume or width of a device; these parameters are associated with the animal population in a cow-house and dimensions of animal compartment.

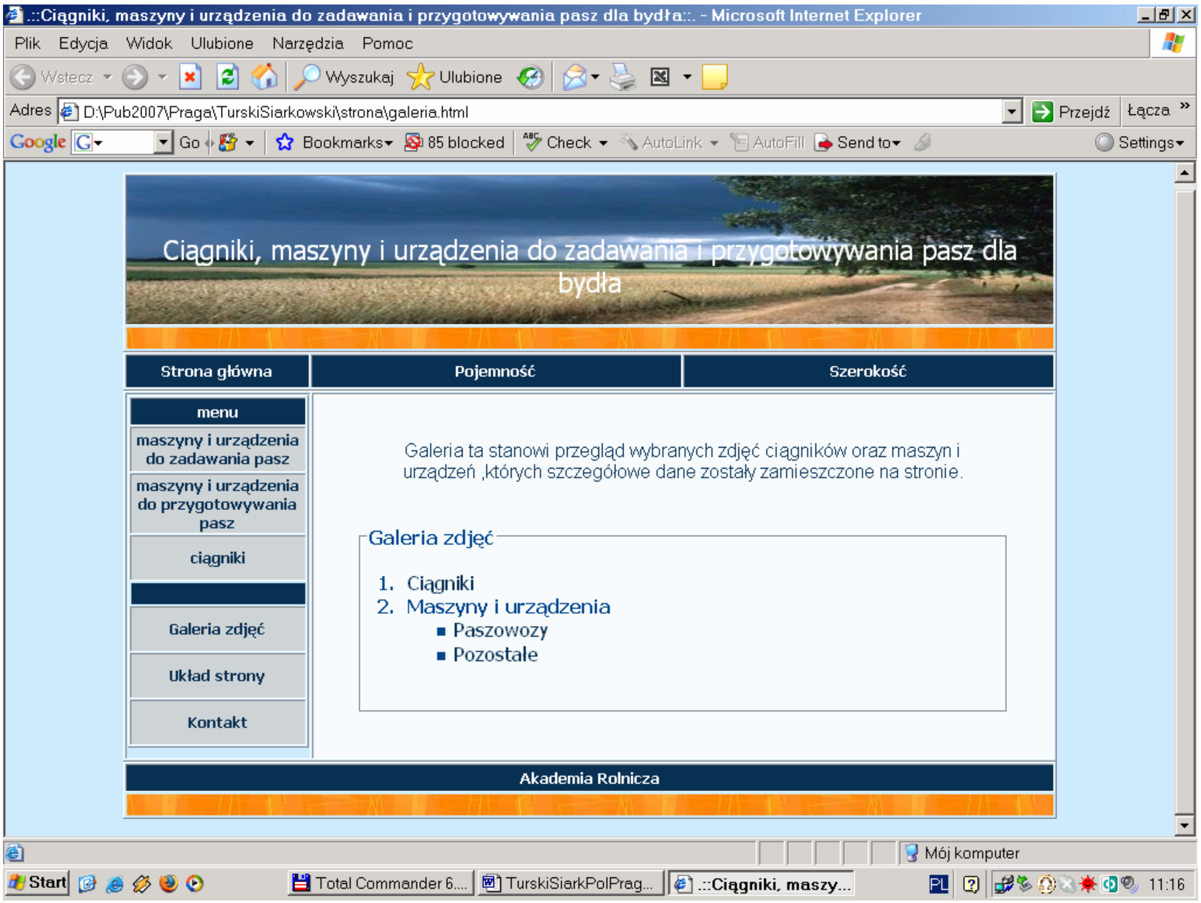

Figure 1. Window for selecting the device for fodder supply in a cow-house

Figure 2. Example window for presenting the fodder supplying cars in a cow-house

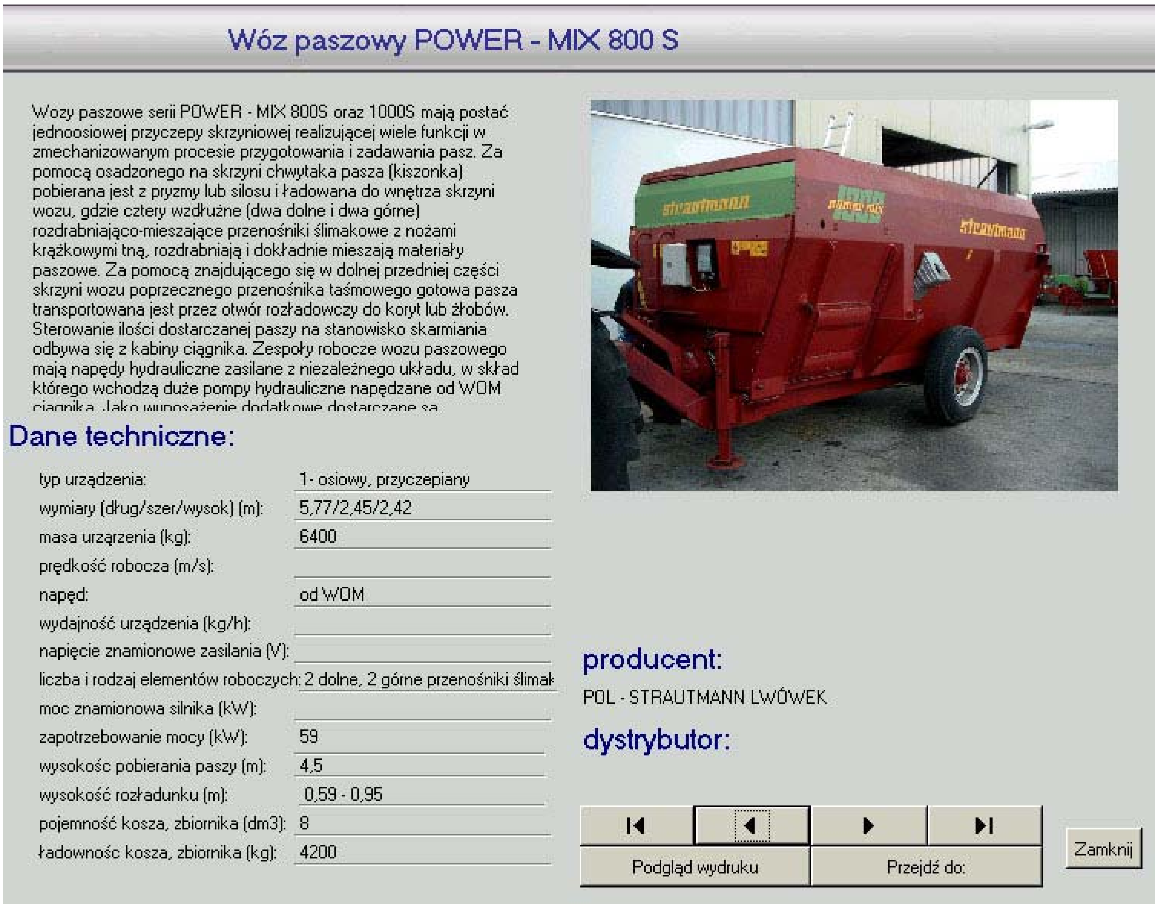

Figure 3. Example form of a page with fodder supplying car description

Summary

The paper presents the website on tractors, machines, and devices for preparation and supply of fodder for cattle. Created website provides with fast and easy access to information contained. Software integrated in FoxServ, including Apache server for operating with MySQL system and PHP language as a specific bridge between database and HTML programming language was used to create the database. Selection of those programs was perfect not only sue to economical reasons (free software), but also interaction of software used. From a view of project designed, applied technologies are a perfect tool for creating the dynamic websites, their modernization and development. The website uses appropriately worked out database and may be a tool useful in advisory system for cattle producers. Easily accessible and functional database is a useful instrument for collecting and updating information as well as it make easier to select machines for a given farm. The method makes possible to select all types of devices applicable in cow-house with a given width of fodder passage. Accepted way of website programming makes possible to easy modify its content or develop by another modules for machine selection, e.g. machines for waste removal or mechanical milking.

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FEASIBILITY STUDY ON A REAL-TIME DIRECT NOZZLE INJECTION SYSTEM FOR SITE-SPECIFIC PESTICIDE APPLICATION

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The aim of this study was to optimize a direct injection system for real-time site specific herbicide application. According to the process flow the system was investigated in two separate parts: injection system, and transport and mixing system. In order to reduce the response time of the injection system, design optimization of injection device is needed. However, the control process represents the main optimization potential of the injection system. Hence, the injection system and new control process has been developed and tested.

The transport and mixing time depends directly on the distance between the injection point and the nozzle. However, the whole homogenization process has to be finished before the mixture enters the nozzle. The aim of optimization was the transport and mixing time reduction and simultaneously achieving of desired mixing homogeneity of CoV 5%. The combination of new designed and controlled injection system and reduced mixing chamber provided demanded homogeneity with response time less than 400 ms for the 2.5% output concentration.

Introduction

Precision farming has become topical in recent years. The reduction of the chemical load in the environmental and “intelligent” handling of pesticides is often emphasized. Audsley (1993) has predicted that the economic value of spraying will increase as the minimum area that can be selectively handled is reduced.

There are two ways to control the site-specific pesticide application. Offline application is based on the maps and the position detected by Global Positioning System (GPS). The pesticide targets are known before application and demanded pesticide mixture can be prepared in advance.

Real time controlled application (Figure 1) is based on application maps (soil type, application history) as well as on the current position of diseases (weed, fungus, etc.). This system combines the knowledge of the offline control system and of a real time sensor monitoring current diseases distribution. Thus the efficiency of chemical applications is decreasing environmental contamination and crop stress. In this case, there is no information about the mixture needed in advance. The application technique preparing the mixture on demand in real time has to be developed. It is assumed that the distance of sensor and nozzle must not exceed one meter to ensure the stability of the boom. Consequently the systems response time is not allowed to exceed 0.33 s by traveling speed of 3 m s^{-1}.

The direct injection systems (DIS) for crop sprayers are developed to enable the site-specific pesticide application in the field, to reduce the environmental pollution and to preserve the operator’s safety. The basic principle of DIS is that water and pesticide are kept in separate containers. By activating of DIS a metered flow of pesticide is injected into the water stream. The water stream intermix the injected pesticide and transports the mixture to the nozzle. The investigation of injection point position (Hloben et al., 2006) showed that the injection point has to be moved close to the nozzle orifice and that further optimizations of the injection system are necessary to reduce the response time as demanded.

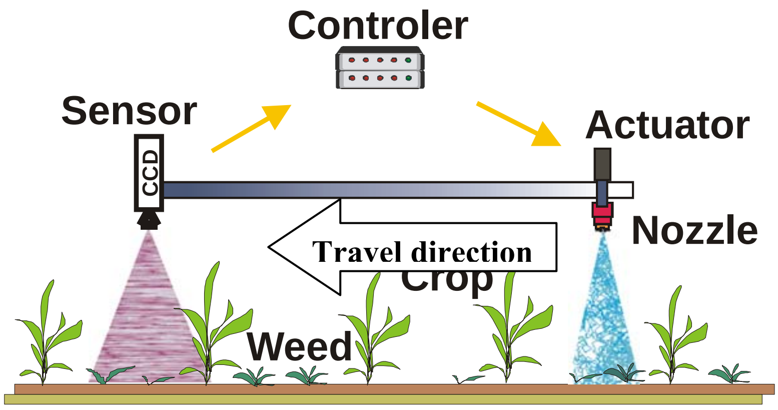

Figure 1 Principle of real time pesticide application

An effective water-herbicide concentration is needed before the mixture enters the nozzle, which applies it on to the target area. The BBA (German Federal Biological Research Centre) has determined the quality of the mixture in a conventional sprayer tank to have less than a 15% deviation in homogeneity. In a typical industrial mixing process an additive might be considered well mixed at 5% CoV (Paul et al. 2003). In a direct injection system the 5% CoV can be taken as the limit for a well mixed homogenous mixture as well.

The aim of this study was to develop an appropriate injection system and to optimize the mixing process in order to reduce the transport and mixing time.

Material and Methods

Injection system

The injection characteristic (concentration vs. time) of the DIS was divided in two parts: transport and mixing, and injection. A typical DIS characteristic is presented in figure 2. The response characteristics of the injection system is called injection time (T_{inj}) – e.g. the time between the control units start signal and the demanded pesticide flow at the injection point - IP (Figure 3). The response characteristic affected by the distance of injection point and nozzle orifice is called transport and mixing time (T_{tm}). This time delay is caused by transporting and mixing the pesticide from the injection point (IP) to the nozzle orifice.

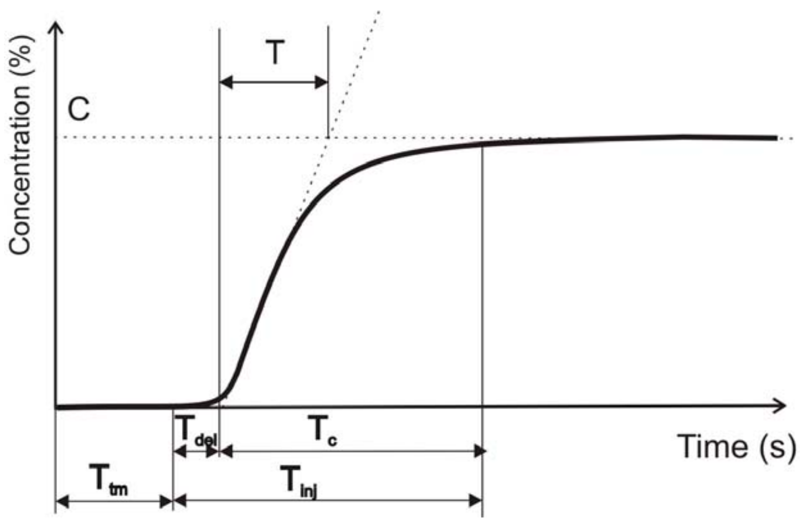

Figure 2 Injection response characteristic of direct nozzle injection system after the start of pulse

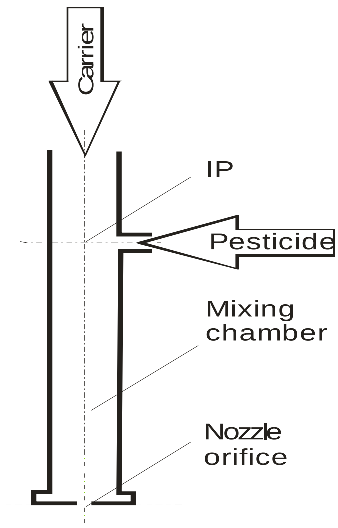

Figure 3 Scheme of DIS nozzle body

Injection time (T_{inj}) is divided in two phases. The first phase is the delay of the injection device (T_{del}) - means the time from the pulse start to the first response. The second phase is the exponential concentration gain. The time delay can be characterized as the time after the start of pulse to the first response in the injection point IP (crossing of the tangent meeting the concentration in the main gain and the zero concentration). The compensation time ($T_{c)}$ is characterized by the time constant T depending on the DIS properties. It is given by the cross points of tangent and the concentration levels. To reduce the injection time, the optimization potentials were looked for experimentally.

