TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15-18 SEPTEMBER 1992

PROCEEDINGS
I.

TAE 1992

UNIVERSITY OF AGRICULTURE PRAGUE
FACULTY OF AGRICULTURAL ENGINEERING

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The papers are in two volumes in alphabetical order of author's names

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PREFACE

Nihil est ab omni parte beatum

There is not anything that could
only have pleasant aspects

Horatius

Present agriculture is at the cross-roads of its evaluation: on the one hand it produces many unmanagable surplusses, while on the othar hand it is unable to ensure even the basic foods for whole polulations of the world. A very similar situation can be observed in Agricultural Engineering - this field makes possible increases in both agricultural production intensity and also human work culture, but at the same time farm machinery contributes to ecological damages.

Agricultural Enginering is also at a cross-roads to further development: incorporation of robotics in base operations of agriculture, utilization of new activities and technologies, use of different technological steps and methods, which take into account greater consideration of products and the environment. All these possibilities give anticipation of future, large-scale, development in Agricultural Engineering. A field in which it is necessary to optimize. Papers presented in the proceedings try to solve this problem.

May, 1992

Jiří Blahovec,
member of organizing
committee

TRENDS IN AGRICULTURAL ENGINEERING
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UTILISATION OF HEAT PUMPS IN ANIMAL BUILDINGS

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Article contains proposal of farm energy system for 370 swine with heat pump, that uses heat from ventilation air for heating and warming service water.

energy system; energy consumption; anumal building; heating; ventilation; heat pump; desk recuperation exchanger

High total energy consumption of classic energy systems in CSFR that provide appropriate micro climatic conditions in animal buildings leads to research, verifying and to continuous realisation of heat pumps, today. Energy systems with heat pumps can realise really optimal climatic and operating conditions along with significantly reduced primary fuel consumption.

Low potential resource for heat pump evaporator can be usually biological heat of animal in any form (ventilation, dung).

Obtained conservation of primary fuel ΔE we can calculate from equation:.

$$\Delta E = 100\left(1 - \frac{\eta_k}{\eta_e \varepsilon_t}\right) \quad [\%]$$

Where:
η_k - efficiency of present source [-]
η_e - efficiency production of electrical energy [-]
ε_t - heating factor [-]

Equation depicted in nomogram in picture1. enables obtaining of percentile conservation of primary fuel and absolute conservation of user fuel consumption (η_e=1) and enables also minimal heat factor with given energy conservation.

Important aspects of economical efficiency of energy system are good thermal characteristics of engineering structure (minimal mean R = 1 m K W), reducing of thermal loss by ventilation and especially by round year use of heat pump in bivalent system with accumulation of acquired heat.

In this article we want to show example of heat pump use. Heat pump is air-water system LV 20 S (produced by FRIGERA Kolín) for 370 swine that are in three objects A, B, C. In A object is 96 swine, 160 gravid swine ad 30 young swine. In B object there are 84 birth boxes with piglets. In C objects there are 1440 older piglets.

Chart of energy system is on picture 2. All ventilation air from A object is directed to heat pump evaporator LV 20 S (1). From heat pump condenser is warmed water conveyed by water pump (2) into 10 cubic m accumulation tank (3), from this tanks water conveyed through three ways mixing valve (8) into central heating system in B object, heating is made from floor panels (4) that are situated in birth boxes and space heating system with low temperature radiation elements (5).

Warmed water from accumulation tank is also conveyed to service water accumulation tank for hygiene and production use(6).

All ventilation air from objects B and C is conveyed to desk recuperation exchanger RVD A 10 (manufactured by Státní statky Šumava) works with mean thermal efficiency η_t =0.38.

In the accumulation tank are installed electric additional heating elements with maximum performance 12 kW that serve as reserve and peak heat sources.

Needed performances and powers of energy system in relevance to outside temperature are depicted in picture 3.

Where:

Q_{tR} - performance of space heating system in object B [kW]
Q_{pan} - performance of heating floor panels in object B [kW]
Q_n - performance for drink water heating to temperature 20 C [kW]
$Q_{TUV,s}$ - performance for hygiene water heating [kW]
$Q_{TUV,t}$ - performance for service water heating [kW]
Q_S - performance for feed heating to temperature 35 C [kW]
Q_k - performance for heat pump condenser LV 20S [kW]
N - power of heat pump compressor [kW]
Q_E - performance of electrical directly heating elements in accumulation tank when outside temperature is below -5 C [kW]
Q_{VE} - power of ventilators of desk recuperation exchangers RVD A 10 [kW]

$Q_C = Q_{tR}+Q_{pan}+Q_n+Q_{TUV,s}+Q_{TUV,t}+Q_S$ [kW]

Fig.1. Nomogram for obtaining saving of primary fuel in energy system with heat pump

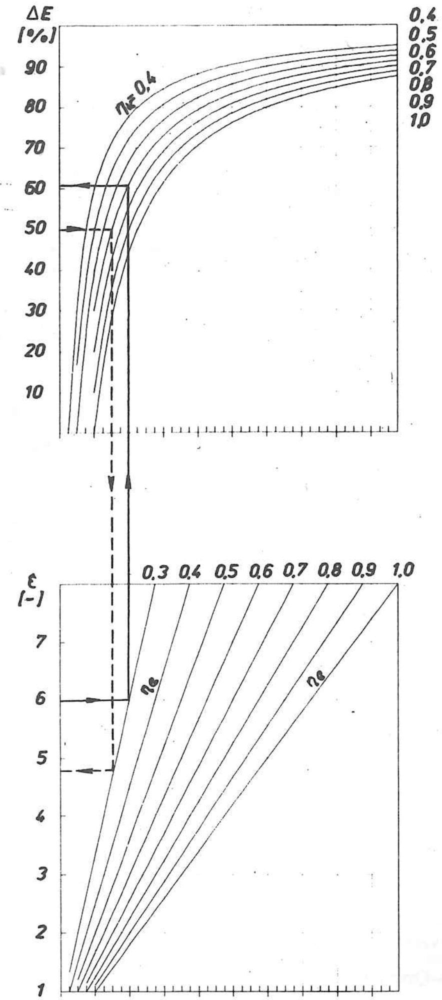
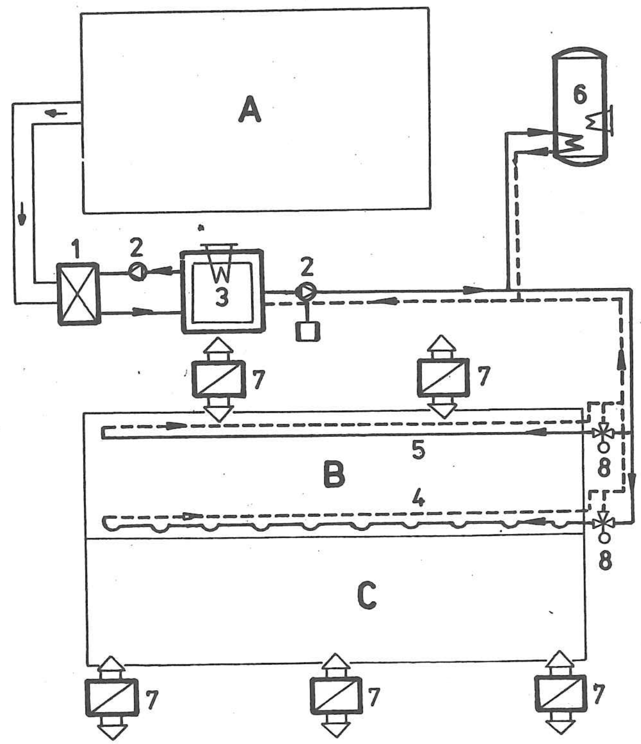
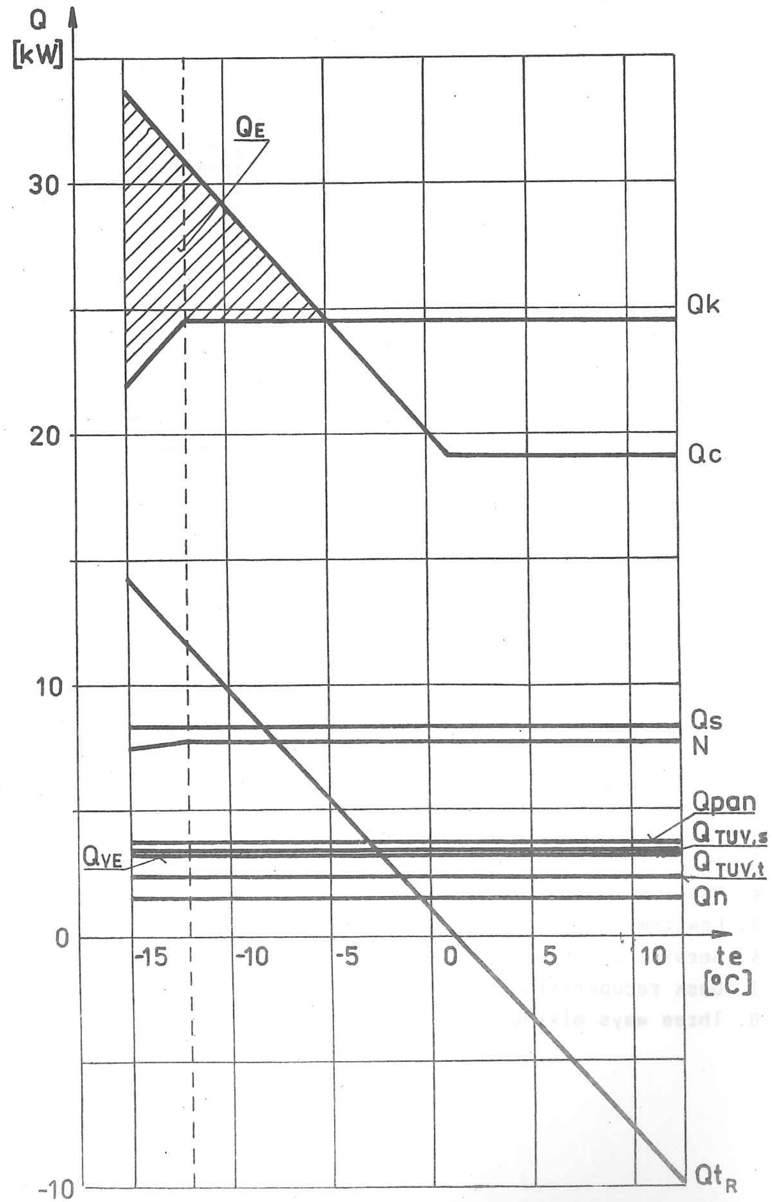


Fig.2. Energy system objects for 370 swine with heat pump



1. Heat pump LV 20 S
2. Hot water pump
3. Accumulation tank
4. Heating floor panels
5. Low temperature radiation elements
6. Service water accumulation tank
7. Desk recuperation exchanger RVD A 10
8. Three ways mixing valve

Fig.3. Needed performances and povers of energy system in relevance to outside temperature



TRENDS IN AGRICULTURAL ENGINEERING
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DRYING PROCESS INFLUENCE ON TOBACCO QUALITY

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Two programs of tobacco leaves drying type Virginia, in a dryer of a domestic and foreign manufacture, have been analyzed in this paper. It was concluded that in the work of dryers, there are considerable deviations from the stated programs. These deviations reflect both in drying air temperature values, and length of individual phases duration. All these essentially influence the tobacco leaves quality (Table 1). This is why it is considered economically justified to introduce computer systems that will control the process.