The transport and mixing time (T_{tm}) can be calculated from the volume between the injection point and the nozzle orifice, and the carrier flow rate (Frost 1990). Consequently, the time delay is influenced directly by the volume of the space between injection point and nozzle orifice, because the carrier flow rate is given by the application process. To reduce the transport and mixing time, the mixing chamber and other "technical" volumes have to be minimized.

Design of the laboratory test bench

The laboratory test bench for simulation of a direct nozzle pesticide injection was set up. The test bench consists of two separate systems: carrier circuit and direct injection system, meeting close to the nozzle orifice. The nozzle bodies have been manufactured to enable exchanging of injection units as well as mixing chambers. The carrier circuit has been connected to the water pipeline with flow control valve in order to provide the demanded pressure.

The metered flow has been created using different orifice plates and the proportional flow control valve to set the difference pressure between pesticide flow and the carrier water flow. A non-return valve has been set in the DIS to preserve the back flow of pesticide. Additionally, a fast reacting proportional valve has been tested and optimized for the pesticide injection. The injected volume has been measured as concentration on the nozzle output using conductivity method.

Mixing process

To reduce the volume of mixing chamber (transport and mixing time), the mixing process was analyzed using test results and modeling. The mixing process inside the mixing chamber of real time controlled systems must be continuous and as fast as possible.

The requirements on mixing process in direct nozzle injection process are as follows:

- The demanded CoV value was set to 5% (see above).
- The mixing process has to homogenize the mixture in all flow regimes.
- Every mixing process output depends directly on the input fluid properties and mixing ratio. The mixing ratio varies from 1:10 up to 1:2000 in pesticide application. The agrochemicals injected have different viscosities and densities. The properties of carrier-water are relatively constant.

The flow is laminar or turbulent, either single or multiphase in the crop sprayer nozzle. There is static or motionless mixers only one design class option for the continuous mixing process. Because of the need to blend with different flow regimes and fluid properties three different mixer designs (KMS, SMX and QADRO) have been chosen for direct nozzle injection systems.

The Computer Fluid Dynamics (CFD) software from Comsol Multiphysics was used for theoretical investigation of the mixing process. This software allows modeling of flow relations as well as chemical reactions in laminar flow. Because of the numerical diffusion effect by CFD software, the results were compared with known data from literature and verified by experimental methods afterwards.

The process results for mixing chamber were correlated by plotting the coefficient of variation reduction / concentration homogeneity (CoV_r = *final CoV value/initial CoV value*) versus length/diameter ratio (*L/D*). In laminar flow there is no effect of viscosity on these correlations by motionless mixers. CoV_r was correlated with the *L/D* in an exponential form,

$$CoV_r = K_i^{L/D} \qquad (1)$$

where blending coefficient K_i depends on the mixing device design and flow regime. The CoV_r represents the effect of mixing ratio in this case.

The initial injection position affects the quality of mixing, especially in motionless mixers where the division on the edge of an element is important for the mixing process. The determination of the optimal inlet position is also necessary for the mixing chamber design.

Results

Optimization of injection process

The injection characteristic of the injection system has been studied in order to optimize the injection time. Two basic areas of the system have been optimized. This system response is characterized by the exponential concentration gain. System design optimization considered on increasing of concentration gain. Furthermore, the control process was optimized in order to use the system potential.

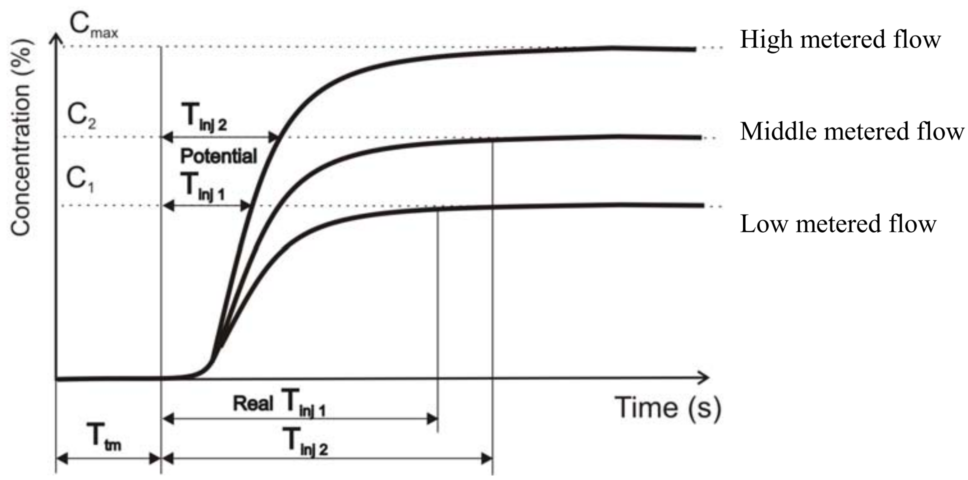

Figure 4 Comparison of injection characteristics of three different injected flows

Development of new control process

In order to use the full potential of the injection system, the control process of the DIS has to be changed. The optimization is based on the specifics of the injection process and different injection flows have been compared (Figure 4).

According to injection characteristics of three different metered flows presented in Figure 4, lower concentration level was reached earlier if higher amounts were injected. Because the potential injection time (T_{inj}) to reach demanded concentration level is significantly shorter than the real injection time, a new dynamic control system using the fast concentration gain after start of injection was developed. The metered flow was stabilized after reaching demanded output concentration.

System design optimization

To preserve any time delay, the injected liquid should be as close as possible to the carrier flow channel (the dead volume has to be minimized). The injection device requires a low pressure drop and the injected chemical should be delivered by powerful device to reach higher injection elasticity (speed of concentration change). An air pressure tank is not suitable device for direct injection in the nozzle, because of the air compressibility, which leads to the decrease of injection elasticity after the start of injection. The combination of aforementioned parameters could several times intensify the injection elasticity. In cooperation with DLR (German Aerospace Centre) the new design of fast reacting magnetic valve has been developed for the purpose of pesticide injection on the nozzle (Figure 6). The valve has been designed with a seat combined with carrier flow channel. The chemical inlet is positioned close to the flow channel to minimise the dead volume between chemical and carrier flow channel. The dead volume causes longer response time and lower dosing accuracy. The concept of the valve allows free combinations of more valves with possible small volumes between first and last valve to reduce the transport time of injected chemicals to nozzle. Thereby one valve per nozzle could be used as well as three or more, depending on number of chemicals to be injected. The valves create one injection unit which is positioned directly before the mixing chamber and nozzle.

The combination of powerful injection system with an appropriate control process caused a rapidly shortening of the injection time. The fastest injection times measured under laboratory conditions were between 40 and 80 ms depending on the injecting volume flow and carrier flow rate.

Mixing chamber

To reach possible shortest response time of the DIS, the distance between the pesticide injection point and the nozzle orifice have to be minimized. The continuous mixing process efficiency depends directly on the flow regimes, mixing fluids ratio, and fluids' properties. Consequently, there is no universal solution for the mixing process. Mixing chamber must be designed for each process individually according to process requirements.

The flow regime can vary from laminar to turbulent in the extreme case. Because of no mixing in the laminar flow, an appropriate mixing device should be used in direct nozzle injecting process. Additional problem is the variation of injected chemicals properties. Especially high concentrated viscous materials cause poor mixing result even in turbulent flow (Zhu 1998). Static mixers are a very efficient option in this case. The efficiency of mixing process of selected mixers was evaluated by the K_i coefficient. Using the CFD software, the blending coefficient for selected static mixers in laminar flow regime has been calculated. The results as well as the mixing properties in turbulent flow are verified by practical tests. The efficiency of three chosen mixers in laminar flow is shown in Figure 5.

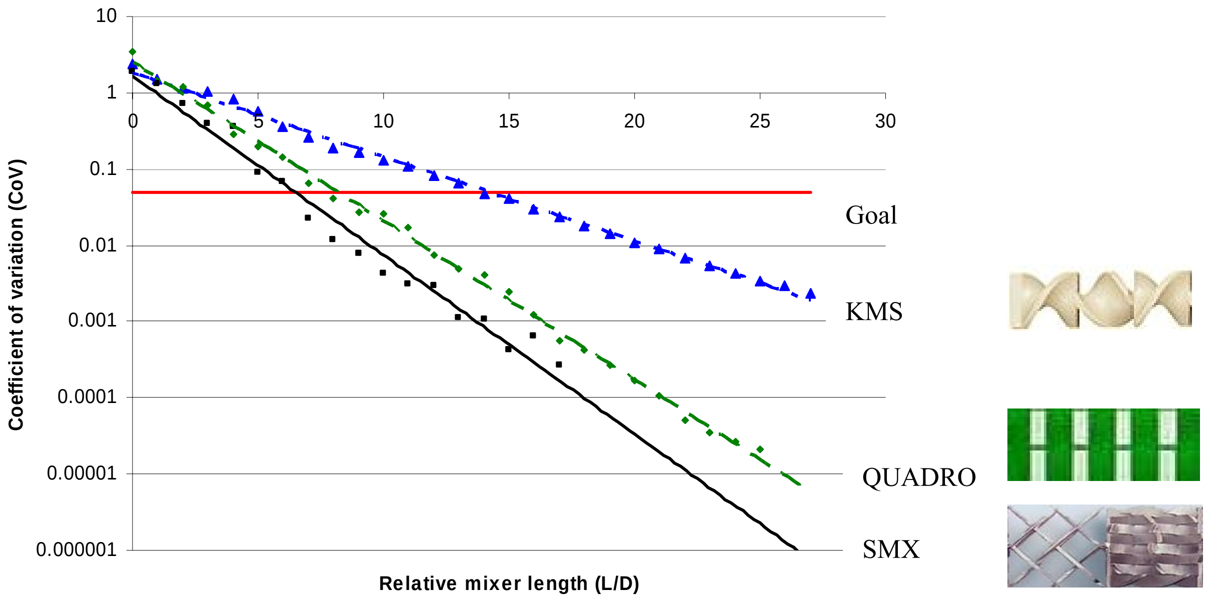

Figure 5 Homogeneity expressed as variation coefficient versus mixer length for three static mixers operating in laminar flow (CFD)

The effect of inlet position has been simulated in CFD as well. The appropriate injection position is important for demanded mixing process. For the KMS and QUADRO mixer, it is preferable if the herbicide concentrate injection is controlled. The simulation confirmed that nonoptimum addition could add the equivalent of six diameters of mixer to get the same CoV. The additional part of the mixer could be left out by optimal injection design. Consequently the mixing chamber volume could be optimized as well as time delay. However, the practical tests showed low or no effect of injection position.

The effect of viscosity and density calculated by CFD software was low and according to simulation it is not significant for laminar flow as expected. According to literature, the effect of density is not important as well if mounting the mixer vertical. The additional forces in flow caused by different fluid densities will be eliminated by the fluid stream. However, the viscosity effect was expected in turbulent flow. The mixer used had to be lengthened. For several mixers additional mixer length could be calculated according to experimental data (Streiff et al. 1999).

First results from practical tests show good homogenizing by 16 L/D KMS and QUADRO mixers. The volume of the mixer was reduced to minimum and the delay on the mixer for the carrier flow rate of 20 ml s^{-1} can be reduced to 40 and 51 ms respectively. The real transport and mixing time is always longer, due to the "technical" volumes in tested configuration, it means all volumes between injection point and nozzle orifice within the mixing chamber.

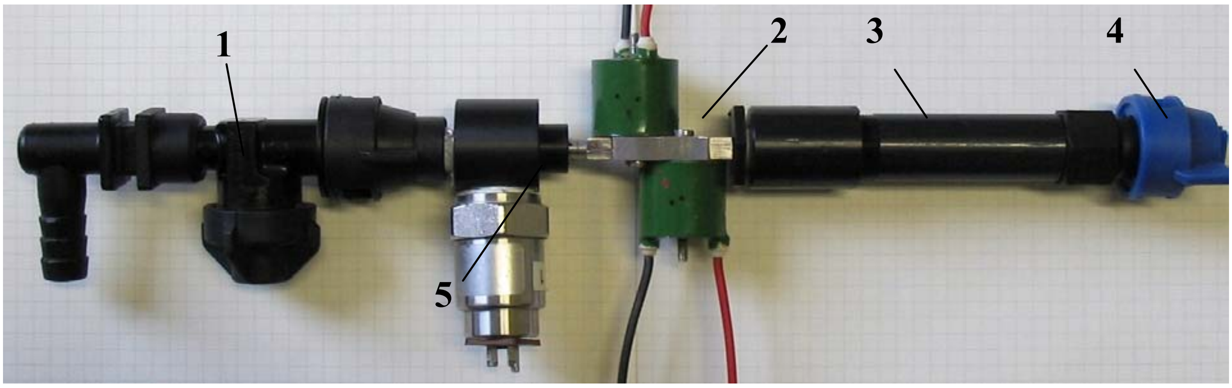

Figure 6 Arrangement of the direct nozzle injection body. 1- standard nozzle body, 2- injection valves, 3 – mixing chamber, 4 – cape with nozzle, 5 – adapter with pressure sensor

Total response time

The total response time of direct nozzle injection system is a sum of injection time, and transport and mixing time. Theoretical response time for the carrier flow rate of 20 ml s^{-1} is lower than 100 ms, the real measured times were around 150 ms.

Conclusion

This paper discussed the feasibility of direct nozzle injection systems for real-time controlled pesticide application. The complete system was divided and investigated in two parts: the injection system and the mixing chamber. The injection control process and a new injection device based on new fast reacting valve ware developed in order to make a direct injection system suitable for all available agrochemicals and to reduce the DIS response time furthermore. The result was the reduction of injection time to less than 80 ms. Using static mixers provided a suitable mixture homogeneity in time less than 52 ms. The potential DIS response time was lower than 100 ms, the really measured DIS response times were about 150 ms for 1% output concentration. Suggested DIS configuration is suitable for real time controlled site-specific crop sprayer.

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LANDSCAPE RECULTIVATION AFTER EARTHWORKS

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While the volume of investments in civil engineering projects, particularly the large-scale ones, grows, the impairment of land resources increases in an unprecedented way similarly as in the case of open-cast coal mining. With the environmental protection regulations becoming stricter, the importance of large-area waste land reclamations is increasing. Land reclamations aim at eliminating the negative impact of predominantly large-scale constructions and mine working, improving the devastated landscape and recovering the ecosystem. The rational means of verifying the applicability of the chosen technology and machinery lies in the analysis of the reclamation processes structure, i.e. the elements and links forming the process chains of reclamation systems and creation of SW instrument with the aid of which the user will evaluate variant solution of the system of technologies incl. machine outfit of technologies which serves under the conditions given for implementation of reclaiming.

Keywords: land reclamation, civil technology, civil machines, SW instrument

1 Introduction

Land reclamations involving large-scale interventions in the landscape have been in the process of a long-term development in our country since 1950's.

It is characteristic of the current situation in the field of land reclamation that in some cases, it is proceeded purposefully, sensibly and perhaps economically; however, in most cases, there is a considerable potential of reserves regarding the reclamation processes ranging from the technological and technical research and manufacture of land reclamation machines in the Czech Republic to the coordination of land reclamation projects and cooperation with the EU member states.

The rational means of verifying the applicability of the chosen technology and machinery lies in the analysis of the reclamation processes structure, i.e. the elements and links forming the process chains of reclamation systems and creation of SW instrument with the aid of which the user will evaluate variant solution of the system of technologies incl. machine outfit of technologies which serves under the conditions given for implementation of reclaiming.

2 SW instrument

Creation of the software instrument for choosing the best type of the earthwork machines needs a lot of different aspects. For the first time we need the extensive database of machines parameters and many various types of construction area, types of soil and land and their physical characteristics. For each type of machine we need as much information and parameters as it is possible. Only in this case we can objectively and precisely choose the exact earthwork machine for our construction. In the base there should be the information about the price of machines and the value of rental per day, week or month.

In this time we can choose from the big set of possibilities of script languages and databases. The most spread database is probably MySQL and by our opinion very easy, comfortable and functional script language is PHP.

3 PHP

PHP-Personal Home Page is a widely-used scripting language that is especially suited for Web development. The main goal of the language is to allow web developers to write dynamically generated web pages quickly. The best thing in using PHP is that it is extremely simple for a newcomer, but offers many advanced features for a professional programmer. Although PHP's development is focused on server-side scripting.

4 Security

Very important during creating and releasing the SW on Internet is security. PHP is a powerful language and the interpreter, whether included in a web server as a module or executed as a separate CGI binary, is able to access files, execute commands and open network connections on the server. These properties make anything run on a web server insecure by default. PHP is designed specifically to be a more secure language for writing CGI programs and with correct selection of compile-time and runtime configuration options, and proper coding practices, it can give you exactly the combination of freedom and security you need.

As there are many different ways of utilizing PHP, there are many configuration options controlling its behaviour. A large selection of options guarantees you can use PHP for a lot of purposes, but it also means there are combinations of these options and server configurations that result in an insecure setup.

The configuration flexibility of PHP is equally rivalled by the code flexibility. PHP can be used to build complete server applications with all the power of a shell user or it can be used for simple server-side includes with little risk in a tightly controlled environment. How you build that environment and how secure it is, is largely up to the PHP developer.

5 MySQL database

The MySQL has become the world's most popular open source database because of its consistent fast performance, high reliability and ease of use. It has used in more than 11 million installations ranging from large corporations to specialized embedded applications on every continent in the world. The MySQL also become the database of choice for a new generation of applications built on the LAMP stack (Linux, Apache, MySQL, PHP / Perl / Python.) MySQL runs on more than 20 platforms including Linux, Windows, OS/X, HP-UX, AIX, Netware, giving the kind of flexibility that puts the user in control.

MySQL database is the collection of many tables and positions. It can be defined by one or more schemas. The basic construct of data selection is the block, which is consisting of the three parts that begin by the rights words (SELECT, FROM, WHERE).

6 Results

Although in this time exist many types of scripting languages a databases, PHP and MySQL are the most popular.

Of course that the database is the life organism and we have to updating the data in the tables of database especially data about the new machines, their parameters and prices. So only in this case the SW can offer if it is better to buy the machine or rent it. If this SW instrument will run in the right way, it can be very useful tool for customers, firms and even so for the dealers of earthwork machines.

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THE MECHANICAL PROPERTY OF THE CELL WALL AND AUXIN-INDUCED GROWTH WITH REFERENCE TO GERMANIUM ACTION

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Growth of plant cells is controlled by the mechanical property of the cell wall, along with the osmotic pressure of the cell sap and water availability. We have developed a method to measure the stress relaxation of the cell wall, which is represented by the equation:

$S = b.\log\{(t + T_m)/(t + T_o)\} + c$, where S is stress, t is time and b, T_m, T_o and c are constants. Auxin, a plant hormone inducing and enhancing plant cell growth, causes a decrease in T_o value. Dividing viscosity with elasticity gives a time value such as T_o. Thus, an effect of auxin could be cancelled in T_o. We reevaluated the auxin effect and found a substantial effect of auxin on elasticity and viscosity of the cell wall. Germanium effect is discussed in addition.

Keywords: auxin, cell growth, cell wall, germanium, stress relaxation

Introduction

Cell growth in higher plants is an increase in the cell volume caused by water uptake. The mechanical properties of the cell wall have been identified as the most important factor in governing cell growth along with the osmotic pressure of the cell sap and water conductivity (Yamamoto et al. 1974, 2000, Masuda 1978, Taiz 1984, Boyer 1985, Cosgrove 1986, Yamamoto and Sakurai 1990, 1992, Yamamoto 1996, Yamamoto and Fujii 2001).

To measure the mechanical property of the cell wall governing plant growth, Yamamoto et al. (1970) developed a stress relaxation method for the cell wall. Stress relaxation of the cell wall is represented by the equation,

$$S = b.\log\{(t + T_m)/(t + T_o)\} + c \quad \text{(I)},$$

where S is stress, t is time and b, T_m, T_o and c are constants (Yamamoto et al. 1974). We have reported that auxin causes a decrease in T_o value and inferred from the change in the T_o value that auxin causes a decrease in the mean molecular weight of polysaccharide components of the cell wall (Yamamoto et al. 1970, 1974). In fact, auxin has been reported to decrease their mean molecular weight (Sakurai et al. 1979, Nishitani and Masuda 1982, Inouhe et al. 1984). Stress relaxation of the cell wall is also expressed by the following equation,

$$S/\varepsilon = E_1.\exp(-t/\tau_1) + E_2.\exp(-t/\tau_2) + E_3.\exp(-t/\tau_3) + E_4 \quad \text{(II)},$$

where S is stress, ε is strain, t is time, τ's are relaxation times equal to viscosity divided by elasticity (Yamamoto et al. 1970).

Dividing viscosity with elasticity gives a time value such as T_o. Since both viscosity and elasticity are decreased by auxin action (Yamamoto et al. 1970), an effect of auxin on the quotient of viscosity and elasticity such as T_o could appear as a cancelled one. This study reevaluated the auxin action on viscosity and elasticity with the same stress-relaxation data as used to obtain the T_o value.

Excised organ segments have long been used in growth studies. In segments, water uptake takes place solely through their lateral sides (Yamamoto, 1995) and thus water enters through the cuticle at their lateral sides from the ambience into segments. The cuticle is composed of a waxy membrane and thus seems to act as a barrier against penetration of hydrophilic substances including water and ions. As far as stem segments are used, inhibitory ions such as mercury and aluminum at relatively high concentrations failed to inhibit auxin-induced growth and abrading segments with carborundum enhanced an effect of these ions (Yamamoto et al. 1995; Ma et. al 2000). With this abrading technique, germanium effects on auxin-induced cell growth and the mechanical property of the cell wall were examined.

Materials and Methods

Plant materials

Okra (*Abelmoschus esculentus* Moench cv. Clemson Spineless) seeds were soaked in running water overnight to germinate. Germinated seeds were transplanted to a plastic tray for hydroponic culture and grown for 5 days under continuous fluorescent light (15 W/m^2) at 25^{o}C. Segments (1 cm long) were excised from the upper region of hypocotyls (ca. 3-5 cm long) with a double bladed cutter and gently abraded with carborundum powder (mesh 220) between the thumb and the index finger, or with fine sandpaper (mesh 400). Incubation of abraded segments for 3 h in buffer was reported to resume their responsiveness to auxin (Yamamoto and Fujii 2001).

Growth condition

The segments were incubated in a petri dish (diameter: 4 cm) with 4 ml of Na-MES (2[N-morpholino] ethanesulfonate) buffer (10 mM, pH 6.0) containing or not containing 0.01 mM NAA (naphthalene acetic acid), 5 mM germanium oxide and 10 mM silicon oxide under continuous fluorescent light (15 W/m^2) at 25°C. Solutions of silicon oxide were prepared by partly removing sodium from sodium silicate with an ion-exchange resin. Addition of the silicone oxide to test solutions did not disturb the pH of test solutions. The length of segments was measured with a binocular microscope or with taking their photographs in order to monitor growth. The microscope was equipped with an ocular micrometer (x 6.3). After incubation, the segments were fixed with boiling methanol for 5min, stored in cold methanol and subjected to the stress-relaxation analysis.

Stress relaxation analysis

The stress-relaxation properties of the cell wall were determined with a tensile tester (RE-33005, Yamaden Co, Tokyo, Japan). Methanol-killed okra hypocotyl segments were rehydrated. A rehydrated segment was fixed between the upper immobile and the lower movable clamps of the tensile tester. The distance between clamps was 5 mm. The segment was then stretched to give the strain of 10% by lowering the lower clamp at 5 mm/sec. Stress relaxation, the decay of the stress at a fixed strain, was recorded by a computer equipped with a data acquisition apparatus (NI USB-6009, National Instruments, USA). Stress relaxation parameters in the equation (I) and (II) were calculated with a non-linear least square method with C computer language.

Result

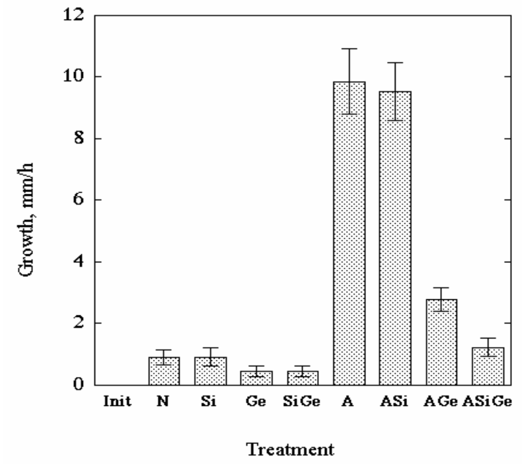

Fig 1. Effect of auxin, germanium and silicon on the rate of growth. N: none, Si: 10 mM silicon oxide, Ge: 5 mM germanium oxide, A: 0.01 mM NAA

Hypocotyl segments were excised from the upper parts of 5 day-old okra seedlings and gently abraded with carborundum or sandpaper. They were incubated in Na-MES solution for 3 hr and treated with auxin, germanium and silicon for 3 h. Auxin enhanced growth of the segments as shown in Fig 1. Germanium oxide at 5 mM inhibited auxin-induced growth of segments. An addition of silicon oxide at 10 mM did not recover the germanium inhibitory effect (Fig.1). Silicon does not seem to act a germanium antagonist.

The mechanical properties of the cell wall have been identified as the most important factor in governing cell growth. A change in the mechanical property of the cell wall was evaluated with the stress relaxation analysis. Okra segments incubated with auxin and germanium for 3 h were killed with boiling methanol, rehydrated and subjected to the analysis. Stress relaxation was measured with a tensile tester and applied to determination of T_o value. We reported that auxin causes a decrease in T_o value in the equation (I). Fig 2 shows auxin and germanium effects on T_o value. Auxin tends to decrease the T_o value but the effect does not appear to be significant. We sometimes encountered such incidences with little significance in the T_o value. Germanium appeared to inhibit the auxin effect.

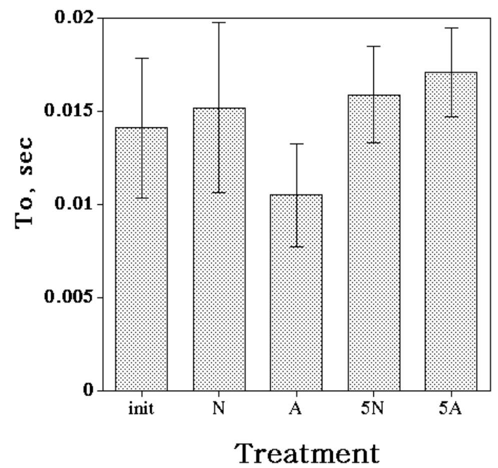

Fig 2. Effect of auxin and germanium on T_o value. init: before treatment, N: without auxin and germanium, A: with 0.01 mM NAA, 5N: with 5mM germanium oxide, 5A: with NAA and germanium.

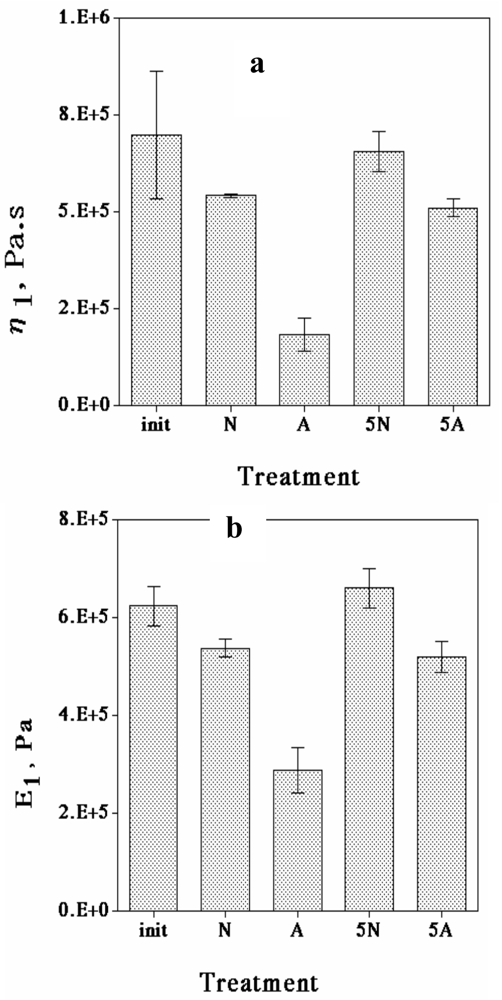

Fig 3. Effect of auxin and germanium on viscosity (a: η_1) and elasticity (b: E_1). init: before treatment, N: without auxin and germanium, A: with 0.01 mM NAA, 5N: with 5mM germanium oxide, 5A: with NAA and germanium.

Using the same stress-relaxation data as used for calculation of the T_o value, we calculated the values of viscosity and elasticity in equation (II). Viscosity (η's) was obtained by multiplying elasticity (E's) and the relaxation time (τ's) together. Fig 3 shows the effect of auxin and germanium on them. Auxin substantially decreased η_1 and E_1. Auxin also decreased other E's and η's (data not shown). Germanium inhibited the auxin effect on decreases in the values of viscosity and elasticity. Auxin effect on viscosity (Fig. 3a) appeared to be bigger than that on elasticity (Fig.3 b).