Key words: tobacco drying, quality of dried leaves

1. INTRODUCTION

The technology of tobacco type Virginia production consists of more parts out of which the drying process is of a special importance. The tobacco leaves drying can be **natural**, when the surrounding air is used, and so called **„artificial„** when the air is heated and directed to a specially designed devices. The advantage of the second mentioned is, that the unfavorable atmospheric influences are eliminated, and that the process is speeded up so that we obtain a product of a better quality.

In the regions where the tobacco growing is a tradition, as in Panonia Valley, Herzegovina and Macedonia, both types of drying are applied what depends on a local climate conditions. Where these conditions are more severe, as for example in Panonia Valley, the devices with a very wide range of output, are constructed. Most often they are of a domestic manufacture, though there are some imported ones.

In this paper we shall analyze the process regimes of tobacco type Virginia leaves drying in a domestic dryer manufactured by „Univerzal„ from Podravska Slatina and in a dryer of Canadian manufacturer „DeCloet„.

2. METHOD OF WORK

The process of tobacco leaves drying is quite a specific process and it consists of the following phases /1,2,3/: The first phase tanning (changing into yellow color), the second phase fixation (keeping) of color and leaves surface drying, the third phase the drying of the main leaf nerve. There are certain biochemical processes in each of these phases and they dictate the air drying situation.

The tanning phase is characteristic of starch, albumen, carbohydrates and nicotine disintegration so that the optimal air temperature for these processes is 30°C to 40°C, and relative humidity approx. 80%. The duration of phases is from 24 to 26 hours and the increase of air temperature is 0,5 to 1,0°C per hour. The same must not be shortened by fastening the process, since in this case, due to sudden water deduction, the cells would die out with quite a lot of starch in them, what unfavorably influences the quality.

The moisture remaining in the leaf evaporates in the following phase - phase of color fixation, but in such a way that the characteristic leaf color is kept. The mean air temperature must not be over 47°C until the leaves mass does not decrease to 50%. This phase lasts approx. 20 hours and during each hour the air temperature is increased for 0,5 to 1,0°C. After that, the air temperature can be increased up to 55°C.with the speed of 1,0 to 1,5°C per hour. During this time, the drying of a leaf surface will take place.

The drying of the main nerve is the last stage where the moisture has to be removed from the main rib (nerve), so that we can stock the leaf safely. The drying air temperature is from 57°C to 74°C with a low relative humidity. The duration is approx. 35 hours, and what is important, is to stress, that higher temperatures must not be applied, since the sugar caramelaziation appears and the leaf gets red color.

After drying the leaves mass is cooled and wetted in order to become elastic and suitable for manipulation in the storehouse. The air temperature is approx. 40°C lasting for eight hours.

The specific technological drying process requirements have conditioned the equipment design that can realize it. These are batch dryers in which the material is in a layer of a certain thickness. In order to provide the corresponding drying air situation, all dryers are equipped with dry and wet thermometers, as well as, with the possibility of recirculation, i.e. air circulation within it. Figure 1. shematicly represents the dryer manufactured by Universal, Podravska Slatina /4/, but it has to be stressed immediately, that a dryer of the Canadian manufacturer DeCloet /5/ is of a similar construction.

The drying air is directed from the bottom through the perforated floor and passes through the containers with leaves. The air is collected above the container and distributed either on recirculation and used air, or the whole quantity is discharged into the atmosphere. The control of the mean drying air temperature is by two valves. The valve (item 13. Fig 1.) in front of the burner, controls the quantity of fresh air that is taken in the drying process. This, at the same time, regulates the required temperature of the dry air thermometers.

Valves (item 8 and 14 Fig. 1) control the air quantity which recirculate in the drying chamber, or is let out into atmosphere. In such a way, we regulate the temperature value of the wet air thermometer. Both temperatures are measured by the built in instruments directly at the inlet into the drying chamber.

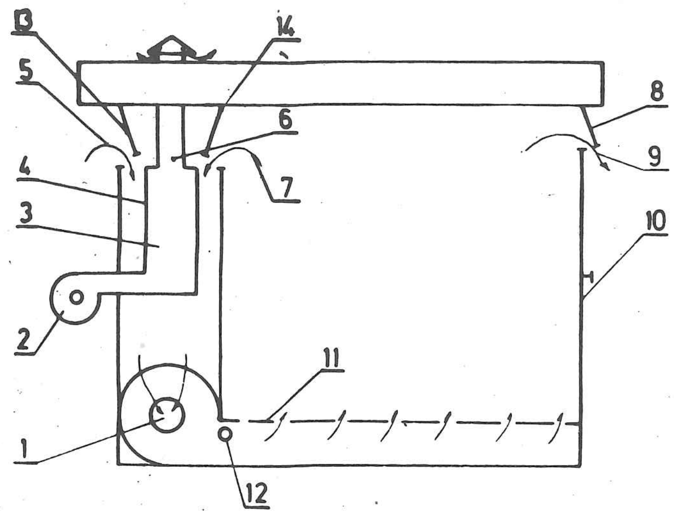

Fig. 1. SHEMATIC VIEW OF „UNIVERSAL" DRYER /4/

Items : 1. fan, 2. burner, 3. burning chamber, 4. heat exchanger, 5. air input, 6. chimney, 7. air input recirculation, 8. valve, 9. air output, 10. door, 11. perforated floor, 12. sprayer for tobacco wetting, 13. 14. valve,

In a counter heat exchanger (item 4), which makes a whole with the combustion chamber, the surrounding wet air passes over the exchanging surfaces and is heated there. The product of burning is discharged into the atmosphere through the chimney (item 6). It ought to be stressed that through the same heat exchanger the fan takes in a portion of the air from the drying chamber so that it is combusted here. With such partial recirculation the energy efficient drying process is achieved.

During the work regime of tobacco leaves drying analysis in dryers DeCloet located in Knićan, and Universal dryer in PIK Prigrevica, in Prigrevica /2/ the temperature values read from the installed instruments were used, since by the control measuring it was established that a fault in measuring is irrelevant.

3. INVESTIGATION RESULTS

Diagrams on Fig. 2 present the temperature of tobacco leaves type Virginia drying regime that are achieved in the mentioned dryers.

Comparing the realized drying regime with the predicted one /5/ in a dryer of a Canadian manufacturer, we have concluded that there is an insignificant deviation. Namely, during the first night, the necessary leaves tanning (getting yellow) did not occur, but the increase of dry air thermometer temperature to 40,5oC was done immediately. This temperature increase of a dry

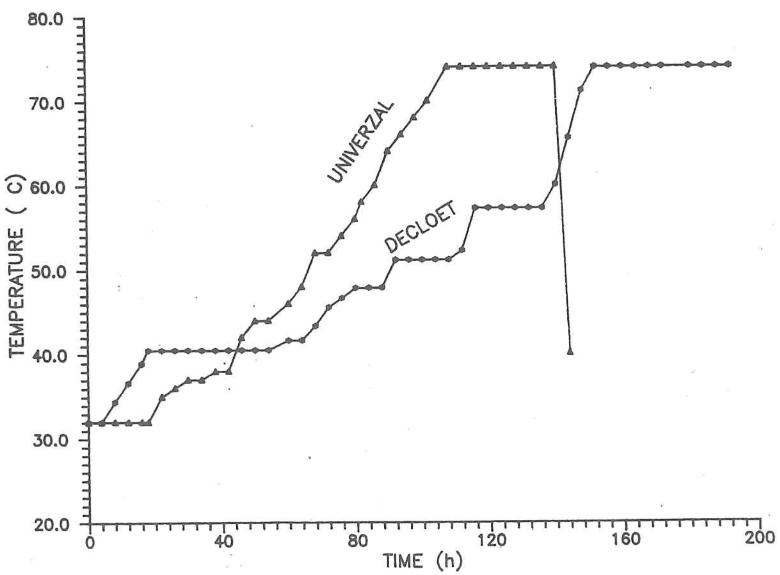

Fig.2. TOBACCO DRYING PROGRAM /2/

thermometer temperature was realized for 20 hours and not for 30, as foreseen by the program. This practically means that air temperature increase was bigger. This has occurred because the valves of a fresh air intake were closed. The shortening of the leaves tanning phase influenced the quality of a final product which is transferred to the other phases in a drying process.

The curve of a dry thermometer temperature in a dryer Universal, considerably deviates from the generally accepted work regime /2/. During the drying process there was not a required technological maintenance of this parameter in a determined duration in any of the phases (turning into yellow, color fixation, leaf drying and main nerve drying). That practically means that the attention was not paid to the degree and length of the valve opening for fresh air intake (item 13 Fig. 1.) and to the quantity of recirculation air. The special problem that occurred during the work of this dryer, is the fact that sprinklers wetted the air very unevenly, and consequently the leaves mass. Due to this, latter on, there was rottenness in bales what decreased the percentage of tobacco leaves of the first and second class, Table 1.

Table 1: Quality of the dried tobacco /2/

Quality	Percentage (%)	Quality	Percentage (%)
I class	3,3	IV class	38,5
II class	6,5	V class	21,8
III class	18,4	VI class	11,5

Due to a low participation of Virginia tobacco of the first and second class, the production was not economically justified and that was the reason that the same was not continued the following year. On the fields of PIK „Prigrevica„ the yield of 1100 to 1200 kg/ha of the dried leaves was realized, and it represents the satisfactory result. However, with the inadequate drying process maintenance, the participation of tobacco leaves, of the first and second class, the most expensive ones, was considerably decreased. It has also to be stressed that, the ratio of dried and raw tobacco, which is from 1:4 to 1:6, depends on a drying process, what has the essential influence to the business too.

4. CONCLUSION

On the basis of general information in connection with the operation of the centers for tobacco drying, it can be concluded that there is a lack of the literature from this field. This is, most probably, the reason why there is little known about the complexity of thermo-physical appearances that occur. Besides, the instruction for the dryers themselves, are not very clear and with very little data:

It is concluded that the obtained measuring results of the achieved drying regimes, differ for the predicted ones. Mainly, the dry thermometer regulated temperature increase is not maintained, and the values of wet thermometer temperatures are rarely followed. Much attention is also not paid to the time of maintaining certain temperature regimes. Due to all these, the corresponding quality of the dried tobacco leaves is not achieved.

In connection with all above stated, we are of the opinion, that the introduction of computer systems for the drying process control, is economically justified. Such systems would correctly follow the predicted work regimes and carry the process, that would provide considerably bigger percentage participation of higher class tobacco leaves.

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THE INTERCONNECTION BETWEEN WHEAT KERNEL PHYSICAL PROPERTIES

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The aim of investigation is to establish the influence of physical properties to the aerodynamic properties of wheat kernel. In this paper we have studied the interconnection of pressure drop along air stream in a kernel layer from the air velocity.

The experimental scientific method has been applied. The experimental plant has been constructed. The experiment was carried for different type of samples and wheat moisture content. By measuring the values of pressure drop on a measuring orifice and pressure drop through the sample (layer) have been established. The measuring results have been processed by an original computer program. The results graphic interpretation has been done by a computer program Grapher. *The physical properties of a wheat kerners were of different varieties and different moisture content. The influence of different characteristics to pressure drop dependency from the air velocity can be seen.*

By the analyze of kerner behavior in the air stream it has been establish that further investigation in this field has to be directed to the discovery the physical properties depending to pressure drop from air velocity. These physical properties are the ones determined in standard laboratories tests. The characteristic properties are: porosity, mass of 1000 kernels, angle of repose and moisture content.

Key words: fluidization, fluidization layer, wheat, grain physical properties.