Discussion

The mechanical property of the cell wall has been identified as the most important factor in governing cell growth. Several methods were designed to obtain the mechanical parameters correlated with cell growth (Heyn and van Overbeek 1931, Olson et al. 1965, Cleland 1967, 1971, Masuda 1969, Yamamoto et al. 1970, 1974, Cleland and Haughton 1971, Cosgrove et al. 1984). They are essentially divided into three types. (1) A constant extension is given to a specimen and the change in the stress is measured, for example, the stress-relaxation measurement (Yamamoto et al. 1970, Cleland and Haughton 1971). (2) A constant load is given to a specimen and the change in the extension is measured, for example, the creep measurement (Hager et al. 1971, Cleland 1971, Jaccard and Pilet 1975, Tanimoto et al. 2000). And (3) the changing load or extension is given to a specimen and the extension or load is measured, for example, the load extension and the resonance measurements (Virgin 1955, Olson et al. 1965, Cleland 1967, 1971, Masuda 1969). The situation in the third type of measurements is rather complex since both the stress and the strain change. Recently a nondestructive measurement of fruit quality using a laser doppler vibrometer have been developed (Muramatsu et al. 1998, Terasaki et al. 2001, Sakurai et al. 2005). This method is classified to the third type but this is an excellent measurement with disadvantages overcome. The stress-relaxation and the creep measurements appear to have advantages in analyzing the mechanical properties of the cell wall because only one of the stress and the strain changes in these methods. To measure the creep, application of a load causes an overshoot of the extension and an oscillation in the extension occasionally. A tensile tester has been employed to measure the load-extension relation of the cell wall (Olson et al. 1967, Cleland 1967, Masuda 1969). A tensile tester has been also employed to measure the stress relaxation (Yamamoto et al. 1970, Cleland and Haughton 1971) and the creep (Tanimoto et al. 2000) of the cell wall of higher plants. With a tensile tester, we undergo little errors derived from the shock due to the load application or the careless operation of the apparatus. In the principle of the stress-relaxation measurement, the specimen is supposed to be extended and thereafter the decay of the stress is measured.

The creep, the extension under a constant force, was argued to mimic the cell growth process (Cleland 1971). The suction force of the cell has been described to be the osmotic pressure minus the turgor pressure, which is equal to the wall pressure. Thus a decrease in the turgor pressure or the wall pressure causes water uptake leading to growth. A decrease in the wall pressure can be expressed as stress relaxation. It can be said that the primary cause for cell growth is stress relaxation of the cell wall (Yamamoto 1996).

Yamamoto et al. (1970, 1974) have developed a stress-relaxation method to measure the mechanical property of plant cell walls and elucidated the auxin effect on the cell wall as physically defined terms. The present study employed the stress relaxation technique. The stress relaxation property is represented by several parameters, b, T_m, T_o and c (Yamamoto et al. 1974). Auxin, a plant hormone inducing plant cell growth, causes a decrease in the values of T_o and b (Yamamoto et al. 1970, 1974, Sakurai et al. 1982). T_o values were reported to be correlated well with the capacity of plant cells to grow (Masuda et al. 1974). Since then, T_o has been used as the parameter to indicate the change in the mechanical property of the cell wall governing plant growth. As mentioned above, we sometimes have come across incidences accompanying statistically little significance in an auxin effect on T_o values, although auxin has kept a tendency of decreasing the T_o values. We have suspected that a small auxin effect on T_o values is due to a setoff of its effect on elasticity to that on viscosity, because the relaxation time is obtained by division of viscosity with elasticity. The results of Figs 2 and 3 clearly show that this is the case. The viscosity and elasticity are better parameters to represent changes in the mechanical property of the cell wall governing plant cell growth than T_o.

Silicon is abundant in all soil, which is mainly composed of silicates. Plants grow on soil and thus may receive some effects from soil silicates. In fact, silicon has promoting effect on rice plants and has been applied to rice fields as a fertilizer in Japan. Silicon has long been considered as a non-essential element for plants, but it has reported to play significant roles in many aspects of plant physiology and proposed to be designated as quasi-essential (Epstein, 1999). We have reported that silicon enhances growth in seedlings of some graminaceous plants and affects the mechanical property of the cell wall (Hossain 2002, 2007). If requirement of silicon by plants generally is very low, it is hard to find the effect of silicon by means of exogenous administration of it to plants. It is also hard to determine experimentally whether or not silicon is essential. Germanium belongs to the same group in the periodic table as that of silicon and thus it may be able to act as silicon antagonist in many plants. Germanium could become a good tool to examine silicon action and thus we attempted to examine germanium effect on plant growth.

Excised tissue segments are used in growth studies. As far as tissue segments are used, the cuticle acts as a barrier against penetration of hydrophilic substances. From this reason, stem segments are not good experimental materials to examine actions of mineral elements such as mercury and aluminum. In fact, these elements at relatively high concentrations failed to affect auxin-induced growth in plant stem segments. We developed an abrasion technique using carborundum and obtained good response of plant stem segments to these substances (Yamamoto et al. 1995, Ma et al. 2000). Abraded segments responded to auxin and grew. In abraded segments, germanium inhibited the growth as shown in Fig. 1, while silicon did not recover the inhibition due to germanium. Germanium does not seem to be a silicon antagonist. On the contrary, silicon seems to inhibit growth further (Fig.1). Since the mechanical property of the cell wall has been substantiated to govern plant growth, germanium effect on the mechanical property was examined. The result presented in Fig 3 shows that germanium inhibit auxin-caused changes in the mechanical property of the cell wall, suggesting that germanium acts on the cell wall and prevent plant growth thereby.

The mechanism of germanium inhibition has yet to be elucidated. We will examine the germanium action on metabolism of the cell wall components. Our preliminary experiments show that germanium affected metabolism of cell wall polysaccharide containing arabinose. Chemical analysis of the cell wall and germanium effect on it will be reported elsewhere.

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THE GEOMETRICAL POSITIONING OF THE ROTATED PARTS OF REVOLVING MACHINES AND COMPARISON OF THE ACCURACY AND SENSITIVITY FOR THE DIFFERENT METHOD OF ADJUSTMENTS

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The Revolving machines adjustments are obvious activity during installation of the new machines, or during dismantling and maintenance of the working machines. In practice still revaluate procedures based on the intuition of the fitters. Just simple mechanical tools are used. There are also simple and cheap tools based on existing lasers and optical principles. Also computer software's are available for the analysis of the measured data and evaluation of the exact adjustments. The authors experimentally compared the precision of the adjustment for the two revolving machines connected by shafting, by chain, or strap. This contribution is about results for comparisons of different methods of adjustment.

Keywords: Aligned revolving machines, side and alignment corrections.

Method and the results of the comparison

Collinear adjustments of the two revolving machines with shafting were tested for the centrifugal water pump driven by the electromotor, figure 1. Small modification of the industrial devices was done by students working in the laboratory for the easier adjustment of the machine geometrical positions.

Assembly was done (figure 1) using standard methods (precise rulers). Alignment i.e. measurement of the axes co-linearity was performed using „Fixtur laser Colibri" device, which for given dimensions of the setup predicts direct corrections i.e. directions and absolute values for side and height displacements in the fixation points (figure 2).

Side corrections were adjusted using screws A,B,C,D and points E,F,G,H for the height corrections correspondingly (using exact shims).

Figure 1 - Experimental set up for the shaft connection with the Fixtur laser Colibri.

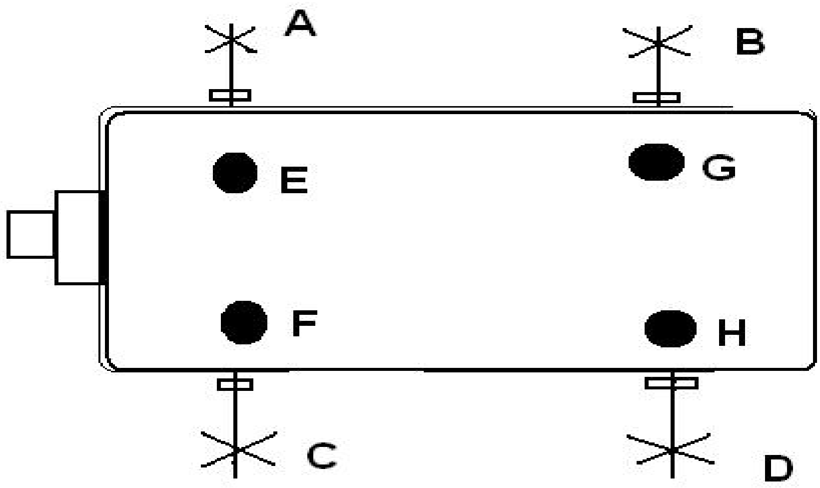

Figure 2 - Side and height corrections for the pump position (top view of the measuring points)

Collinear adjustments geometrical positions machines and driven by chain was done on the ruler for testing brake and power output, figure 3. Cylinders are fixed on the bearings in the separated ball bearing, fixed to the common frame. One from the cylinders is free and second is driven by synchronous electromotor using chain.

Side and co-linearity correction was again done by standard methods (using precise rulers). The adjustment was tested using device Easy-Laser BTA Compact. Height correction (figure 4) were done using exact shims (A,B,C,D).

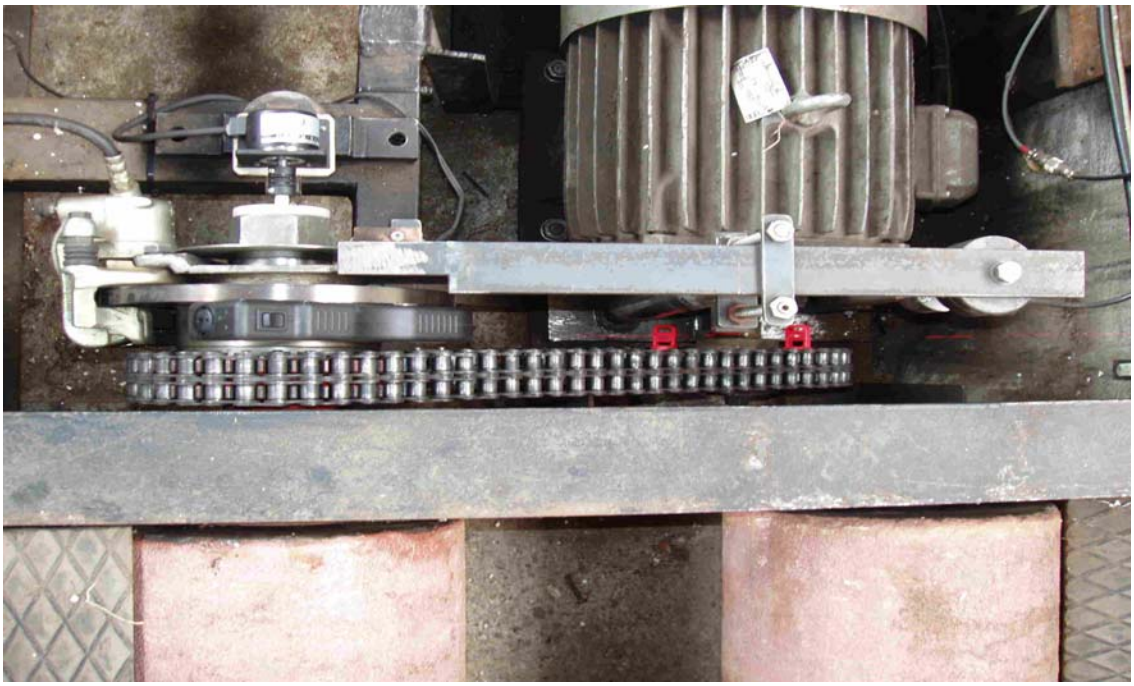

Figure 3 - Pump driven by electromotor using roller chain. Measuring device “Easy-Laser BTA Compact” mounted

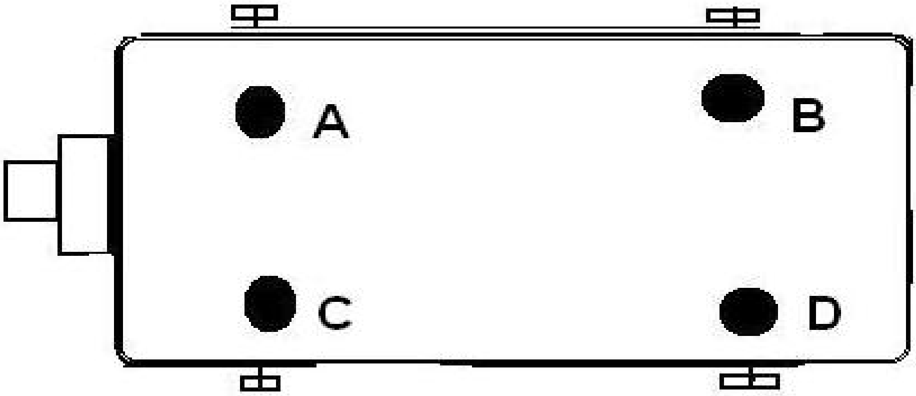

Figure 4 - Height corrections for the pump position (top view of the measuring points)

Figure 5 - Device Fixtur laser Colibri

Figure 6 - Device Easy-Laser BTA Compact

Table 1 - Spread of adjustments for the shaft connection

VALUE [mm]	A	B	C	D	E	F	G	H
Beginning	2	8	3,5	4	2	2	2,5	2
New	4,2	6,6	4	3,9	2,8	2,6	2,7	3

Table 2 - Spread of adjustments for pump position (top view of the measuring points)

VALUE [mm]	A	B	C	D
Beginning	12	7	8	7
New	15	6	8	9

Deviations from the correct values adjustments (measured by the presented devices) for the several standard procedures with the help of the rules are presented in tables 1, 2. Results were obtained using precise caliper.

Conclusion

The presented results show, that standard methods using just rulers and calipers don ´t give satisfactory results even in the case of very careful adjustments. This has serious consequences, for the life span of the motors, especially bearings chains, packing and chain wheels.

That's why it is essential to use sophisticated equipment for the finding and adjustment of the correct geometrical position for the revolving machines. The proper training for students of the technical school and universities is the right way to go.

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TRANSLATION PROBLEMS OF DAIRY FARMING TERMINOLOGY

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Dairy farming as an industry is not a new one, but it is the one with continuous development causing appearance of new technologies and equipment within its framework. Latvia accession to the European Union has only made this process more active and frequent. The appearance of new technologies, equipment and products create new terms that have to be translated, but it is not always done correctly. Mainly because of the lack of appropriate dairy farming dictionaries, the terms have been translated literally. But literal translation is not correct translation in all cases, therefore there is a large number of incorrect and inaccurate translations found in sources. Problem lies in the fact that words are translated literally and such factors as different meanings of a word, relationships between words, idea of sentence, text type and the readership are not taken into account, which leads to formation, spreading and usage of incorrect terms that causes the "pollution" of terminology with the incorrect term translations.

Keywords: Dairy farming terminology, literalness, translation problems, term

1. Dairy farming terminology

Before starting to speak about dairy farming industry and its terminology, we should clarify the meaning of this term. Encyclopedia *Wikipedia* defines *dairy farming* as "a class of agricultural, or more properly, an animal husbandry enterprise, raising female cattle for long-term production of milk, which may be either processed on-site or transported to a dairy for processing and eventual retail sale". From the definition the author concludes that dairy farming is connected with female cattle rearing and milk production.

1.1. Description of the Field of Dairy Farming

Dairy farming as an industry is not a new one, but it is the one with continuous development causing appearance of new technologies and equipment within its framework. It has a long history, although there is delusion to think that the history of dairy farming industry begins with the Soviet Union times. It is true, that during this period there was the biggest development concerning dairy farming industry. But the first traces of the dairy farming in Latvia were detected already during the middle and end of the Neolithic era (end of the3rd century and the beginning of the 2nd century B.C). But, of course, it confined itself only to some cows and their milking; there was neither machinery, nor special equipment at that time. They appeared only during the 19th and 20th century. Exactly in the 20th century the new manure handling system was introduced, the type of farms were changed, milking practice was developed and improved, the watering system was built in farms, cow feeding was improved. Also the European Union has promoted the development of dairy farming industry in Latvia, due to the introduction of new technologies and equipment and strict requirements. Today machine milking has reached very advanced level, manure handling is very convenient, feeding equipment and practice are precise and suitable to the performance of each cow, cow watering is automatic. In the past everything was done manually, but due to the technological progress now all operations can be done automatically and does not require hand work.