1. INTRODUCTION

It is necessary to know the aerodynamic properties of grain for designing and qualitative operation control. The air stream of grain material or its fluidization is the process which occur in machines and devices in agricultural technique. These are for example: separation devices of

wheat combine, aspiration grain separator, ventilation in storages, induction points in pneumatic transport and grain dryers. It is necessary to know for designing and operation control air drop pressure dependence along the air stream in a stable and fluidization layer. It is of a special importance to know all these properties for the wheat kernel it is one of the most distributed crop.

Notation

$A/m^2/$ - area of kerner cross section
$C_d/-/$ - particles drag coefficient
d_{ekv} - kernel diameter equivalent
$h/m/$ - layer height
$e/\%/$ - kernel layer porosity
$F/N/$ - drag force
m_{1000} - mass of 1000 kernels
$v_f/m/s/$ - air velocity
$w/\%/$ - grain moisture content
$\alpha/^o/$ - repose angle
$\Delta p/Pa/$ - pressure drop along air stream
$\nu_f/m^2/s/$ - kinematic viscosity of air
$\rho_f/kg/m^3/$ - air density
$\rho_n/kg/m^3/$ - bulk density

2. MATERIAL AND METHOD OF WORK

The choice of wheat varieties in this experiment depends on different physical properties relevant for this investigation. The kernel layer resistance during air stream depends on density, size, shape, surface condition and kerner porosity. The interdependence of these properties is taken as the represent of their physical properties. The second choice of wheat varieties was that the samples are taken from the same area (similar soil and technology). On the basis of these criteria the following Yugoslav varieties have been chosen: Rana Niska, Zvezda and Balkan. The samples were taken from Vrbas region in 1991.

Moisture content was taken as a factor within the values appearing in real processes.

Some physical properties of tested samples are shown in Table 1.

Table 1.: Some physical properties of tested wheat sample

Variety	1000 kern. w. [g]	Bulk density [kg/m^3]	Porosity [%]	Moisture [%]	Angle of rep. [^{o}]
Balkan	41.07	797.3	38.5	13.96	31.19
Zvezda	42.96	823.0	36.8	13.82	30.78
Rana Niska	36.26	822.3	37.7	14.11	32.29
Rana Niska	38.04	861.7	36.1	10.94	30.05
Rana Niska	41.59	744.9	39.9	19.08	38.80

The original experimental plant was designed for this investigation (Fig, 1). Sample (06) is places in the glass tube (05) on the perforated sheet metal (07). The air is directed by fan (03) through the measuring tube (02) where orifice is placed (01). From air stream stabilizator (09) the air passes through deflector (08) which is made of plastic tubes stock of 3/4" and 3/8" dimensions. The task of the deflector is to neutralize the air stream whirling and to make homogenous air velocity field along the glass tube section. The glass tube was perforated and on these opening the connectors for static pressure measurement were placed in front and behind the layer. The sieve is located at the glass tube end for light kernels retaining which terminal velocity is smaller then air velocity in the glass tube (04).

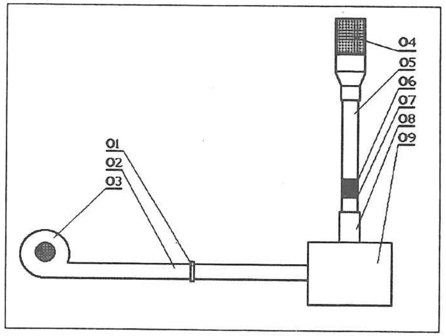

Fig. 1: Experimental plant
(1 - orifice, 2 - measuring tube, 3 - fan, 4 - sieve, 5 - glass tube, 6 - sample 7 - perforated sheet metal, 8 - deflektor, 9 - stabilizator)

Experimental method was used in this investigation as a special scientific method. After a certain grain sample has been placed into the glass tune the fan was started. By regulation valves on the fan, the air velocity in the measuring tube is adjusted. The experiment starts with very low air velocity values. At the same time air conditions is determined (dry and well bulb temperature is measured). During each measured air velocity value, the pressure drop through the layer is measured. The measuring points of static pressure are above the perforated sheet metal and above the grain layer.

For the investigation purposes a special computer program was made for the data calculation on air drop pressure at the measuring orifice, static pressure drop, air situation as in a determined pair of values of pseudo air velocity in glass tube and individual air pressure drop in the layer.

The Grapher program has been used for the graphic presentation of investigation results. A certain number of experiments were carried out but in this paper some characteristic results are presented. The results are obtained by Grapher program in the corresponding mutual diagrams.

3.INVESTIGATION RESULTS AND DISCUSSION

Fig. 2 presents the experimental results for three different varieties (Table 1) with a very close moisture content (Rana Niska - w = 14,11%; Balkan - w=13,96%, Zvezda - w=13,82% wet basis).

Fig. 3 presents experimental results for different grain moisture content of one wheat variety (Rana Niska).

The characteristic shapes given in these diagrams (Fig. 2 & 3) are mainly in accordance with the literature sources /2/ and /3/. In a phase of a practically stable layer the air pressure drop change at the air velocity increase is important and has got a monotonous rising character. Term dp/dv is constantly rising. At the end of this phase air pressure drop is decreasing and after that it is approximately constant. Before the pneumatic transport occurs air pressure drop slightly decreases. The appearance of histeresis was confirmed while the air velocity is decreasing.

By analyzing Fir. 2 it can be concluded that there is a functional difference between air pressure drop in grain layer and air velocity for different wheat varieties. In this the analytical interpretation was not established, since it is a question whether it is necessary or not. The establishing of analytical model for each variety separately would be a difficult task, so such a strategy for know-

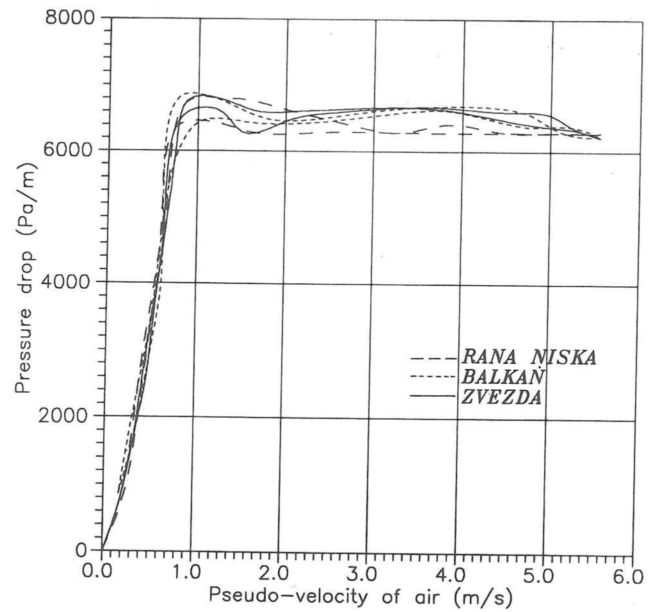

Fig. 2. Dependency of pressure drop in grain layer on air velocity for some wheat varieties

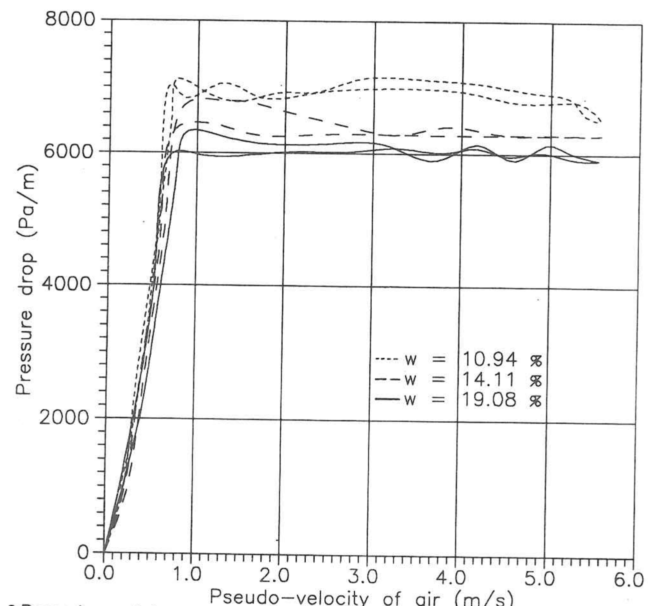

Fig. 3 Dependency of air pressure drop in grain layer from moisture content and air velocity

ing the aerodynamic properties should be avoided. The aim of these experiments was to point out the differences of the aerodynamic properties for varieties having the different physical properties.

The influence of a very important physical grain properties - moisture content to aerodynamic properties can be analyzed in graph on Fig. 3.

The grains of lower moisture content obviously influence the appearance of bigger air stream resistance. The resistance of grain with higher moisture content is smaller what can be explained by its lesser surface roughness, since the moisture „lubricates„ the grain surface. However, this is not the only influence to the aerodynamic grain state during the air stream through the layer. The moisture is within the grain itself, so it influences to bulk density change.

Drug force equitation that influences the particle during the air stream /1/ is:

$$F = \frac{1}{2} C_d \rho_f A v_f^2 \qquad (1)$$

On the basis of literature sources the following equitation can be made:

$$\Delta p/h = f(\rho_f, v_f, e, d_{ekv}, \rho_n, \nu_f) \qquad (2)$$

By the analysis of the elemental physical properties which influence to the air pressure drop in grain layer and on the basis of the equitations (2) (3) we can write:

$$\Delta p/h = f(\rho_f, v_f, e, d_{ekv}, z, w, m_{1000}, \rho_n, \alpha) \qquad (3)$$

Necessity for knowing the aerodynamic properties can be met by a suitable manner of expressing the relation between these properties. The mathematical model based on practical knowing of elementary grain physical properties in equitation (3) is very convenient for practical uses. However it is necessary to meet another condition and this is that this mathematical model is suitable for calculation on personal computer.

4. CONCLUSION

The elementary conclusions based on these results are:

- The experiment proved that the varieties that have the different physical properties have the different functional dependencies of air pressure drop to the air velocity and wheat layer.

- Grain moisture content influences the aerodynamic wheat kernel properties so that the air pressure drop along the air stream in the layer is bigger the moisture content is lower.

- Further investigation has to be continued for the establishing the quantitative influence of the basic physical properties on aerodynamic properties. The mathematical model that would present this influence ought to be suitable for practical use by the designers and the engineers. It has also to be suitable for possible use in the process control by computer.

- The basic physical properties that have to be represented in the mathematical model are: porosity, equivalent diameter, sphere, grain moisture content, mass of 1000 kernels, bulk density and repose angle.

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TECHNICAL DIAGNOSTICS USING FUZZY EXPERT SYSTEM

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This paper describes the fuzzy expert system technology developed as a computer assisted diagnostic system. An expert system is an special algorithm that mimics the behaviour of an expert. This fuzzy oriented expert system is based on the using of linguistic variables/values and rules in form of conditional statements.For uncertainty description uses the fuzzy set theory and the inference engine is based on the fuzzy logic. A diagnostic algorithms are specified by a set of conditional statements.

expert systems; linguistic variable; fuzzy set; fuzzy logic;diagnostic system; linguistic quantification; knowledge base; test of consistency

1. INTRODUCTION

The technical diagnosis is determination of which from subsystems are violating sufficient conditions for satisfying the process performance. The technical diagnosis can be also defined as a search for the causal origin of an observed pattern of abnormal system behaviour. A diagnosis can be also considered as an complex identification problem. Stated informally, if the complexity of system increasis then human ability to make precise and simultaneously significant statements about its behaviour diminishes. If a threshold is reached then precision and significance become mutually exclusive characteristics.