The concept *dairy farming* embraces many subfields, namely:

- Milking
- Manure handling
- Feeding
- Tending
- Milk handling

The milking subfield deals with cow milking, milking equipment, its cleaning. The manure handling refers to the processes and equipment that helps to get manure out of a cattle-shed. The feeding involves cow feeding, appropriate feed rations, feeding strategies, various feed types, feeding equipment, feed additives and concentrated feed. The tending includes everything connected with cow care and its comfort, udder care, its preparing for milking and its after care, dehorning and paring, clippers and combs for hair care. The milk handling deals with milk storage, cooling, pumping in cistern.

The dairy farming sector is not a very broad sector; it is one of the sub-sectors of the agriculture industry that is why speaking about the dairy farming terminology, we could also speak about the agriculture terminology, which is very broad industry. Actually, dairy farming terminology goes under the agriculture terminology, but as it is distinct sub-sector it has independent its own term glossary and as such it should be taken. But sometimes dairy farming and agriculture are put so closely to each other that even people start to mix up the difference between them and quite often forget that it is not one and the same industry, but only sub-industry of the one very broad industry. Only terms referring to female cattle rearing and milk production form the glossary of the dairy farming terminology, for that reason terms referring to meat animals or grain crops are not related to the dairy farming terminology. The whole dairy farming terminology can be divided into sub-groups according to the above mentioned sub-fields of the dairy farming sector, consequently we can speak about milking terms, feeding terms, tending terms and terms referring to manure and milk handling. To give just some insight into specific dairy farming terms, forming particular terminological sub-groups, the author will give some basic terms in each group:

- Milking terms (machine milking, to milk, milker, milk yield, pipe line, premilking, yield, milking parlor, herringbone parlor, parallel parlor, rotary parlor, cluster, liner, tubes, bucket milking system, pulsator)
- Manure handling terms (manure, slurry, liquid manure, scraper, slurry scraper, alley, manure scraper, cable scraper, manure storage pit, screening and filtration system)
- Feeding terms (feed, feeding area, forage, silage, hay, feeder, dry matter intake, fiber, mixer wagon, haylage, totally mixed ration, partly mixed ration, feeding stations, feed supplement, tube feeder)
- Tending terms (udder, teat cleaner, foam cup reservoir, udder paper, teat canal, dehorning, lame cow, claws, rubber coverage, cow brushes, clippers, footbath, fan, water bowl, California mastitis test, dip cup)
- Milk handling terms (cooling tank, open cooling tank, closed cooling tank, milk receiver, milk meter, tank cleaning unit, milk pump, milk tube)

1.2. Usage of Dairy Terms

As the dairy farming is one of the main agriculture industry sub-sectors in Latvia, in translation we come across this discipline quite often. The dairy farming terms like other terms are used both in printed sources and on the Internet. And like many terms on the Internet, also regarding dairy farming terms there are many incorrect and not precise terms found on the Internet. In relation to the Internet, dairy farming terms are used in the home page of the Ministry of Agriculture of Latvia, in home pages related to dairy farming and agriculture, home pages of agricultural companies, also in home pages of agricultural magazines. Speaking about printed sources, there the situation is a bit better and the wrong terms can be found more rarely, though as they are printed materials their quality and correctness before printing have to be checked very carefully in order to get hundred per cent reliable source. But unfortunately it is not so in all cases and incorrect terms can be found also is agricultural books of seemingly reliable authors. The same problem refers also to agricultural product catalogues and brochures. They are representative materials and are meant to present products, so there should be only precise and correct usage of terms, but, in fact, the catalogues and brochures are full of incorrect dairy farming terms. It not only influences the spreading of incorrect terms, but also gives bad impression about the particular company. Quite poor situation can be noticed also in agricultural magazines, because apparently they are not considered to be very serious source and therefore also the correction and editing process is not so serious. To my mind people more often read such magazines than agricultural books and also they are published more often, so the magazines are more available for people as well, therefore so many mistakes are not admitted.

In order to speak about dairy farming terms it is useful also to look at readership of such texts. As they are dairy farming texts, then, of course, the main readership is farmers, practicing exactly dairy farming. In order to perfect their knowledge, they are reading both books and magazines about dairy farming and also searching materials on the Internet. Farmers are the ones that read agricultural product catalogues and brochures as well. But since very often dairy farming texts are published in overall agricultural magazines or books, they are read not only by dairy farming farmers, but also by farmers who are rearing beef cattle or growing crops. Besides farmers such texts are read also by people working in agricultural product companies, who are wishing to obtain knowledge about some issue related to their work. Dairy farming texts apply also to lecturers giving lectures about dairy farming issues and, of course, to students, studying such subjects. The former use dairy farming texts to prepare for the lectures, but the latter – to acquire the course of lectures. Veterinarians also are ones who read agricultural texts, whishing to perfect their knowledge in the dairy farming field. Readers are the ones, who create demand for such texts and therefore they are also the ones, who influence the offer.

2. Literalness as a Translation Problem

After having studied materials about dairy farming and analyzed the terms, the author has ascertained that the literalness is a very typical and serious translation problem in dairy farming terminology. Literal translation causes creation and spreading of incorrect terms, which, in turn, influences the usage of incorrect terms and "pollution" of the whole dairy farming terminology.

2.1. Literalness

The main translation problem in the translation process of the dairy farming texts is literalness. According to the Oxford Advances Learner's Dictionary, *literalness* is a noun from the word *literal*, which means" basic or usual meaning of a word or phrase". Pursuant to the definition we get that literalness is connected with first and traditional meaning of words. Literal translation is a word-for-word translation, where each word is translated independently, literally and the fact the words have different meaning in different contexts and situations is ignored, as well as relationships between words, idea of sentence, text type and the readership are ignored too. It reminds some kind of automatic transference of words and therefore the literalness is very common phenomenon in the described translation style. When a text is translated literally and the literalness problem is not being taken into consideration, the translated text becomes unnatural and laborious, and quite often even illogical and incorrect, for that reason the literal translation should be avoided.

2.2. Literalness as a Problem

As it is clarified above, literalness is a serious translation problem translators are daily facing, because literal translation is not always the correct translation. A translator can face the literalness problem, when translating all kinds of texts, but the author considers exactly the dairy farming texts to be very characteristic ones for the literal translation problem due to the lack of proper dictionaries. As there are practically no dairy farming dictionaries, translators tend to translate terms literally, which causes incorrectness. If there are available dictionaries, then the literal translation is not so common, but if a translator has to completely translate the dairy farming terms on his/her own, because he/she has no sources where to look up for already given translations, it makes the problem more typical. The literal translation is not correct translation in every situation, because not all words or terms can be translated literally in order to get correct and precise translation. In such a way an incorrect translation is made and afterwards as such it is unfortunately left. The literal translation is the simplest way for a translator, because he/she simply translates the word or term literally and does not need to look for the correct translation in the sources and to check the correctness of it. But if such literally translated terms are left and they are not corrected, there arises a problem regarding spreading of incorrect terms. The incorrect terms are published in books and magazines, and also they appear on the Internet and that is why they are available for large range of people. They all notice incorrect terms and if they are not specialists in the particular filed, they decide that the published terms are the correct ones and next time the incorrect terms are used, which leads to spreading and usage of incorrect terms. And also a translator searching for a possible translation comes across to an incorrect term translation and taking it for the correct one uses it in his/her translation. Afterwards the translation with incorrect terms is published in a certain printed source or on the Internet and other people having got influenced by these incorrect terms start to use them. Later on it is really hard to separate the correct terms from the incorrect ones, because they all are mixed together and therefore even bigger mess in terminology is created. So, literalness is a huge translation problem causing formation, spreading and usage of incorrect terms that consequently leads to the "pollution" of terminology with the incorrect term translations.

3. Analysis of Translation Problems in Dairy Farming Terminology

There can be found various translations for one term in sources that results from the fact that different translators translate one term differently, for example, the author managed to find 10 various incorrect literal translations for the term *milk cooling tank*. In various sources there are used various translations of one term and even there are cases, when a term is translated differently in one source, but just in different places, for example, the term *calf hutches* in the magazine *Agro* (2005, June). Such incorrectness is not permissible and translators should think about literalness problem more carefully.

Milk cooling tank – "is a large storage tank for cooling and holding milk at a cold temperature until it can be picked up by a milk hauler". (*Encyclopedia Wikipedia, www.wikipedia.com*). It is one of the terms having many incorrect translations, since it is very common term. The term is used in product catalogues, both in printed version and on the Internet (www.keskoagro.lv, Westfalia product catalogue, DeLaval product catalogue). Besides product catalogues, the given term can be found in agricultural books, magazines and Internet pages as well. A translator should translate the term so that the meaning reveals exact idea of the term and meanings of words should be checked in explanatory dictionary of Latvian in order to choose the correct one and not to make mistake in translation of the term.

Calf box – is a place, where a calf lives separated from a cow. The term is used in books about calf rearing, in product catalogues, as well as in texts about calf management, published in magazines or on the Internet. Regarding the term *calf box* the tricky word in the particular term is *box* that is translated literally and therefore incorrect terms have been created. Surprisingly, incorrect translations of the term were found in various product catalogues, in that way, costumers can have a bad impression about a company and since it is a representative material, such mistakes should not appear there.

Manure scraper – is very common term used in texts about manure handling. It is used to remove manure out of a farm. This is the term causing a lot trouble to translators, because they are translating it literally and trying then to make a compound, use different endings or create two independent terms. The most serious mistake is to omit translation of word manure, because then a reader cannot understand what scraper is used for. This term like the term *milk cooling tank* are very wide spread term, found in large number both in printed sources and on the Internet.

Rotary milking parlour – is one of the most common types of milking systems. The meaning of the term is "a raised, round rotating platform or carousel on which cows ride while being milked. (www.epa.gov/oecaagct/ag101/dairyglossary.html). The term is used in specific texts about cow milking and in general texts about cow rearing, if there is mentioned cow milking. It is also wide spread in agricultural product catalogues, where are offered various milking systems.

Herringbone milking parlour – is another commonly used type of milking systems. The rotary and herringbone milking parlours is the two most widespread milking systems in big farms. The term means "a milking parlor in which cows stand side-by-side, angled towards the pit. This allows milking from the side of the udder" (*www.epa.gov/oecaagct/ag101/dairyglossary.html*). The term in common with the term *milking parlour* is used in texts about cow milking and in agricultural product catalogues.

Loose housing – According to the dairy farming glossary, meaning of the term is "facilities that allow cattle access to a large, open bedded area for resting. In the case of loose housing there should be provided at least 200 square feet per animal for feeding and resting in a cattle-shed. (www.epa.gov/agriculture/ag101/glossary.html). Cows can freely walk in a farm and access whatever they want, because they are not chained. The term is used in texts about cow rearing and their welfare. The term is wide spread, because this new method is introduced more and more also in Latvia. It is important to translate the term *loose housing* in such manner as it is not clumsy and translation is not too long and a translator has to think more carefully about word meaning and not to mix them.

Herd replacement – is a process, when a culled cow is being replaced with a new cow or heifer, in order to get more productive herd. No matter whether a cow is old, ill or unproductive. The term is frequently used in various laws, requirements and regulations, since it is EU requirement to replace culled cows. Correct terms should be used in laws and regulations in order not to influence spreading of incorrect terms, but unfortunately it is not so in the case of the term *herd replacement*, since its wrong translation can be found exactly in different official home pages, where laws and regulations are published.

After the research the author has discovered that besides literal translation the most common mistakes regarding dairy farming texts are not complete revealing of the idea that is embraced in a term (the reader dos not get the full meaning and idea of a term), usage of a foreign word instead of a Latvian one (Latvian terms should be used and not the foreign words, which pollutes the language and makes the text more difficult to perceive), misuse of terms (the translator does not know the correct meanings of terms and mixes up different terms), creation of unnecessary compound (undesirable translation strategy because of redundancy of words and style).

Conclusions

The concept *dairy farming* is an agricultural sector dealing with female cattle growing for milk production.

The dairy farming terms could be divided in the following subfield: milking, manure handling, feeding, tending, milk handling terms.

Dairy farming terms are used both in the printed sources, and on the Internet, but more incorrect and inaccurate terms can be found on the Internet, because, seemingly, texts published there are not edited and corrected so seriously as it is with texts published in books.

The main readers of dairy farming texts are exactly farmers doing dairy farming business.

Literal translation is a word-for-word translation, where each word is translated independently and the fact the words have different meaning in different contexts and situations is ignored.

Literalness is a very typical problem exactly in the dairy farming terminology mainly because of lack of proper dictionaries; therefore translators tend to translate terms literally, since they have to completely translate the dairy farming terms on their own. But if such literally translated terms are left and they are not corrected, there a problem arises regarding creation, spreading and usage of incorrect terms that consequently leads to the contamination of dairy farming terminology.

There can be found various translations for one term in sources that results from the fact that different translators translate one term differently, for example, the author managed to find 10 various incorrect literal translations for the term *milk cooling tank*.

Besides literal translation the most common mistakes regarding the translation of dairy farming texts are not complete revealing of the idea that is embraced in a term, usage of a foreign word instead of a Latvian one, misuse of terms, creation of unnecessary compound.

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SCIENCE EDUCATION TEACHING METHODS FOR DEVELOPMENT OF COGNITIVE SKILLS

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Teaching any subject, but especially science subjects, it is necessary to find and investigate methods for development of cognitive skills. The teachers' main goal is to work on the students' strong hemisphere, not underlining and lessening the weak one. Human brain hemispheres' anatomical structural asymmetry is closely connected with its functional asymmetry. It is important to know each hemisphere's function and use this knowledge in the teaching process. The teacher must differentiate the teaching process, thinking in four ways: 1) how experience develops students' personality (right underneath), 2) how to help to develop concepts' and laws' perception (left top), 3) how to help to apply the adopted (left underneath), 4) how to create new ideas, new meaning (right top).

Introduction

Science education is the basic element in modern education, but not everybody understands it. It is indispensable in all areas of life – everyday, social and professional life. In various professions the science knowledge is the essential element. Examples are doctors, farmers, engineers, environmental protection specialists as well as science subject teachers and scientists dealing with the corresponding areas of research. But the most important role of science education in forming developed cognitive skills, such as interdisciplinary critical thinking, problem solving, decision making, is not estimated enough. In this context, everybody needs science education, but the development of science education needs international collaboration.

Changes in the society cause new demands in education, revising the role of science education. In the course of the author's academic experience with students at the Latvia University of Agriculture, the conclusion has been drawn that many students lack background knowledge and cognitive skills. The problem is to find and investigate methods of the formation of scientific and technological literacy.

Materials and methods

According to didactics as the theory of education [1] the result of education is both: material education (getting concrete knowledge, students ″open the world for themselves″) and formal education (getting the skills for further education, students ″open themselves for the world″) "Fig.1".