The most procedures and techniques employed for analysis of complex systems are analytical or statistical nature. These classical approaches have failed if ill-known systems have to be studied. For dealing with ill-defined complex systems an approach is needed which is tolerant to imprecision.

2. ENGINEERING REASONING

An engineering diagnostic reasoning does not seem to perfectly fit the mathematical logic model. The key elements in human reasoning are *words* and not numbers.The human ability summarize information plays an essential role in the description of complex phenomena and is connected with using of natural languages. Nearly each word in natural language can be considered as linguistic variable or linguistic value.

A linguistic variable is this variable whose values are sentences in a natural or artificial language. For example a *temperature* or a *pressure* can be linguistic variables T^L,P^L and *small, medium, high, very high* are linguistic values.

Simple relation (dependence) between linguistic variables can be described by the conditional statements. The dependence of linguistic variable *pressure* P^L on linguistic variable *temperature* T^L can be expressed as conditional statement

$$\text{if } T^L \text{ is } \textit{high} \text{ then } P^L \text{ is } \textit{high} \qquad (1)$$

The linguistic values are wieved as labels of fuzzy sets. A fuzzy set F is characterized by a *membership function* μ_F: U->[0,1] which associates to each element y of universum U a number $\mu_F(y)$ in interval [0,1]. This number represents the *grade of membership* of element y in fuzzy set F.

Using fuzzy set theory can be linguistic variables transformed on fuzzy variables and linguistic values on the fuzzy values , it means fuzzy sets. The variable T^L and P^L can be transformed on the fuzzy variables T^F and P^F. The relation between fuzzy variables may be expressed as fuzzy conditional statements

$$\text{if } T^F \text{ is } \textit{high}^F \text{ then } P^F \text{ is } \textit{high}^F \qquad (2)$$

where values $\textit{high}^F$ are now the corresponding fuzzy sets. Fuzzy conditional statements play a basic role in the description and execution of fuzzy algorithms. Transformation of the linguistic value on the fuzzy set is quite expert job.

A fuzzy algorithm is an ordered set of fuzzy conditional statements.Using "rule of inference" is find in knowledge base an approximate solution to a specified problem.

The fuzzy conditional statements or production rules are of the form showing in eq.(2).The interpretation is different, according to the specific application. For example :

if <set of conditions> then <diagnoses>

if <situation> then <action>

and so on.

3. FUZZY LOGIC

The logic of human thinking is not two-valued but multiple-valued with the approximately rules for a decision. Human being very often use experience instead of deductive reasoning.

Fuzzy logic is a multiple-valued logic which is much closer to human thinking and natural language than the traditional logic. Briefly, provides an very effective means of capturing the approximate nature of real world. Fuzzy logic provides a means of converting a linguistic knowledge on an expert knowledge.

In fuzzy logic exists the important fuzzy implication inference rules (generalized modus ponens). We can introduce the linguistic variables T,P and the linguistic values are transformed on fuzzy sets A, A', B, B'

premise 1 : T is A'
premise 2 : if T is A then P is B (3)

consequence : P is B'

The modus ponens is closely related to the forward data inference.

4. FUZZY KNOWLEDGE BASE

The behaviour of a fuzzy complex system is described by a set of linguistic conditional statements based on expert knowledge. In this way is generating fuzzy knowledge base.

A practical fuzzy knowledge bases are usually multidimensional and multiconditional. A general form of such structures can be :

$$\begin{array}{l} \text{if } A_{11} \text{ and } A_{12} \ldots \text{ and } A_{1n} \text{ then } B_1 \text{ with } w_1 \text{ or} \\ \text{if } A_{21} \text{ and } A_{22} \ldots \text{ and } A_{2n} \text{ then } B_2 \text{ with } w_2 \text{ or} \\ \quad \vdots \\ \text{if } A_{m1} \text{ and } A_{m2} \ldots \text{ and } A_{mn} \text{ then } B_m \text{ with } w_m \end{array} \qquad (4)$$

where A_{ij} is one dimensional fuzzy set representing for example linguistic value of j-th independent variable. Symbol B_i is one dimensional fuzzy set representing linguistic value of dependent variable in i-th conditional statement.

Any row in this structure (matrix) represents one conditional statement in a knowledge base. The precision of different statements in the knowledge base is taken in the consideration by weight factor w_i in statement.

5. EXAMPLE OF APPLICATION

As an example of application can be presented diagnosis of centrifugal machine working in a process industry. Failure diagnosis is based on the monitoring of variables speed [s^{-1}],power input [kW],temperature-1, temperature-2 [^oC], pressure [MPa],noise [dB] and vibration [mm],causal origins on malfunctions are pump, belt, brake, bearings and unbalance . The linguistic variables, values and fuzzy sets are Table 1.

Table 1

Vari-able	linguistic values	fuzzy set a	b	c	d
SPEED	nonaccept	0.0	300.0	560.0	600.0
	low	580.0	600.0	640.0	650.0
	normal	645.0	650.0	660.0	665.0
POWER	low	12.0	13.0	17.0	18.0
	normal	17.0	19.0	21.0	22.0
	high	20.0	22.0	28.0	35.0
	v-high	29.0	37.0	80.0	100.0
TEMP-1	normal	35.0	40.0	50.0	60.0
	high	50.0	60.0	70.0	80.0
	v-high	70.0	80.0	90.0	100.0
TEMP-2	normal	35.0	40.0	50.0	60.0
	high	50.0	60.0	70.0	80.0
	v-high	70.0	80.0	90.0	100.0
PRESS	nonaccep	0.0	0.2	1.3	1.7
	accept	1.3	1.7	2.3	2.7
	normal	2.3	2.7	3.0	3.2
NOISE	normal	75.0	80.0	85.0	90.0
	high	85.0	90.0	95.0	100.0
	v-high	95.0	100.0	110.0	115.0
VIBRAT	normal	0.0	0.0	7.0	7.1
	high	7.0	7.1	17.0	18.0
	v-high	17.0	18.0	24.0	25.0
	nonaccept	24.0	25.0	50.0	50.0
DIAGO	pump	0.5	0.9	1.1	1.5
	belt	1.5	1.9	2.1	2.5
	brake	2.5	2.9	3.1	3.9
	bearings	3.1	3.9	4.1	4.5
	unbalanced	4.5	4.9	5.1	5.5
	n-operation	5.5	5.9	6.1	6.5

The fragment of the knowledge base is in Table 2. Now we can put the query to this knowledge base. For example :

if speed is normal and power is high and temp-1 is high and temp-2 is normal and press is normal and noise is high and vibrat is normal then ???

On this query expert system gives following answer :

causal origin is in : **bearings** with weight 1.0 ,
unbalance with weight 0.5 ,
brake with weight 0.3 .

This expert system answer is not quite clear, is umbiguous. On the bases imperfect input information can be doing adequate judgment only.

However the main problem connected with a practical expert system application is estimation of the knowledge base properties. It is very difficult but very usefull evaluate "quality" of the knowledge base.

The first step should be a consistency test which can uncover the discrepancy in knowledge base.A cognitive science has developed a different methods and algorithms, namely query-answering mechanism. The cognitive analysis of query answering mechanism can be used to evaluation the properties and discrimination ability of a fuzzy knowledge base. This enables detect "weak part" in the knowledge base.

Table 2 - Fragment of the knowledge base

SPEED	POWER	TEMP-1	TEMP-2	PRESS	NOISE	VIBRAT	DIAGO	W
naccept	low	normal	normal	-	high	normal	belt	1.0
naccept	low	normal	normal	-	high	high	belt	0.8
naccept	low	high	normal	-	high	high	belt	0.8
.	.	.	.	.	.	.	.	.
low	high	normal	normal	normal	v-high	high	brake	0.8
normal	high	normal	normal	normal	v-high	high	brake	1.0
.	.	.	.	.	.	.	.	.
normal	normal	v-high	high	normal	high	normal	bearing	1.0
normal	normal	v-high	v-high	normal	high	normal	bearing	1.0

6.CONCLUSION

The technical diagnostics seems to be privileged field for expert systems applications. Many companies are now using this relatively new computing tool as a operator support or maintenance support. The purposes why use expert system are particularly following:

- the methods of reasoning are successful when solving diagnosis problem with expert system approach
- escape from fatigue, retirement, errors of a human expert
- expert system is available immediately 365 days a year and 24 hour a day
- possibility collect knowledge and not only information

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TRENDS IN AGRICULTURAL ENGINEERING
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APPARATUS FOR SIMPLE APPROXIMATIVE DETERMINATING THE DENSITY OF OPEN-PORE STRUCTURE MATERIALS.

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A simple laboratory apparatus for approximative measuring the density, namely the volume of liquid and solid portions of porous materials hes been described in this paper. Also a measuring methodology inclusive of a concrete example has been shown in brief. In conclusion, the connection of the problems described with possible utilization for measuring moisture content has been mentioned.

porous materials; density; aeration; measurement; measuring apparatus; moisture content

1. ntroduction

For determinating the density of porous, i.e. also most agricultural materials, a value denominated as aeration P_A (Kutílek, 1978) is very important. This is the content of air filled pores in the material. Therfore, it is also possible to determine it of the whole volume of the sample and of its liquid and solid portions volume. For determining the aeration, Fiala (1966), Rees et al. (1983) and other autors used a method of controlled air expansion into the examinated sample. The object of this work is a design of a new apparatus arrangement, to give more precision to the method mentioned, and its application for determining the density of model agricultural material.

2. Material and procedure

Achieving higher precision of this method will ensue from the following description of the apparatus application shown in Fig. 1. A material sample is inserted into a vessel (1) with a cover hermetically sealed on its circumference. Two thermistors (8) and (9) are introduced into the vessel (1) in different places, together with the sample. The vessel (1) is inserted into a thermal insulating box (7), and afterwards into a temperature controller (6). After temperature stabilization in the vessel (1) (after 10 to 20 hours), a small quantity of distilled water inlet, with the valve (14) turned on, into the portions (2), (3), and (17) of the U-tube. The water level in the left tube branch (3) is from a syringe (15) covered with a thin oil film. Afterwards, by handling the hose (17), with the valve (13) turned on, the zero water level in the tube (2) is achieved. The position of the hose (17) is then fixed, the valve (13) is turned off, and the original zero water level is finally set up by means of a syringe (16). The valve (14), turned on till this time, is turned off, and further distilled water is let in from the reservoir (5) through the valve (12) up to the level hight ho limited by the overflow (4). A vent (11) aids in better filling the tube. The level hight ho is kept constant during all the measurement. The time behaviour of the overpressure h in the vessel (1) is measured by direct reading at the tube branch (3) with uniform cross section S_t, the atmospheric pressure behaviour p_a is measured by means of a barograph, temperature variations in the vessel (1) are measured by thermistors (8) and (9) with low thermal inertia. After a few hours, the water is let out through the hose (17), and the sample is taken out. Water covered with thin oil film was used for calibrating the apparatus.

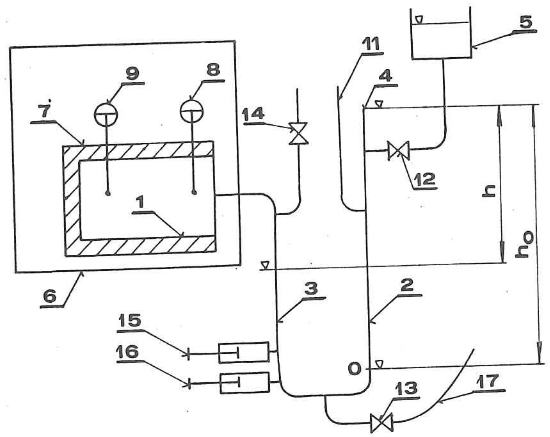

Fig. 1 Diagram of apparatus for determinating aeration

3. Theory

Considering the process described above to be approximately an ideal gas state change in the vessel (1), it is possible to write for any moment after filling up the U-tube:

$$\frac{(V_0+V_1-V_p).p_a}{T_A} = \frac{(V+V_1-V_p).(p_a+\Delta p_a+h.\rho.g)}{T} \qquad (1)$$

where
V_0 .... volume of the apparatus U-tube measuring branch (2), corresponding to the level hight ho as shown in Fig.1

Replacing the volumes in the equation (6) by portions of respective masses and densities gives :

$$\frac{m_w}{\rho_w} = \frac{m_c}{\rho_c} . (1 - P_A) - \frac{m_s^*}{\rho_s^*}$$

where
m_w .... mass of liquid by which the sample has been moistened
m_c .... mass of material sample
m_s .... mass of sample dry matter
ρ_w .... density of liquid by which the sample has been moistened
ρ_c .... volumetric mass of the material sample corresponding to the volume V_c
ρ_s^* .... density of dry material at its zero porosity

and after modifications using $c_v = \frac{m_w}{m_c}$ and $1 - c_v = \frac{m_s^*}{m_c}$

$$\rho_s^* = \frac{(1 - c_v) . \rho_c . \rho_w}{(1 - P_A) . \rho_w - c_v . \rho_c} \qquad (7)$$

where
c_v .... sample moisture content

4. Results

The application of the apparatus described here above has been documented by an example for measuring the volume V_p of a not hulled rice sample.

In Fig. 2 is shown the time behaviour of actual water level hight in the U-tube (ho - h) read on the apparatus, compared with the values of this hight calculated from changes of atmospheric pressure and of temperature in the vessel in the course of measuring. The modified relation (1) was used for the calculation.

Fig. 3 then illustrates the time behaviour of volume V_p calculated according to (2), here converging to the value of 354,5 cm^3. The sample mass m_c was 500,125 g. The sample density ρ_p thus results in 1411 $kg.m^{-3}$. The gravimetrically obtained moisture content c_v was 12,52 %. This would according to (7) correspond to the dry matter density of 1498 $kg.m^{-3}$, in case of validity of the principle of superposition (5).

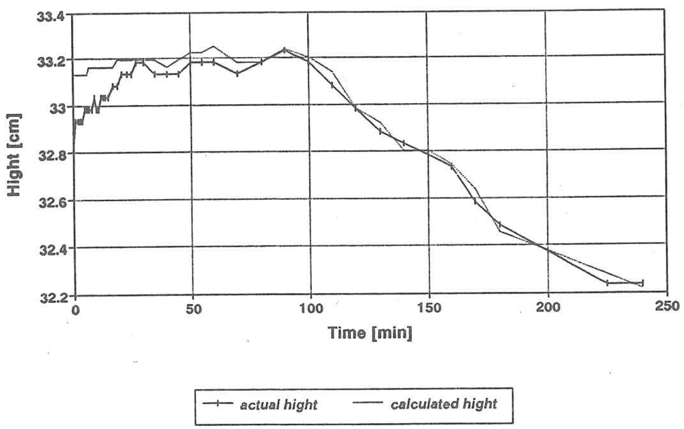

Fig. 2 Time behaviour of the difference betwe,en actual and calculated hight with an unhulled rice sample

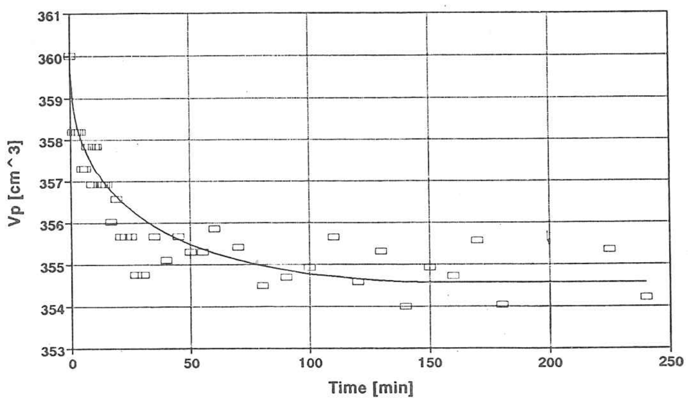

Fig. 3 Time behaviour of measured volume V_p of an unhulled rice sample

V_1 .... volume of the vessel (1) inclusive of interconnection with the U-tube according to Fig.1

V_p .... volume of sample liguid and solid portions

V .... volume in the U-tube of the apparatus between the levels during measuring as shown in Fig.1

p_a .... atmospheric pressure at the moment of filling water up to level hight h_0

Δp_a .... atmospheric pressure p_a change untill the moment of measuring

h .... difference of levels in the U-tube during measuring

ρ .... density of distilled water in the U-tube during measuring

g .... acceleration of gravity

T_A .... average temperature measured by the thermistors (8) and (9) at the moment of filling water to the h_0

T .... average temperature measured by the thermistors (8) and (9) at the moment of measuring

From where after modifications using $V_0 = S_t.h_0$, and $V = S_t.h$ an expression for the volume of sample liquid and solid portions will be obtained:

$$V_p = \frac{(S_t.h + V_1).(p_a+\Delta p_a+h.\rho.g).T_A-(S_t.h_0+V_1).p_a.T}{(p_a+\Delta p_a+h.\rho.g).T_A-p_a.T} \qquad (2)$$

where

S_t.... cross section area of the apparatus U-tube according to Fig. 1

The following relations for the aeration P_A and for the density ρ_p of wet material are subsequently valid

$$P_A = \frac{V_c-V_p}{V_c} \qquad (3) \qquad\qquad \rho_p = \frac{V_p}{m_c} \qquad (4)$$

where

m_c .... mass of material sample in the apparatus

If accepting the opinion stated by Rees et al. (1983) that the material liguid and solid portions volume decreases just by the lost water volume, it is possible (neglecting the volume of gases absorbed in water ...) to divide the total material volume V_c to three portions: the volume of water V_w, the volume of dry matter V_s, and the remaining by gases filled volume V_v:

$$V_c = V_w + V_s + V_v \quad (= V_p + V_v) \qquad (5)$$

Substituing from (5) in the aeration definition (3), it will be obtained:

$$\frac{V_w}{V_c} = (1 - P_A) - \frac{V_s}{V_c} \qquad (6)$$

5. Discussion

The difference between the calculated and actually measured highth in the beginning of the measurement (see Fig. 2) and the corresponding relationship of volume V_p versus time (Fig. 3) is explicable in the main as a result of thermal inertia of the thermistors that are not able to promptly respond to the initial compression temperature rise in the vessel. This is supported by experience of previous period, when the vessel was not thermally stabilized, and the temperature changes caused substantial measuring errors. It may surprise in this connection that there is the heat exchange in the apparatus limited by insulation between the vessel and the environment. The insulation damps especially the fluctuation in temperature in the vessel owing to temperature variatioins inside the temperature controller (approximately $\pm$ 0,25 K). For the next time, I am planning to replace the insulation by a massive metal case with substantial heat capacity and with better heat removal from the inner walls of the vessel as well. A better heat removal would perhaps, with some materials, cause more significant undesirable temperature deviations in different places inside the vessel.

During the initial as well as further measuring phases, also the influence of air adsorption on the material, moisture exchange between air and material, a slow or absolutely impossible air diffusion through fine pores, portion of pores closed with water in narrowed area, portion of completely closed pores and voids, may become evident. It stands to reason that no biochemical processes characterized by exchange of substances or heat exchange to environment must not be active in the material sample.

The measured values dispersion is connected above all with the sensibility of measuring instruments applied.

First experience with the apparatus described here above indicates that the influence of the here enumerated, and also further possible physical processes, negative for measurement accuracy, need not involve an invincible obstacle with usual biological materials. In compliance with my existing information, and probably also according to my first results, the principle of superposition referred to by relation (5) evidently much differs from reality. This is probably connected with the bond of fluids - especially liquids in cells and in intercellular spaces, and also with their variable physical and chemical composition. Also the density variations in the monomolecular layer of the adsorbed liquid may exercise influence.

In case of success in achieving sufficient precision for a probably not too variable relation (7) between dry matter density ρ_s and moisture content c_v for a certain type of material, it will be possible to think upon developing a new prompter apparatus for estimating moisture content of some porous materials.

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TRENDS IN AGRICULTURAL ENGINEERING
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The Material Properties of Various Berry-Like Fruits

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The relation between the compressive force of two approaching plates and the amount of compression of the object has been evaluated for several kinds of berry-like fruits. The agreement of a relation with experiment has been proved in the range of 1.5 - 2 of the exponent. It was found that the berries are damaged at certain values of compression. Further it was found that for correct evaluation of the compression curve, an accurate determination of the compression curve origin is of prime importance.

Keywords: Berry-like fruits, strength, two plates, compression

1. INTRODUCTION

A group of fruits of cultural plants is characterized by almost spherical shape, relatively tough but thin skin and liquid or semi-liquid internal content. This group of berry-like fruits comprises wine grapes, currants, gooseberries, all stone-fruits and many other fruits. The damage to these fruits and the loss resulting from this damage is relatively simple due to the effect of outer elastic and dynamic forces. The resistance of these fruits to mechanical damage is dependent mostly on the skin characteristics of the fruit and may be tested by compression between two plates.

Theoretically, this problem has been solved by Blahovec (1992) who found that the relation between the compressive force *F* of two plates and the relative compression of the fruit ϵ may be written in the form

$$\frac{F}{2\pi\, r\, t\, E_c} = a\, \epsilon^{n} \qquad (1)$$

where r is the radius of the spherical fruit, t is the skin thickness, E_c is modulus of elasticity of the skin and a, n are parameters dependent on the characteristics of the liquid within the fruit. For the case of a non-viscous liquid within the fruit the value of $n \doteq 4.2$ has been calculated.

In our work we have tested the applicability of relation (1) in several kinds of real berries.

Table 1 Tested products (M.c. - moisture content)

Product and variety	M.c. %	fruit weight g	refract. index °Brix	skin thick. mm
1a currant var. Heineman	80.6	0.51	11.0	0.06
1b Slovakia	84.9	0.49	8.3	0.035
1c Bohemia	83.9	0.42	10.4	0.04
1d Eva	80.8	0.77	13.5	0.045
2a aronia var. Nero	83.7	0.63	10.6	0.08
2b aronia var. Nero	80.4	0.87	16.5	0.105
3 lilac elder (Sambucus Nigra L.)	86.1	0.14	15.5	0.07
4 rowanberry (Sorbus aucuparia L.)	71.5	0.58	23.0	0.10
5 haw (Crataegus oxyacantha)	59.6	0.69	-	0.135
6 dogberry (Cornus mas)	77.0	1.80	15.5	0.115

2. EXPERIMENTAL TECHNIQUE

The sample size of berries used for the experiments usually contained several dozen of the fruit (minimum 20). The fruit had been obtained in several ways: from the University garden, from trees in parks, etc. (Table 1). The fruit had been harvested in a mature state and experimental investigations had been made immediately after harvesting.