According to J. Piaget [2] people development has four stages. The first is sensory - motor stage (about 2 years old) when children learn reflection motion, playing games. The second is pre-operational stage (about 2-6 years old). At this age children develop language and investigate themselves. The third is concrete operational stage (about 13-18 years old) and the forth is formal operational stage (about 13-18 years old). Differences between concrete and formal thinking are shown in Figure 2.

CONDITIONS	PERSON: Knowledge Level of knowledge and culture Historic situation	
↓	↓ ↓	↓
GOAL	Material education and formal education	
↓	↙	↘
CHOICE	Educational contents getting concrete knowledge, students ″open the world for themselves″	Form of lesson getting the skills for further education students ″open themselves for the world″.
↓	↘	↙
RESULT	Reversible deployment	

Figure 1. Didactics as the theory of education

	Concrete thinking	**Formal thinking**
General thinking and judging	Uses only known objects and properties	Uses abstract conceptions and theories
Doing operation	Needs detailed description	Is capable to plan oneself, knowing general rules and means
Formulations	Discrepant statement, is not aware of thinking move	Is capable to control formulations
The possibility to think proportionally	Is not able	Able
The separate changing quantities	Is not able	Distinguishes, is able to control

Figure 2. Difference between concrete thinking and formal thinking

In the course of my work experience teaching Physics at the Latvia University of Agriculture, the conclusion has been drawn, that many students are capable only of concrete thinking. One of the roles of science education is to develop logical (formal) thinking. The problem is that many students lack background knowledge in science subjects and they are not aware of conscious study process methods, i.e., students "do not know how to learn". Never having achieved success in their studies, students often lose any interest about science subjects and either believe that subjects are unnecessary or complain that a lecturer's requirements are too demanding for them to fulfill.

Teaching any subject, but especially science subjects, it is necessary to find and investigate methods for development of cognitive skills. The teachers' main goal is to work on the students' strong hemisphere, not underlining and lessening the weak one. Human brain hemispheres' anatomical structural asymmetry is closely connected with its functional asymmetry. It is important to know each hemisphere's function and use this knowledge in the teaching process. The teacher must differentiate the teaching process, thinking in four ways: 1) how experience develops students personality (right underneath), 2) how to help to develop concepts' and laws' perception (left top), 3) how to help to apply the adopted (left underneath), 4) how to create new ideas, new meaning (right top).

Developing left hemisphere, use right hemisphere techniques such as metaphor, direct experience, visual thinking, evocative language, fantasy, music, multisensory thinking, kinesthetic perception [3]. According to the theory of constructivism [4], [5] the teacher's role is seen as a facilitator guiding students generate their own knowledge. The teacher can use different strategies to develop the higher level of cognitive skills. One of them is "Advance Organizer" [6]. The teacher forms the "scaffold" for acquiring further knowledge indicating the interdependence and promoting students to fill knowledge with personal meaning. This is a principle "top- down". The other main strategy is "Hierarchical Structure" which is based on the consecutively arranged material from simpler to more complicate [7]. This is a principle "bottom-down". According to Gagne thecognitive developing process gets through subsequent steps: "Inarticulate knowledge" ⇒ "Stimulus – reaction learning" ⇒ "Connection the information" ⇒ "Verbal learning"⇒ "Learning disconnect "⇒ "Concept learning"⇒ "Learning regularities"⇒ "Problem solution". In the learning process it is very important directly to remark the hierarchy of the last three steps because we often have situations that students try solve the problem not having knowledge in concepts and regularities.

One way:

Experience → **Perception** → **Applied** → **Creative**
(right underneath) (left top) (left underneath) (right top)

Second way :

Experience ← **Perception** ← **Applied** ← **Creative**
(right underneath) (left top) (left underneath) (right top)

Figure 3.Two ways of organizing teaching process

Each student is individuality and each student has own learning style. According to the theory students can be divided into four categories depending on their learning styles: activist, thinker, theorist and pragmatist. Approach to the learning for **activist** is perceptive and absorptive and in the learning process she/he gladly uses
concrete experience accordingly production of knowledge based on experience but judgments – on feelings. This kind of students likes to share feelings and solve real problems. Approach to the learning for **thinker** is objective and definite and in the learning process she/he often works out own opinion. This kind of students likes interpretation of expert and needs definite time for reflection. Approach to the learning for **theorist** is analytical and conceptual and production of knowledge based on logic and rational assessment. This kind of students likes to build theories based on own investigation. Approach to the learning for **pragmatist** is active and energetic and in production of knowledge she/he often has experiments. This kind of students likes practical problems and discussions in small groups.

According to the categories of the learning styles there are divided four learning styles: 1) distribution style, in which are united the qualities characteristic activist and thinker; 2) appropriation style, in which are united qualities characteristic thinker and theorist; 3) modification style, in which are united qualities characteristic theoretic and pragmatic and 4) adaptation style, in which are united qualities characteristic pragmatic and activist.

Results

In order to satisfy the above-mentioned hemispheres functions and learning styles, the learning process can divided into eight steps (see Figure 4.). At first we must detect the problem. For identification of the problem we can 1) create the students' experience (right hemisphere) and 2) use reflection and analyse this experience (left hemisphere). It corresponds to the Distribution learning style. Then through transition process we can approach to the content of learning. At first we use 3) reflection and analysis integration in concepts (right hemisphere) and 4) creation of concepts and skills (left hemisphere), which correspond to Appropriation learning style. At the second we can 5) practice to use given models (left hemisphere) and 6) practice and add from own experience (right hemisphere), which correspond to Modification learning style. For understanding the expression of the learning concept we can take the seventh and eighth step: 7) analyses about availability and significance of application (left hemisphere), 8) implementation and application in new situations (right hemisphere).

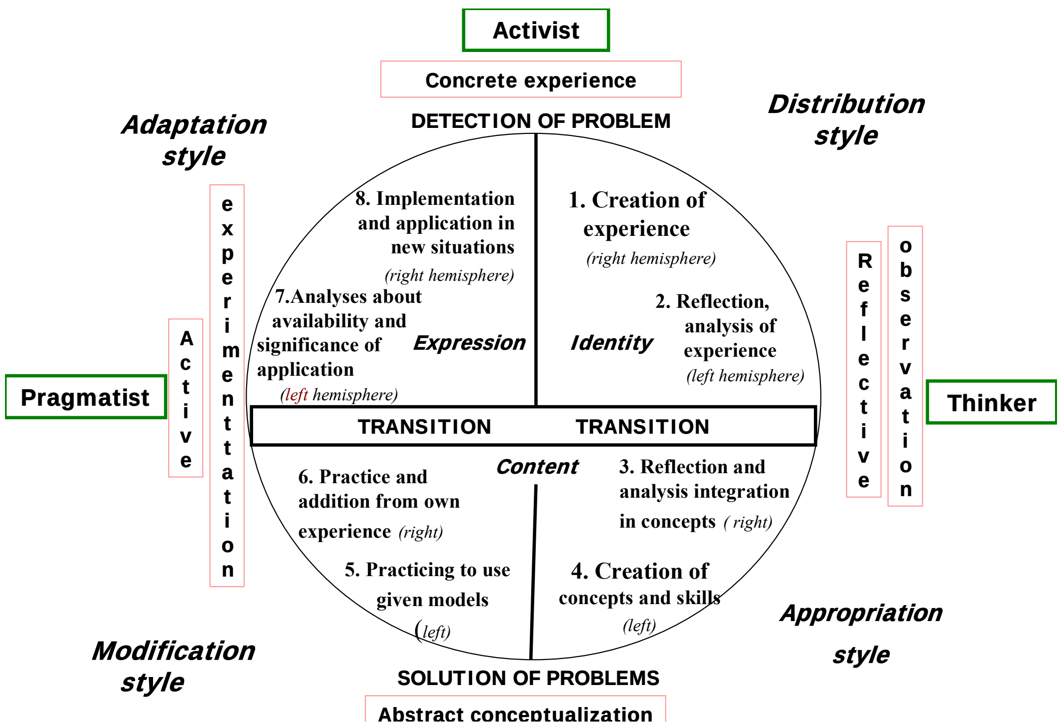

Figure 4. Circle of the learning process

Conclusion

Teaching any subject, but especially science subjects, it is necessary to find and investigate methods for development of cognitive skills. Each student is an individuality and each student has own learning style. According to the theory students can be divided into four categories depending on their learning styles: activist, thinker, theorist and pragmatist. According to the categories of the learning styles there are divided four learning styles: 1) distribution style, 2) appropriation style, 3) modification style, and 4) adaptation style. The teachers' main goal is to work on the students' strong hemisphere, not underlining and lessening the weak one. But, working with students' strong hemisphere teacher must develop all learning styles. The circle of the learning process shows eight steps how the teacher can organize the learning process using all learning styles and developing both brain hemisphere functions.

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APPLICATION OF HIGH RESOLUTION CAMS IN METEOROLOGY

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Cameras with high resolution used equidistance every three minutes give time lines described local status interesting for biological and meteorological observation is placed . There are found using of these lines yet. This article describes fotobox used for observation stations of Hydronet.cz project. This project obtains datas and gives it on-line to internet.

Introduction

Some scientific branches doesnt use common available technology with high resolution and high speed of data collection yet. In commercial sphere there are very precision and fast apparatus but very often there wasn´t found enough industrial and scientific using. For example high-resolution cams. One of first practical application of standard cams for physical measurement was used for Hydronet.cz project.

In this poject there were used some external high-resolution cams which obtain meteorological aimed pictures with 3 minutes time step, nowadays almost continues fourth year yet. This aplication of high resolution cams is much more cheaper than using of professional meteorological cams. In addition to control, non-proffesional cams have very often more usefull functions like zoom, flash, viewfinder and so one.

Experiment

In hydronet.cz project there are used old types of semi-professional and professional cams Olympus, Agfa and Nikon which are available for reduse price. But there is condition of their ability of distance control with using of OS Linux systemCameras are controlled from PC by Gphoto2 and PhotoPC programs.

Because of impossibility to get camera near to computer, there is not used usb connection either for new cameras. Communcation if serial RS line is much more better for possibility of long distance connection of control computer and camera, ordinary to kilometres. It is interesting that there is not said about this possibility of long distance connection and control in manual of cameras, some types of cameras (f.e. Nikon Coolpix 8700) even said that it is impossible.

External cameras in extreme weather conditions need special care for ensure constant condition of their operations (f.e setlement Jizerka with the highest rainfall per year and with the lowest winter temperature in the Czech Republic- under -30 °C; Vrbata challet in Giant mountain- speed of wind over 80,78 miles, humidity 90%).

Camera with accesories is placed in plastic box with IP 67 (fig.1) closed by polarscreen of good quality-ussually Hoya or B&W mark-without margin circle with diameter from 35 to 55 mm.

Very often is neccesery to bask camera box. It is done by help of copper circle with 10 Ω resistors around polarscreen. Details showes fig.2.

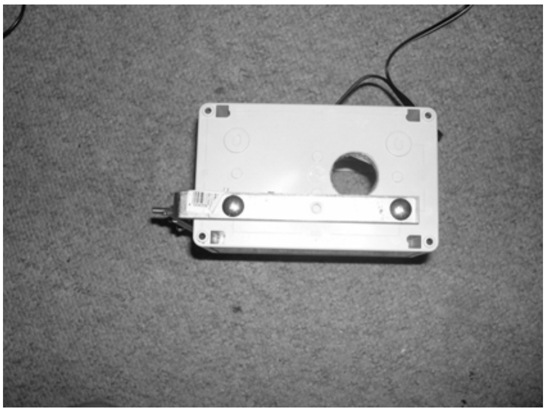

Fig.1. Example of used plastic box for camera protection. It is good visible slot for polarscreen.

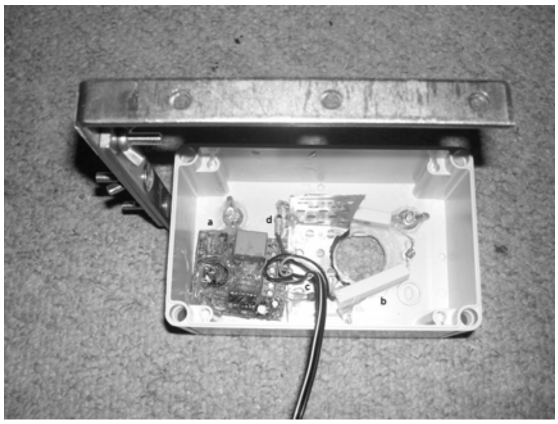

Fig.2. Opened plastic box prepared for camera instalation. a-termostat, b-10Ω resistors, c-temperature sensor, d-temperature protection.


Fig.3. Camera fixed inside plastic box by help of tripod screw.

Sometimes is possible to use for heating of inside space of camera box unprofitable output of its AC adapter, which is placed inside plastic box too. Camera is fixed in plastic box by angle-iron (fig.3.). For hermetic closing of plastic box there is used special silocon for electrotechnical use, common sililicon produces vinegar acid, which reacts to camera electronics. For cable passage through box is used special component with covering IP 67. For maximum protecting of camera from humidity there are placed small bags with silicagel inside box, too. In the end all connections of closed box are covered by insulation tape. We try to keep maximum flat surface of plastic box and the thinest distance between box and polarscreen. There isn´t good to use neither small roof nor some shades because of icing.

Conlusion

Online publication of pictures of landscape with three minutes steps showed that high resolution picture available on internet gets for many people more interesting informations about local meteorology situation than graphs of temperature, air pressure or humidity. These picture began to use other scientific branches, too, f.e. ornithology and botany. Winther pictures provide information about zero isotherm. Examples of these pictures show fig.4.-7.. They show the same shot in different seasons from camera located on Vrbata challet in west Giant Mountains.

EXIF information about each picture takes usefull information about sun shininig intensity (fig.8). It could be use for presumtion of right placing of solar panels.

Extreme meteorology situations like windstorm or flood very often destroy usual sensing devices or common sensing devices didn´t work in such extrem conditions. In these situations can pictures provide the only one actual weather and meteorology informations.


Fig.4. View from camera placed on Vrbata challet to Mt. Kokrhac (Mt. Kotel) in west Giant Mountains. Spring.


Fig.5. View from camera placed on Vrbata challet to Mt. Kokrhac (Mt. Kotel) in west Giant Mountains. Summer.


Fig.6. View from camera placed on Vrbata challet to Mt. Kokrhac (Mt. Kotel) in west Giant Mountains. Autumn.


Fig.7. View from camera placed on Vrbata challet to Mt. Kokrhac (Mt. Kotel) in west Giant Mountains. Winter.