Experimental testing has been performed according to Fig.1. Each tested fruit has been put on a solid plate and compressed by another pressure plate in strain testing machine FPZ 10/1 with a constant speed of 0.5 mm/s, until the rupture of the fruit. The measured compression curves have the form depicted in Figure 1b which may be described by the equation (1) - see also Fig. 1b - and are ended by characteristic values of F_m and ϵ_m. Finding the origin of

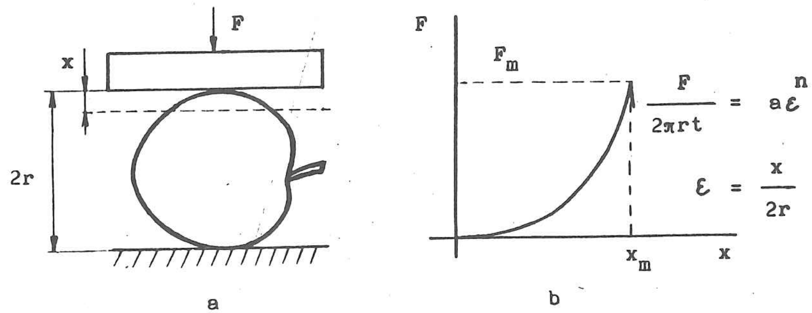

Fig.1 Compression test between two plates - schematic description of the experimental arragement (a) and an evaluation of the obtained compression curve (b)

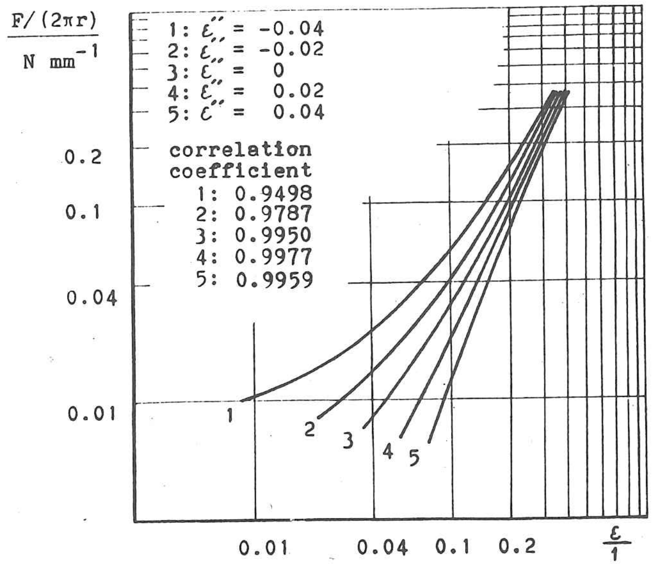

Fig.2 Dependence $F/(2\pi r) - \epsilon$ described by the equation $F/(2\pi r) = a\epsilon^n$ where $\epsilon = \epsilon' + \epsilon''$ is the relative compression, ϵ' is the relative compression in coordinates with roughly estimated origin, ϵ'' is the displacement of such selected origin and a, n are the parameters of the regression analysis of this relationship.

compression curve has been very difficult. For this purpose the following method has been selcted: the origin is roughly estimated and its ϵ' coordinate is found and then the displacement of ϵ'' is looked for to obtain the most accurate power relationship with ϵ'' displacement (see Figure 2 where the most exact relationship is designed 4 with maximum value of correlation coefficient $r = 0.9977$). The closeness of the fit has been evaluated in the range of values $\epsilon'' = \pm 0.05$ where $\epsilon = \epsilon' + \epsilon''$. The estimation of ϵ' coordinate origin has been made using a linear regression of the strain curve slope in the range of 2 per cent of relative compression.

3. RESULTS

Examples of compression curves for various fruits are in Fig.3. From this sample it is clear that in the lower range of relative compression the dependence of $\ln(F/2\pi r)$ on $\ln(\epsilon)$ is linear and accurately fits relation (1). In most cases there exist the values ϵ_1 and $F_1/(2\pi\ r\ t)$, where the slope of dependence is changed and the parameters of this second part of compression curve are designated a_1 a n_1. The resulting values of the derived parameters are given in Table 2, the values $F_m/(2\pi\ r\ t)$, $F_1/(2\pi\ r\ t)$, ϵ_m and ϵ_1 are displayed in graphical form in Fig.4.

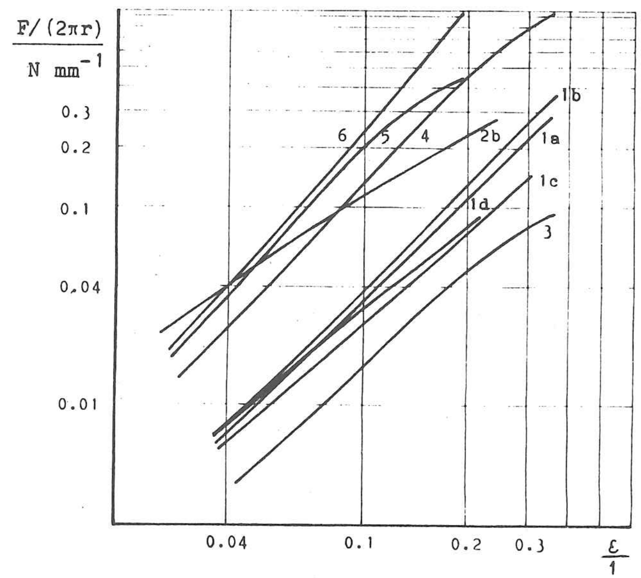

Fig.3 Examples of compression curves in logarithmical coordinates - designation see Table 1.

4. DISCUSSION

The strength of the berries is determined by their compression. The value ϵ_m of berries of various origin is almost the same in all cases, in the range of 0.25 - 0.4. The strength of berries has much wider range, 0.7 - 7 MPa (Fig.4).

Equation (1), between the force and the relative compression, is valid in most cases. The parameter n has values in the range 1.5 - 2 in all cases except Aronium (see also Fig.3). The slope n_1 is higher than the slope n in currants and lower in other fruits.

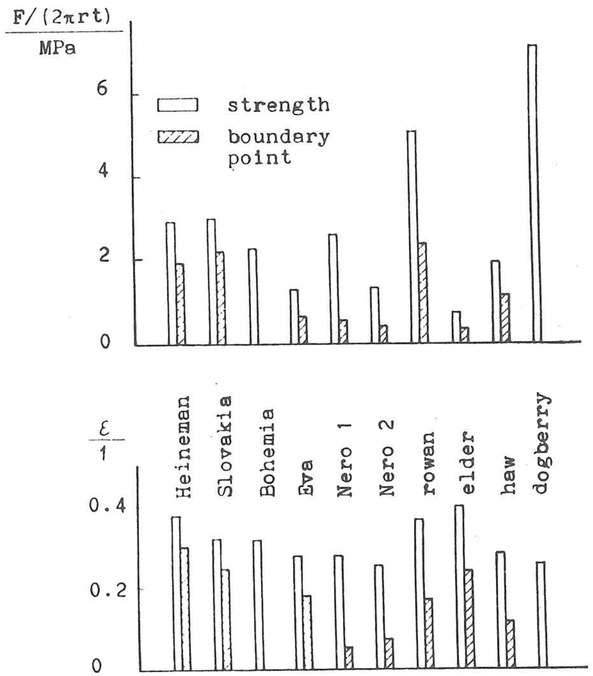

Fig.4

5. CONCLUSIONS

It was found that a berry's compressive behaviour is determined by eq.(1), with the exponent n in the range 1.5 - 2. At higher strains the tendency to higher values n for currant and lower values n for other tested products has been observed. It was found, that the exact determination of the compression origin is of principal importance for the application of equations like eq.(1).

Table 2 Measured values

Grop and variety	r (mm)	ϵ_m (1)	$F_m/(2\pi rt)$ (MPa)	ϵ_1 (1)	$F_1/(2\pi rt)$ (MPa)
1a	4.85	0.373	2.91	0.295	1.87
1b	4.75	0.319	3.80	0.237	2.23
1c	4.70	0.316	2.29	-	-
1d	5.55	0.277	1.30	0.178	0.62
2a	5.25	0.276	2.63	0.049	0.51
2b	5.85	0.257	1.34	0.068	0.35
3	2.95	0.362	0.76	0.167	0.28
4	5.0	0.397	5.20	0.186	2.34
5	4.95	0.277	1.91	0.146	1.12
6	5.80	0.248	7.36	-	-

Grop and variety	a	n	a_1	n_1
1a	1.64	1.66	3.10	2.19
1b	1.89	1.73	1.82	1.73
1c	0.93	1.44	-	-
1d	0.71	1.49	1.05	1.75
2a	2.64	1.14	1.32	0.92
2b	2.56	1.33	1.23	1.06
3	1.00	1.78	0.37	1.25
4	11.10	1.85	2.91	1.10
5	10.21	1.85	1.81	0.92
6	41.38	2.03	-	-

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

SEITENKRÄFTE AN SCHRÄGLAUFENDEN ANGETRIEBENEN ACKERSCHLEPPER-RÄDERN

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With a single wheel tester of Hohenheim University tractive and side forces have been measured on driven tractor tyres of different sizes on a hard stubble field and on a tilled field with higher moisture content. It was found, that the lateral forces are diminished as the tractive forces increase. The maximum lateral force was at little negative tractive force, corresponding with small negative wheelslip.

driven angled tractor tyre, lateral force, soil property, inflation pressure, ride comfort, tyre stiffness, contact area, slip, skid, tyre-ground-interface, shear force.

Reifen von Ackerschleppern und selbstfahrenden Landmaschinen sollen neben der Federung des Fahrzeuges und der Dämpfung von Fahrzeugschwingungen vor allem die auf das Fahrzeug wirkenden Kräfte am Boden abstützen. Dies sind in der horizontalen Ebene in Längsrichtung die Trieb- und Bremskräfte, quer dazu die Seitenkräfte und in vertikaler Richtung das Fahrzeuggewicht einschließlich der dynamischen Radlaständerungen. Seitenkräfte wirken auf das Fahrzeug bei Querfahrt am Hang aufgrund der Hangabtriebskräfte, bei Kurvenfahrt aufgrund der Zentrifugalkräfte und durch Geräte mit schräg angreifenden Kräften.

Durch die Seitenkräfte läuft das Rad nicht mehr in der Bewegungsrichtung des Fahrzeuges, sondern wird seitlich abgedrängt, so daß Radlängsrichtung und Bewegungsrichtung des Fahrzeuges einen Winkel, den Schräglaufwinkel α bilden (Bild 1). Wegen des Schräglaufs ist die bekannte Schlupfdefinition zu erweitern. Mit den Bezeichnungen in Bild 1 gilt für den Trieb- bzw. Bremsschlupf

$$i_T = 1 - \frac{s_G \cos\alpha}{s_{OR}} \qquad i_B = \frac{s_{OR}}{s_G \cos\alpha} - 1$$

Untersuchungen zur Klärung der Zusammenhänge zwischen Längs- und Seitenkräften wurden vor allem für Kraftfahrzeugreifen auf fester Fahrbahn durchgeführt [1]. Sie haben gezeigt,

daß die maximalen Seitenkräfte im Bereich kleiner Längskräfte liegen und daß bei hohen Längskräften die Seitenkräfte sehr gering werden. Während dieses Verhalten grundsätzlich auch für Ackerschlepperreifen gilt (Bild 9), konnte im Gegensatz zu den Untersuchungen auf festen Fahrbahnen für das Fahren im Gelände eine Annäherung der maximalen Seitenkräfte an eine Asymptote für größere Schräglaufwinkel (α > 10°) nicht festgestellt werden.

Messungen an landwirtschaftlichen Reifen wurden vor allem an frei rollenden Rädern durchgeführt [2,3]. Krick [4] hat erstmals an angetriebenen Ackerschlepperreifen Längs- und Seitenkräfte bei Schräglaufwinkeln bis 25° in der Bodenrinne gemessen. Seine Ergebnisse wurden durch eine tiefe Spurbildung beeinflußt, die vor allem im Bereich von Bremskräften zu hohen Seitenkräften führen kann [5]. Im Bereich der Triebkräfte entsprechen seine Ergebnisse denen von Matejka [6], der Messungen im Freiland mit angetriebenen Reifen der Größe 6.00-16 mit Triebradprofil durchgeführt hat. Weitere Untersuchungen auf harter und oberflächlich gelockerter Geländefahrbahn stammen von Janosi, Kamm und Wray [7], die ein entsprechendes Reifenverhalten wie auf festen Fahrbahnen feststellten. Über Schräglaufmessungen an Schleppern, die durch eine definierte seitliche Kraft belastet wurden, berichten Baker u.a. [8] sowie Meyer u.a. [9].

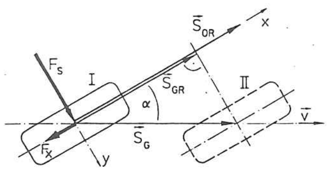


Bild 1: Kräfte und Strecken am schräglaufenden Rad

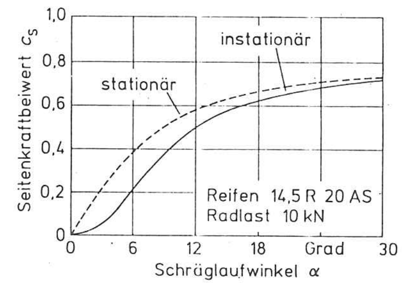


Bild 2: Vergleich von stationärem und instationärem Schräglauf (Innendruck 120 kPa, Lenkgeschwindigkeit 6°/s, Fahrgeschwindigkeit 1m/s, Auslastung 94 %)

Über den instationären Reifenschräglauf an rollenden landwirtschaftlichen Reifen hat Heine [2] Ergebnisse veröffentlicht. Im Gegensatz zum stationären Reifenschräglauf, bei dem das Rad unter einem konstanten Schräglaufwinkel läuft, wird bei Messungen von instationärem Reifenschräglauf der Schräglaufwinkel kontinuierlich verstellt. Dies entspricht dem Einlenken von Fahrzeugen in eine Kurve oder dem Aufbau von Reifenschräglauf beim Auftreten von Seitenkräften. Beim instationären Reifenschräglauf sind die Seitenkräfte zunächst geringer als bei stationärem Schräglauf, Bild 2. Für das Fahrverhalten von Fahrzeugen beim Fahren in einer Kurve bedeutet dies größere Schräglaufwinkel mit einem Hinausschieben der Vorderachse aus der Kurve.

Für die Messung von Seitenkräften bei stationärem Schräglauf mit angetriebenen Ackerschlepperrädern heute verwendeter Größen wurde in Hohenheim die in Bild 3 gezeigte und in [10] ausführlich beschriebene Einzelradmeßeinrichtung entwickelt.

Bei den Untersuchungen mit den in Bild 4 gezeigten Reifen eines Herstellers, gleicher Bauart aber unterschiedlicher Abmessungen wurde die Drehzahl des Versuchsreifens stetig erhöht und so der gesamte Längskraftbereich von Bremskraft bis Triebkraft bei

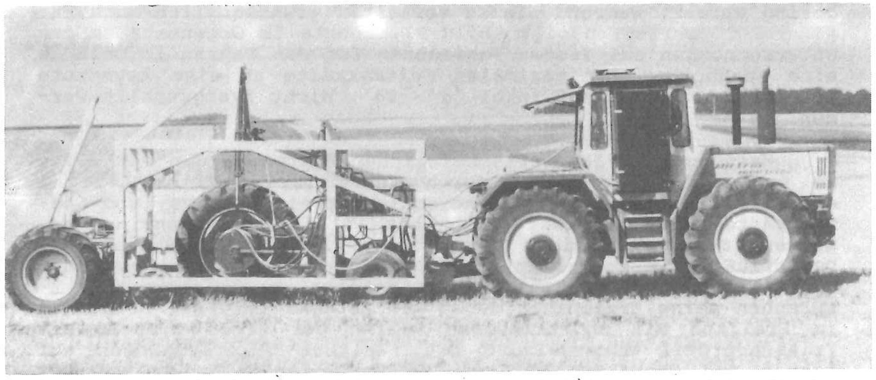


Bild 3: Einzelradmeßeinrichtung für angetriebene schräglaufende Ackerschlepperräder

Bild 4: Zur Untersuchung eingesetzte Reifen. Von rechts: 16.9 R 30, 16.9 R 34, 16.9 R 38, 18.4 R 38, 20.8 R 38

konstanter Vorwärtsgeschwindigkeit durchfahren. Der Schräglauf wurde von 0 bis 16° in Stufen eingestellt und während einer Versuchsreihe konstant gehalten. Die Ergebnisse sind im radfesten Koordinatensystem (Bild 1) dargestellt.

Die Seitenkräfte werden vom Reifen durch seine Bauart, die Reifenabmessungen, die Betriebsparameter und vom Boden beeinflußt. Auf tragfähigem Boden nehmen sie in erster Linie mit der Radlast zu. Da die Abhängigkeit für konstante Reifenauslastung bei den untersuchten Ackerböden nahezu linear ist, kann die Seitenkraft vereinfachend durch den dimensionslosen Seitenkraftbeiwert c_s beschrieben werden, indem die Seitenkraft auf die Radlast bezogen wird.

$$c_S = \frac{F_S}{F_Z}$$

Die Untersuchungen haben allerdings gezeigt, daß der Seitenkraftbeiwert, abhängig vom Untergrund, auch eine Funktion der Radlast ist. Besonders bei dichtem festen Bewuchs, wie beispielsweise auf Grünland, verzahnen die Stollen mit dem Unter-

grund, so daß die Seitenkräfte kaum noch mit der Radlast steigen. Dann ist die direkte Auftragung der Seitenkräfte vorteilhaft.

Besonders großen Einfluß auf die Seitenkraft hat der Zustand des befahrenen Bodens, Bild 5. Während bei Beton hohe Seitenkräfte erreicht wurden, können unter schwierigeren Bedingungen wie in einem frisch bearbeiteten Stoppelfeld (BI) die Werte wesentlich geringer sein. Der mit Stoppel A bezeichnete Boden ist ein schluffiger Lehm mit einer Feuchtigkeit von U=11,8 %. Stoppel B ist ein schluffiger Ton, U=18,3 %. Auf diesem Boden wurden auch Messungen vorgenommen, nachdem er gegrubbert und durch eine Nachlaufwalze rückverdichtet wurde (BI). Weitere Messungen nach zwischenzeitlichem Regen fanden auf diesem Feld nach zwölf Tagen (BII) und nach 43 Tagen (BIII) statt. Grundsätzlich nehmen die Seitenkräfte, wie auch Bild 5 zu entnehmen ist, mit zunehmendem Schräglaufwinkel zu. Allerdings verlaufen die Kurven bei größeren Schräglaufwinkeln flacher, ohne allerdings die von Kraftfahrzeugreifen bekannte Abnahme der Seitenkräfte bei großen Schräglaufwinkeln zu zeigen. Die Seitenkraftbeiwerte sind für den Schlupf Null, d.h. ohne

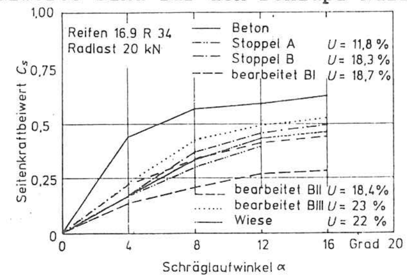


Bild 5: Einfluß des Bodens und des Schräglaufwinkels auf die Seitenkraft (Auslastung 100%, Schlupf 0%)

gleichzeitig wirkende Längskraft, aufgetragen. Wie die Untersuchungen gezeigt haben, ist dies zulässig, da gleichzeitig wirkende Längskräfte zwar den absoluten Betrag der Seitenkräfte verringern, die beschriebenen Tendenzen aber nicht verändern.

Reifeninnendruck und Reifenabmessungen haben einen vergleichsweise geringen Einfluß auf die Seitenkräfte. In Bild 6 sind die Seitenkräfte in Abhängigkeit vom Reifeninnendruck bzw. der Reifenauslastung dargestellt. Die Reifenauslastung beschreibt das Verhältnis der tatsächlichen Radlast zu der vom Hersteller für einen bestimmten Innendruck festgelegten, zulässigen Radlast.

$$q = \frac{F_Z}{F_{Ztab(p_i)}}$$

Bei konstantem Innendruck bewirkt ein Erhöhung der Radlast eine Zunahme der Auslastung. Dies wird bei konstanter Radlast auch durch einen fallenden Reifeninnendruck erreicht. Hieraus resultiert eine stärkere Reifeneinfederung und die übertragbaren Seitenkräfte nehmen vor allem für größere Schräglaufwinkel ab. Während die Seitenkräfte mit der Reifenbreite sowohl für konstanten Innendruck wie vor allem auch bei konstanter Auslastung zunehmen, Bild 7, ist der Einfluß des Reifendurchmessers nicht so ausgeprägt, Bild 8. Bei Unterlastung (q = 50 %) nehmen die Seitenkräfte mit dem Durchmesser zu, bei einer Überlastung (q = 150 %) dagegen vor allem bei kleinen Schräglaufwinkeln ab. Da angetriebene Reifen nicht nur Seitenkräfte, sondern auch

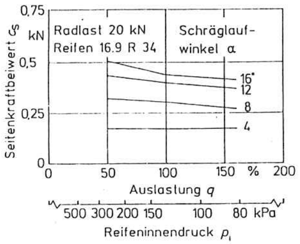
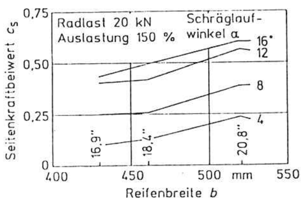


Bild 6: Einfluß der Auslastung auf die Seitenkraft (Schlupf 0%, Boden: Stoppel A)



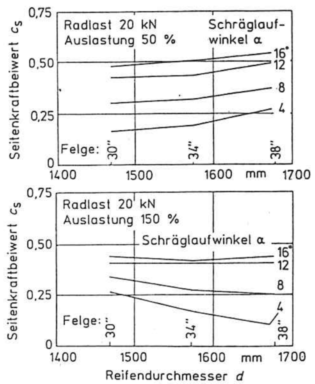


Bild 7: Einfluß der Reifenbreite auf die Seitenkraft (Schlupf 0%, Boden: Stoppel A, Felgendurchmesser 38'')

Bild 8: Einfluß des Reifendurchmessers auf die Seitenkraft (Schlupf 0%, Boden: Stoppel A, Reifenbreite 16,9'')

gleichzeitig Trieb- oder Bremskräfte übertragen, ist die gemeinsame Auftragung beider Größen in einem sogenannten Reifenkennfeld, von besonderem Interesse, Bild 9. Wie schon vom Reifenverhalten an Kraftfahrzeugreifen auf starrer Fahrbahn bekannt, werden auch bei Treibradreifen im landwirtschaftlichen Einsatz die Seitenkräfte kleiner, wenn Triebkraft oder Bremskraft zunehmen. Im Fahrzeugbereich führen blockierende Räder zu einem weitgehenden Verlust der Seitenkraft. Bei den durchgeführten Untersuchungen wurde dieser Fahrzustand jedoch nicht erreicht. Wie Bild 9 zeigt, sind Reifenkennfelder nicht symmetrisch. Die Seitenkräfte sind im Bereich geringer negativer

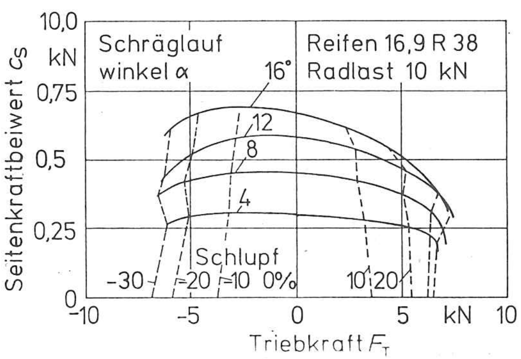


Bild 9: Reifenkennfeld für das Überfahren eines bearbeiteten Bodens (Innendruck 130 kPa, Boden bearbeitet, BIII).