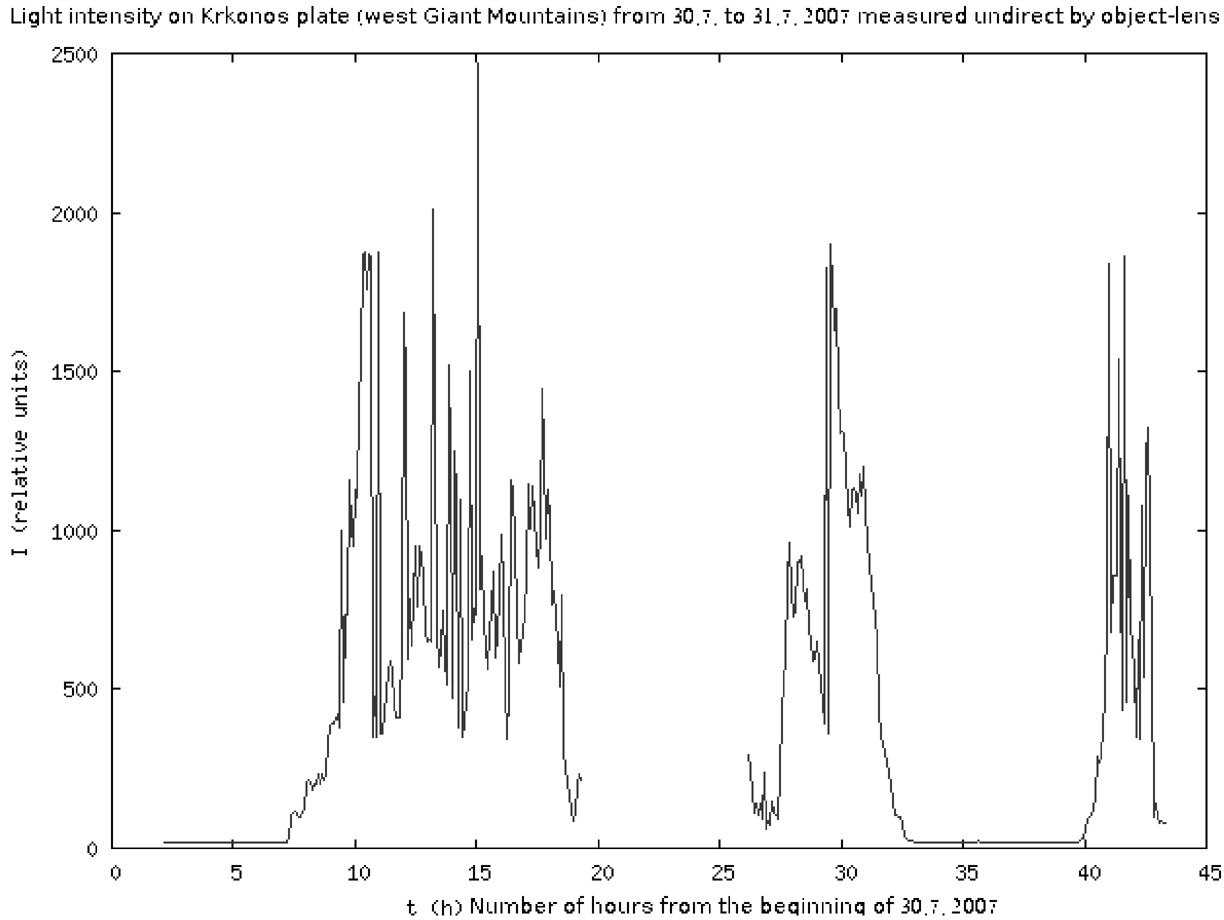

Fig.8. Example of using of undirect measurement by camera. Intensity of light obtained from object-lens. Mt. Devil near Harrachov town in Giant Mountains.

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IDENTIFICATION OF CHANGES OF TRANSFER FUNCTION OF MECHANICAL VIBRATIONS OF HUMAN SPINE AFTER CAR DRIVING

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Influence of vibrations during car drive courses relaxation of intervertebral discs and spinal muscles, too. This changes course translation of own resonace frequences of the spine and change of vibration loading of CNS for different excitation frequences. Ability of spine damping power decreases and it courses increasing of amplitudes in hypersound level, where are, unfortunately, own resonace frequences of the brain in the skull. There was laboratory examination before and after six hour car driving). There are shown only results of laboratory method in this article.

Keywords: spine, intervertebral disc, vibrations, car driving, transfer function

Introduction

Longstanding car driving is connected with low back pain. Professional car drivers are in more risk group than people work in seating (non drivers) or standing position. Frequency of difficulties increases with number of kilometers per year (Porter and Gyi, 2002, Harrison and kol., 2001).

Due Gilbertova (1997) are professional drivers in the most risk group connected with spine diseases. Except static loading there are vibrations, increased stretch muscle and impacts. Kelsey (1975) says that professional car drivers have higher probability of intervertebral disc protrusion, truck drivers four time higher than other people.

Neural system under repeated vibrations and tactile stimulus of vibrated parts of body after some time of these stimulus become dull and keep down attention to external stimulus. It causes worse reactions of drivers owing to so called monotonicity. Only very small part of human brain is able to work so effective like in non vibration setting. It depends individually on anatomy and on amplitude and exposure time of external mechanical frequences.

Material and Methods

This article shows results of experiment of detection of changes of spinal trasfer function of passenger after six hours traveling by privat car Ford Fiesta, you look Drahoradova (2007) too. Basic motiv of this study is the fact that central neural system is very sensitive to vibrations and due long exposition of vibrations happen to decreasing of damping function of CNS protection system (spine). First transfer of vibrations goes through contact place of passenger and car, especially from bottox and lumbar area, which are under load contact with seat. Volume of vibrations transfer dependes, of course, on type of seat (car) and concrete seating position. These facts make direct measurement due car travelling a bit complicated. So we decide to measure spine transfer function before and after car travelling in laboratory condition in normalized seating position („risen seating“-fig.1.) on special constructed vibration seat (fig.2.). These two positions are operative called squid and.Vibration seat with passenger is excited in axial direction. Laboratory seat is fitted with electro-mechanical exciter and accelerometer, too. Three very sensitive acclerometers are orthognal connected on the head of passenger in three main axis of body (fig.3.). Exciter generator is energized by amplifier Pioneer. Source of signal goes from programable transducer ProgGen Papouch mark. It produce linear changed signal with frequency from 1 to 20 Hz repeated with period 7,9 s (fig.4.). Obtained signal is filtred, averaged and spine transfer function is determine as relatio of in- and out-going Fourier images and their correlation (fig.5.,6.). It is done twice, before and after car travelling (fig.7.). By comparation of before an after driving spine trasfer function we can see changes of some peaks to higher frequences (increasing of stiffness). Correlation graphs can show which part of body correspondent to particular peak.

Fig.1. „Standardized“ seating position.

Fig.2. Special constructed vibration seat.

Fig.3. Acclerometers connected on the head of passenger in three main axis of body.

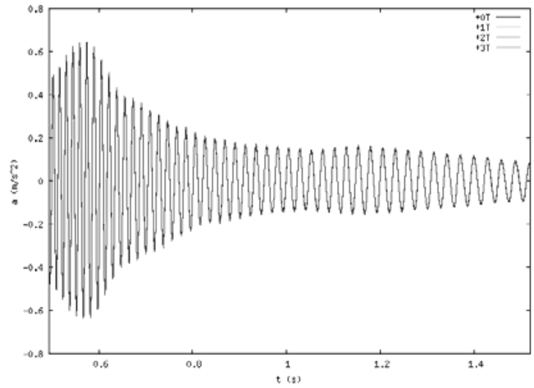


Fig.4. Linear changed excitation signal with frequency from 1 to 20 Hz repeated with period 7,9 s.

Discussion

In results there is visible that six hour car driving significantly influences drift of some frequency peaks as twice up, which respons with four time change up of stiffness of corresponding tissue against stiffness before driving. Similarity of spine transfer functions is for flexion and axial direction is only for heart beating. Fig.8. shows confrontation for three directions of measurement where is almost the same result for flexion and axial direction. Interesting result shows direction of lateral flexion. It is similar to other two directions but there is extra frequency about 4 Hz and isn´t stable frequency of increased trasfer in area about 15 Hz.

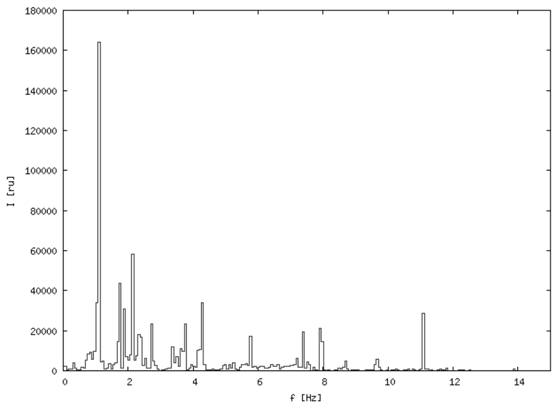


Fig.5. Correlation of spine transfer functions for axial and lateral flexion direction before driving. It shows dominant duration of cycle in area of heart beating (1Hz).

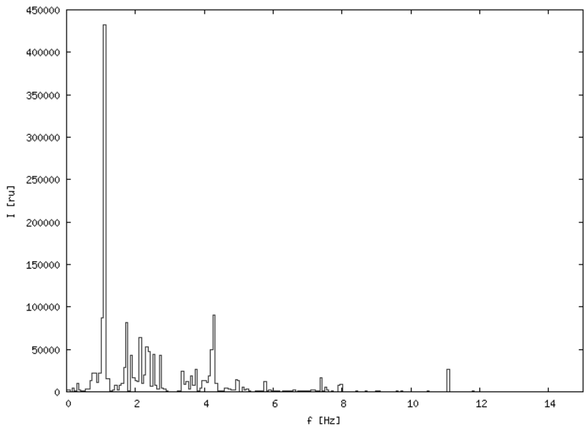
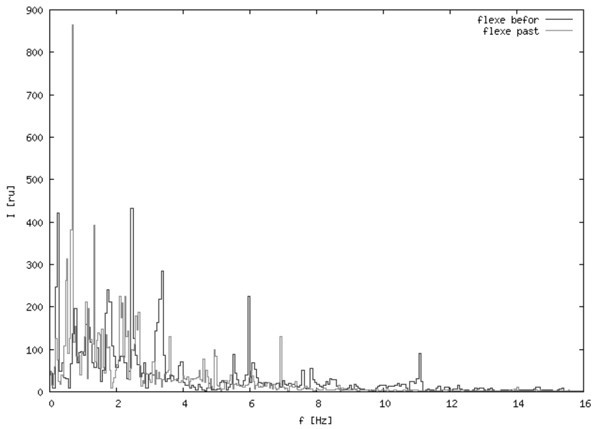
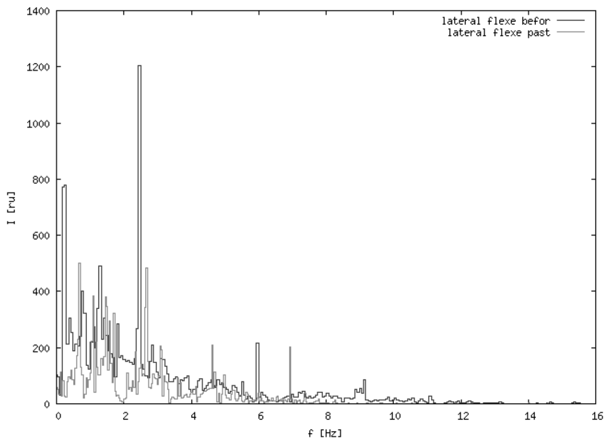


Fig.6. Correlation of spine transfer functions for flexion and lateral flexion direction before driving.





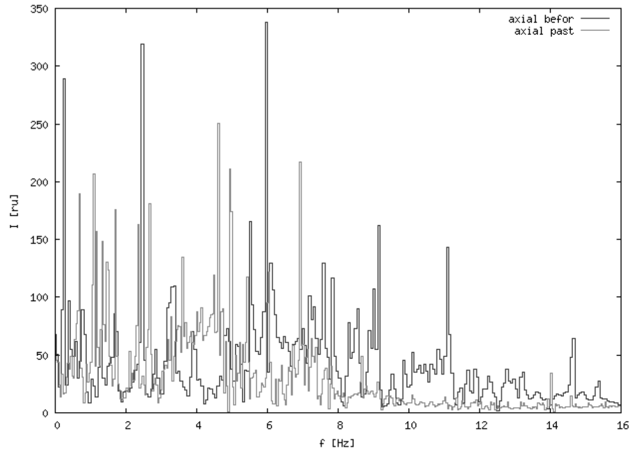


Fig.7. Comparation of spine transfer functions for axial (bottom), flexion(top) and lateral flexion direction before and after driving.

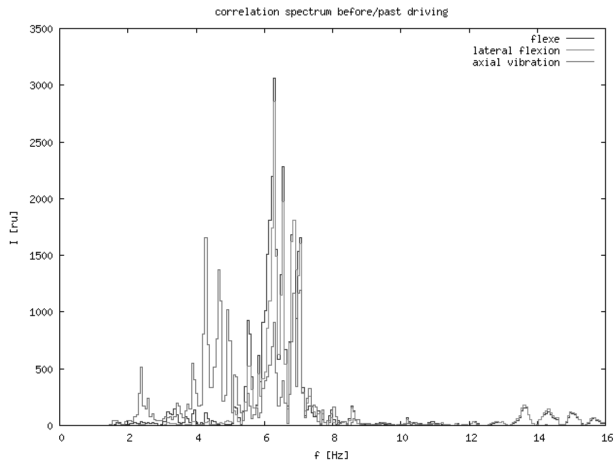


Fig.8. Confrontation for three directions of measurement.

Conclusion

There are shown results of experiment of detection of changes of spinal trasfer function of passenger after six hours traveling by privat car Ford Fiesta.

To assign of frequences to responding organs a tissues is neccesery to analyse distance signals and to start cooperation with laboratory of physiology. Unfortunately, nowadays it isn´t possible.

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INDIRECT AND MIXED-MODE SOLAR DRYING MODELS FOR SULTANA GRAPES

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Active indirect and mixed-mode thin layer solar drying experiments were conducted on Sultana grapes. A combination of a solar air heater and a cabinet dryer were designed, constructed and tested for this product in agricultural engineering department at Shiraz University, Iran. Three air flow rates (0.085, 0.126 and 0.171 m^3/s) and two types of drying systems (indirect and mixed-mode) were adopted. The south wall of drying chamber was covered by a sheet of glass for mixed-mode and the glass sheet was covered by a thick sheet of cloth for indirect type of solar drying system. Seven famous thin layer drying models were used separately to fit the mixed-mode and indirect type experimental data for Sultana grapes. For experimental indirect data, the Modified Page model and for experimental mixed-mode data, the Page model showed the best curve fitting results with highest r and lowest χ^2 values. The constants in the models explain the effect of drying parameters, air velocity and temperature. To take care of these effects, the best correlation equations between the constants and drying parameters were also introduced.

Key words: Thin layer model, cabinet solar dryer, grapes, mathematical model.

1-Introduction

In any dried fruit production activity drying process may be the most important unit operation. This method of preservation if done appropriately can save and improve the quality and quantity of the end product effectively. Unsuitable preservation and storage methods cause losses range from 10 to 30% for cereals and 50 to 70% for fruits [1]. Drying of fruits allows its preservation by reducing its water content, inhibiting microbial growth and enzymatic modification. Some very important advantages of drying for most agricultural commodities are namely the reduction of their size and weight which facilitates transportation and reduces storage space, and more importantly, avoids the need of expensive and sophisticated cooling system for maintaining their quality [2]. Finally, it increases usage diversity allowing alternatives to the consumption of the products in fresh and improving shelf life especially in rural areas.

Open sun drying is still the most common method used to preserve agricultural products in majority of developing countries [3]. Although the way is cheap and simple but due to leaving the product unprotected from rain, windborne dirt and dust contaminations, and infestation by insects, rodents, birds and other animals, the quality may be seriously degraded such that it sometimes become inedible [4]. Solar drying can be a feasible alternative for sun drying because it provides the most cost effective drying technique. In this technique the solar energy is used to heat up a stream of air which in turn flows through a bed of the commodity to be dried naturally or artificially. Since the material is contained there is less contamination and it is less susceptible to adverse weather conditions. Substantial amount of theoretical and experimental works have been reported on solar as well as open sun drying of vegetables and fruits [1. 3 and 5.]

In forced convection (active) solar dryers the drying material may be also exposed to direct solar radiation .This type of drying system in known as mixed mode where as in an indirect type the drying process is only proceeded by hot air stream provided by solar air heater. This study was mainly devoted to:

- Investigating the thin layer solar drying for Sultana grapes using an active indirect and mixed-mode type solar dryer under different operating conditions.
- Choosing a suitable thin layer mathematical model for describing the indirect and mixed- mode solar drying processes.

2-Materials and methods

The rig consisting of a solar air heater, a reducer, a cabinet dryer, a blower with ducting system, a solar meter, temperature sensors, data acquisition system and a portable rig stand. The rig was erected outdoor in agricultural engineering department, Shiraz university. The solar air heater and the dryer were tilted 45° towards the south, [6] , figure 1 (local altitude was 30°).

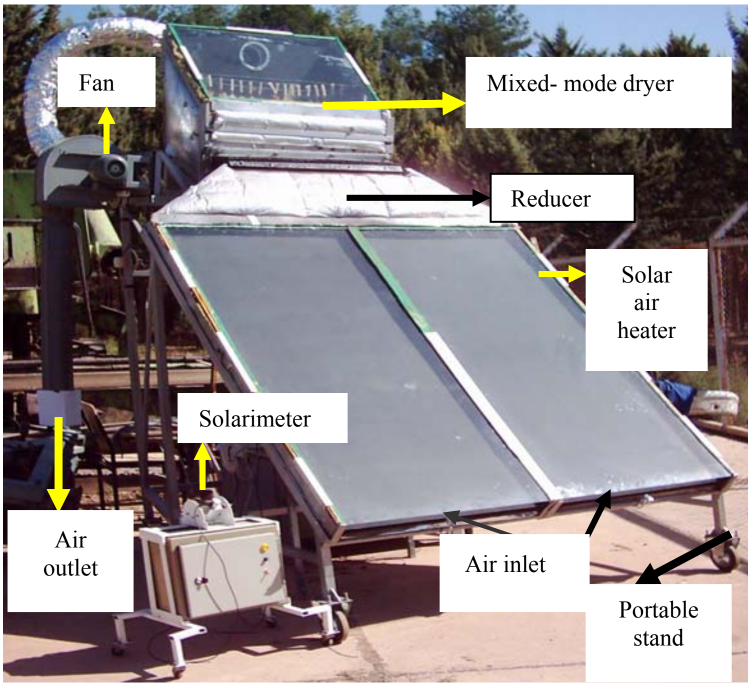

Fig1: Sultana grapes solar dryer in mixed-mode condition type with solarimeter

***2-1 Solar air heater*:** Two single glazing air solar collectors were made from pressed wood 1cm. in thickness whose sides and back walls were thoroughly covered by glass wool (5 cm. in thickness). For each solar air heater a sheet of glass (4mm. in thickness) with 1m. in width and 2 m. in length was used as transparent cover. Two sheets of aluminum (1.5 mm in thickness. 1x2 m.) painted matt black were used as absorber plates. These two collectors were tightly attached together side by side to make a rigid single module solar air heater with effective surface area of 4 m^2 with 10 cm. in depth. In order to connect the solar air heater to the cabinet dryer a reducer with 10 cm in width, 200 cm in length at the larger end and 20 cm in width, 100 cm in length at the smaller end was used. The reducer was made of pressed wood and well insulated with glass wool.

2-2 Solar cabinet dryer. The drying cabinet was constructed with pressed wood, 1cm. in thickness and fully insulated by glass wool on sides, back and bottom walls. The slanted front wall (with 45° inclination) was covered by a glass sheet, 4mm. in thickness to let the sun light to pass through and hits the drying products (mixed-mode). This transparent wall may be covered by an opaque and insulated sheet for indirect mode of dryer application. On the back wall (north side) a lid was incorporated to let an access for the operator for loading and unloading the dryer. On the upper most of the back side wall of the dryer an exhaust hole, 15 cm. in diameter, was made through which the humid air can be sucked out by the fan. On the most lower part of the front wall a rectangular opening 30 cm. in height and 100 cm. in length was made to let the hot air from the solar collector reducer to enter to the dryer plenum chamber. In order to have a uniform air distribution in the dryer, the bottom of the plenum was tilted 22° from front to rear of the plenum for reducing the cross section area of the plenum gradually. The dimensions of the cabinet dryer were 100 cm. in length, 50 cm. in width, 50 cm. front height and 85 cm. rear height. The drying trays were made of a wooden frame on all four sides with plastic net (1.5x1.5 mm.) on the bottom to hold the samples. To conduct the experiments, two trays with the same length but different width were used in the dryer. The lower tray with 96 cm. in length and 46 cm. in width and the upper one with 26 cm. in width (total tray surface area was 0.691 m^2). The distance between the trays was set in such away that the upper tray did not make shadows on the lower one during the mixed-mode experiments .

2-3 Instrumentations: A centrifugal fan (1400 RPM and 750W) was installed on the downstream for sucking the ambient air through the solar air heater and then the cabinet dryer. To conduct the experiments at different air flow rates an adjustable butterfly damper was incorporated into the fan exhaust pipe. A long circular duct (15cm. in diameter with 150 cm. in length) was connected to the fan exhaust. At the end of this duct an accurate photoelectric type air velocity meter, a dry and a wet bulb thermometers were inserted. Air temperatures at different positions of drying system were recorded and monitored by means of ten SMT 160 temperature sensors (±0.5°C) at regular intervals of 5 min. via a data acquisition system. The tips of the sensors were covered properly by aluminum foil to reduce radiation errors. The solar intensity was measured and recorded at the same time interval using a Casella Pyranometer (0 - 2000 W/m^2, 1mv=1W/m^2) placed beside the plane of the collector at the same inclination angle, fig1.

2-4 Experiments: Two series of drying experiments were carried out during the period of September and October 2005 at college of agriculture, Shiraz University, Iran. The first set was devoted to indirect type and the next set of experiment was conducted on mixed-mode type dryer. For each set at a specific air flow rate, three replications were made. Three ranges of air flow rates of 0.171, 0.126 and 0.085 m^3/s were adopted. For each period of drying, the dryer was started at 10.0 a.m. and drying process was continued till 4.0 p.m. everyday. During each trial, the initial and interval weight measuring of the grapes on the trays were performed by an electronic balance (0-20 kg ±1g) by removing the tray from the dryer cabinet for approximately 20 seconds. At 0.171 m^3/s the drying air temperature varies from 37 to 42 ° C, at 0.126 from 42 to 47 ° C and at 0.085 from 48 to 53 ° C. During the course of experiments the average ambient air temperature was 20 °C, the average outside air relative humidity was 15% and the average solar insolation was 870 W/m^2.

The grapes harvested manually (average initial moisture content of 78%) were checked carefully for any infections. In general, the use of pretreatment solutions removes the waxy layer, induces micro pore formation on the cuticle, increases drying rate of grapes, reduces drying time and improves the quality of final products. In this study the grapes were pretreated with 5% K_2CO_3+2.5% vegetable oil solution. Dipping time for pretreatment with the solution was about 5 sec and maximum solution temperature was about 90°C. Then, the grapes were pretreated with SO_2 gas [7]. The prepared samples were spread evenly and tightly in thin layers on drying trays with packing density of 15 kg/m^2 and placed on the shelves of the drying cabinet. The average final moisture content of the product was 15%.

2-5 Thin layer drying mathematical models: Although the moisture ratio (MR) was defined as $MR=(M_i-M_e)/(M_o-M_e)$ [8] but due to continuous fluctuations in drying air relative humidity in solar dryers, the moisture ratio was simplified to $MR=M_i/M_o$ [9,10]. In order to investigate the thin layer drying properties of biological materials, several mathematical models have been applied among which the following models, table 1, were extensively reported to be suitable for high moisture content products [8, 11].

The thin layer solar drying data were fitted to the above models to find the best fit model for the indirect and mixed-mode type solar drying processes separately. To validate the goodness of the fittings, two criteria namely correlation coefficient, r and mean square of deviations, χ^2 (chi square) were employed. Higher r values and lower, χ^2 values indicate a better curve fitting [9,12].

$$\chi^2 = \frac{\sum_{i=1}^{N}\left(MR_{\exp,i} - MR_{pre,i}\right)^2}{N-n} \tag{1}$$

Where: $MR_{exp,i}$ is the ith experimental moisture ratio, $MR_{pre,i}$ the ith predicted moisture ratio, N the number of the observations and n the number of constants in the equations [9].

Table 1: Proposed mathematical models for Sultana grapes thin layer drying

Model's name	Equation
MR=exp(-kt)	Newton (1)
$MR=\exp(-kt^n)$	Page (2)
$MR=\exp(-(kt)^n$	Modified Page (3)
MR=a exp(-kt)	Henderson and Pabis (4)
MR=a exp(-kt)+c	Logarithmic (5)
$MR=a\exp(k_0t) + b\exp(-k_1t)$	Two term (6)
$MR=1+at+bt^2$	Wang and Singh (7)

Where: k, n, a, b, c, k_o and k_1 are constants and t is the drying time.

3- Results and discussions

For two different solar drying types, indirect and mixed-mode, the moisture ratio values of the samples were calculated at different air flow rates and drying air temperatures during the drying processes. These MR values then were fitted against the drying time separately. The Modified Page model showed the best curve fitting results (highest r and lowest χ^2 values) for indirect type and the Page model for mixed-mode type respectively, table 2. Therefore the Modified Page model was selected to present the thin layer indirect solar drying and the Page model for presenting the thin layer mixed-mode type solar drying for Sultana grapes.

There are two constants in each model related to the effect of drying air temperatures and velocities. In order to formulate the relationship between the constants and drying parameters (drying air temperatures and velocities), multiple regression analysis method was employed for all data in each solar drying types In Modified Page model (indirect) the correlations for constants taking into account the drying parameters, drying air temperature and velocity, were:

k= 0.48370-0.0361V+0.000074T
n=0.37588+0.036222V-0.00002T
R^2= 0.994

In Page model (mixed) the correlations for constants were:

k= 1.14003-0.06099V-0.00333T
n=0.2038+0.03227V+0.00226T
R^2=0.930

Using the proper model with known drying air velocity and temperature, the moisture ratio and the moisture contents values can be estimated at any drying time for indirect and mixed-mode type solar dryers.

The experimental and predicted moisture ratio values (MR) versus drying time at three air flow rates and two different drying systems were shown in figures 2 and 3.

The moisture ratio decreases with a diminishing rate at different air flow rates and for two solar drying systems. It means that all drying periods were performed in falling rate period. These results are in good agreements with other researches' [3,9,13and14]. The steepest slope was belong to air flow rate of 0.085 m^3/s and mixed mode type because in this process the drying air temperature was high due to slow air velocity in the air solar collector and the product was also exposed to direct solar radiation. It means that the moisture removal was high not only due to the warmer drying air which resulted in higher magnitude of moisture diffusion coefficient but also due to radiation beam which resulted in a higher temperature and evaporation rate on the product surface.

Table 2: Correlation coefficient, r, and mean square of deviations, χ^2, values for selected thin layer drying models

Model	Air flow=0.085m^3/s	Air flow=0.126m^3/s	Air flow=0.171m^3/s
Modified Page for Indirect type	r=0.999 χ^2=0.000157	r=0.998 χ^2=0.00024	r=0.998 χ^2=0.000055
Page for Mixed-mode type	r=0.997 χ^2=0.000133	r=0.999 χ^2=0.000169	r=0.999 χ^2=0.000281

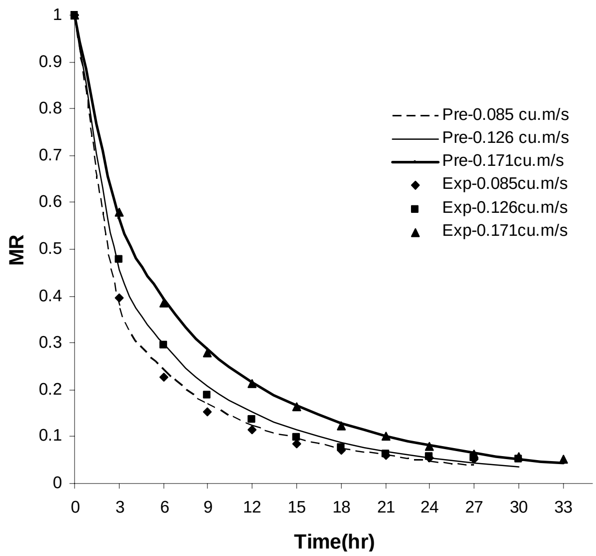

Fig. 2: Comparing predicted and experimental MR values versus drying time at three air flows for indirect type solar drying system

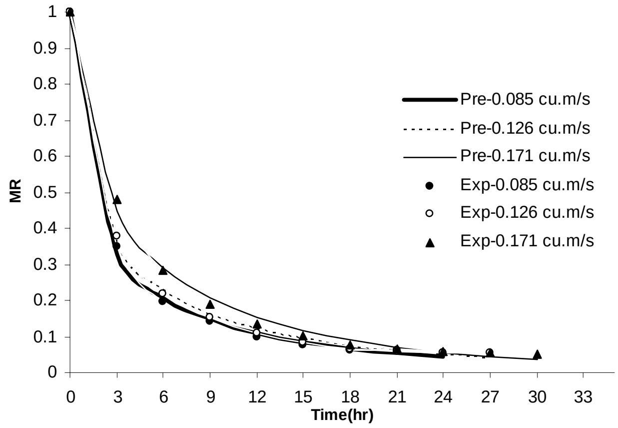

Fig. 3: Comparing predicted and experimental MR values versus drying time at three air flows for mixed-mode type solar drying system

Generally, the drying time for the mixed-mode type solar drying was less than that of the indirect one. The minimum drying time was 4 days (6 hrs of drying period each day) at 0.085 m^3/s for mixed-mode and the maximum drying time was 5.5 days at 0.171 m^3/s for indirect type.

4- Conclusions

In order to find the best mathematical model for Sultana grapes thin layer solar drying for indirect and mixed-mode type, a cabinet solar dryer was employed. Modified Page model and Page model showed the best curve fitting results for the experimental moisture ratio (MR) values for indirect and mixed-mode type respectively. The drying parameter effects namely air velocity and temperature were established by introducing the best fit correlation equations for the constants involving in the selected models.

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