Triebkräfte, vor allem bei großen Schräglaufwinkeln, etwas größer als im positiven Bereich. Dieses Verhalten wird auch durch theoretische Ansätze von Grečenko [11] und Crolla [12] zur Berechnung von Reifenkennfeldern wiedergegeben [10]. Zur Überprüfung der Übereinstimmung von mathematischem Modell und experimenteller Messung ist jedoch die Kenntnis der aktuellen Bodenkennwerte, die das Fahren beeinflussen, notwendig.

Formelzeichen

i_T	Triebschlupf	F_Z	tatsächl. Radlast
i_B	Bremsschlupf	$F_{Ztab(pi)}$	zulässige Radlast
s_G	Fahrstrecke, fünftes Rad	q	Reifenauslastung
s_{OR}	theoretische Wegstrecke	U	Feuchtigkeit
F_S	Seitenkraft	α	Schräglaufwinkel
c_S	Seitenkraftbeiwert		

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TRENDS IN AGRICULTURAL ENGINEERING
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DIE BIOTECHNISCHE ABHÄNGIGKEITE DER AKTIVBELÜFTUNG DER GETREIDEARTEN

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Der Beitrag informiert über Effekte der Aktivbelüftungstechnologie des Großkapazitäten-Getreidesilos beim Prozeß der Getreidelagerung.

die Aktivbelüftung; die Aktivbelüftungstechnologie; die Getreidelagerung

1.0. EINLEITUNG

Das Getreidesilo (GS) 92 000 T Hustopeče - Šakvice verfügt über 100 Lagerräume (LR), in jedem davon gibt es einen Vorhang mit 10 Meßpunkten zur Messug der Temperatur. Der Lieferant des technologischen Teiles, eine französische Firma LORIN, garantierte einen sicheren Betrieb der Aktivbelüftung (AB) bis zu 70 - .80 % des gesamten Lagerkapazität.

Aufgrund davon wendeten sich k.p. ZZN Brünn, ZZNZ Břeclav u. Großkapazitäten-Getreidesilo (GGS) Hustopeče - Šakvice an den Lehrstuhl der Theoretischen Basis der Technik der Hochschule für Landwirtschaft Brünn, um eine Verbesserung der technisch-ökonomischen Lage zu erzielen. Zum Ziel wurde die Analüse derjenigen Größen, die parametrisch den Lagerprozeß beeinflußten, ferner Effekte der vorhandenen Technologie der AB vom Getreide beim Prozeß der Getreidelagerung und Ermittlung der Systemreserven.

2.0. BEOBACHTETE GRÖßEN

Es wurden beobachtet: die abgeführte Feuchtigkeitsmasse [kg], Zeit der AB [St.], das Volumen der Luft, die durch LR getrieben wurde V_L [m^{-3}], die durchschnittliche Aufnahmefähigkeit [g . m^{-3}] und der Wert der durchschnittlich abgeführten Feuchtigkeit m_w [kg .St^{-1}].

Die Ausgewählten LR des GS wurden 3 Lagerperioden hindurch beobachtet, und die Schlußfolgerungen wurden zur Programmbildung "RIZENI AV ZRNA" für den technologischen Computer verwendet.

2.1. Getreide des Lagerraumes 33 L (1985 - 86)

Die Lebensmittelgerste wurde im Laufe von 6 Tagen ursprünglich in den LR 14 L bis zu Höhe 42,3 m eingeschüttet. Das Getreide verfügte nach der Einschüttung über eine hohe Temperatur t = 26 °C und eine Relative Feuchtigkeit φ = 16,8 %. In der zweiter Dekade, vom 7.8. bis 8.8. 1985, wurde die Partie in der Trockenanlage LSO 50 unterbrochen, zum LR 33 L überführt und anschließend intensiv belüftet. In der 3. Dekade (Tab. 1) wurde die größte Feuchtigkeitsmasse abgeführt m_w = 2082 kg, die durchschnittliche Aufnahmefähigkeit der Luft erzielte den höchsten Wert der gesamten Lagerperiode j = 17,0 g . m^{-3}, wenn auch das Volumen der durch den LR getrieben Luft geringer war, als in der 2. Dekade, was mit der immer wieder beharrenden hohen Temperatur des Getreides zusammenhängt. Den größten Wert erreichte in der 3. Dekade auch des durchschnittliche Massenfluß der Feuchtigkeitsübertragung m_w = 43,8 kg .St^{-1}.

In der 4.Dekade wurde das Getreide belüftet bei entsprechenden Bedingungen bei großer Luftaufnahmefähigkeit j = 40,8 g . m^{-3} (Abb. 2), trotzdem wurde die maximale Getreidetemperatur bis zum Wert t = 34 °C verringert (Abb. 1). In der 5. Dekade mußte man das Volumen der durch den LR getrieben Luft vergrößern. Dadurch wurde das Getreide auf die max. Temperatur t = 25 °C abgekühlt, wobei die minimale Temperatur auf t = 15 °C fiel und blieb auf diesem Wert bis zur 8. Dekade (Abb. 1). LR wurde bis zur 13. Dekade Aktiv belüftet. Selbst bei unoptimaler Luftaufnahmefähigkeit wurde vom Getreide die Feuchtigkeit abgeführt und das Getreide so abgekühlt, daß die minimale Lufttemperatur in der 12. Dekade t = 5 °C und die maximale dann t = 17 °C erreichte. Dieser Thermozustand stabilisierte sich bis zur 19. Dekade (Abb.1).

Von der 14. bis zur 17. Dekade wurde der LR nicht belüftet, weil das Getreide maximal abgekühlt und abgetrocknet war.

In der 18. bis 23. Dekade wurde der LR aktiv belüftet, aber wenig intensiv, weil die Aktivbelüftungsperiode Kürzer war, und nicht einmal die Luftaufnahmefähigkeit war optimal (Abb. 2). Infolgedessen kann es im LR zur Temperaturerhöhung, und die minimale Temperatur schwankte um t = 10 °C in der 20. und 21. Dekade, am Anfang der 22. Dekade fielen die minimalen Temperaturen auf t = 0 °C dank der Kaltluftbelüftung (Anfang Februar). Diese Temperatur wurde bis zur LR-Entleerung der Partie anfangs Juli 1986 eingehalten. Maximale Temperatur stieg ab der 22. Dekade bis zur Entleerung auf t = 8 °C.

Von der 23. bis 32. Dekade wurde der LR nicht aktiv belüftet, mit der Ausnahme der 29. und 32. Dekade, wann es im Laufe von 8 Stunden der AB ca. m_w = 200 kg der Feuchtigkeit abgeführt wurde (Tab. 1).

Die Gesamtzeit der AB des LR betrug τ_v = 867 Stunden, und es wurden m_w = 200 kg der Feuchtigkeit abgeführt. Das Gesamtvolumen der durch den LR getriebenen Luft betrug V_L = 2,78 . 10^6 m^3, zur Zeit der AB war die Aufnahmetähigkeit der Luft j = 6,1 g . m^{-3}. In einer Stunde der AB wurde durchschnittlich m_w = 19,3 kg .St^{-1} der Feuchtigkeit abgeführt (Tab. 1).

Beim Getreide im LR kann es während der kurzen Zeitperiode (2 Monate) zur Schaffung der Optimalbedignungen für langzeitige Lagerung, seine relative Feuchtigkeit wurde ca. um φ_M = 3 % verringert und eine geeignete Lagerungstemperatur wurde erreicht.

Am 8.7. 1986 wurde die Lagerung beendet aus dem Grunde der Reinigung, Überführung zum LR 20 P und teilweise des Entlagerung. Die Gesamtzeit der Getreidelagerung im LR 33 L betrug 344 Tage.

Das Getreide wurde im LR 33 L langzeitig stabilisiert aufbewahrt und es kam zu keinen negativen qualitativen Veränderungen.

3.0. ABSCHLUSS

Für die Entscheidung über AB in diesem Lagerraum wurden auf maximale Weise sowohl die gemessenen Werte der Außen- (Außenluft) und Innenparameter (Getreidefeuchtigkeit und -temperatur), als auch die Erfahrungen vergangenen Saisons, ausgenutzt. Der Lagerraum wurde streng beobachtet und der AB große Aufmerksamkeit geschenkt. So war es möglich, eine sehr wirkungsvolle Behandlung vom Getreide zu erzielen, ferner auch die Einhaltung der Getreidequalität zum Zwecke des langzeitigen Lagerung auch in einem LR dieser Kapazität. Eine aktive Belüftung aller LR des GS aufgrund von nur einer subjektiven Einschätzung der Außenluftparameter, und der Parameter des zu lagernden Materials, erwies sich für die Einhaltung dieser Qualität als praktisch unmöglich. Deshalb kam es zur Realisierung eines Computerprogrammes "RIZENI AV ZRNA", damit der ganze Trocknungsprozeß durch einen Computer gesteuert werden könnte.

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	die Dekadenummer											
	1		2		3		4		5		6	
die Größen	a	b	a	b	a	b	a	b	a	b	a	b
von - bis	24.7.	2.8.	3.8.	12.8.	13.8.	22.8.	23.8.	1.9.	2.9.	11.9.	12.9.	21.9.
Δm_w [kg]	556	556	1632	2188	2892	5080	1714	6794	1571	8365	894	9259
τ_v [St]	34	34	52	86	66	152	42	194	84	278	54	332
$V_L .10^{-6}$ [m³]	0.12	0.12	0.18	0.30	0.17	0.47	0.12	0.59	0.18	0.77	0.09	0.86
ϑ [g.m⁻³]	4.6	4.6	9.1	7.3	17.0	10.8	14.3	11.5	8.7	10.9	9.9	10.8
m_w [kg.St⁻¹]	16.4	16.4	31.4	25.4	43.8	33.4	40.8	35.0	18.7	30.1	16.6	27.9
	die Dekadenummer											
	7		8		9		10		.11		12	
die Größen	a	b	a	b	a	b	a	b	a	b	a	b.
von - bis	22.9.	1.10.	2.10.	11.10.	12.10.	21.10.	22.10.	31.10	1.11.	10.11.	11.11.	20.11.
Δm_w [kg]	55	9314	1023	10337	386	10723	523	11246	579	11825	1168	12993
τ_v [St]	8	340	68	408	30	438	46	484	62	546	60	606
$V_L .10^{-6}$ [m³]	0.01	0.87	0.14	1.01	0.06	1.07	0.08	1.15	0.12	1.27	0.15	1.42
ϑ [g.m⁻³]	5.5	10.7	7.3	10.2	6.4	10.0	6.5	9.8	4.8	9.3	7.8	9.2
m_w [kg.St⁻¹]	6.9	27.4	15.0	25.3	12.9	24.5	11.4	23.2	9.3	21.7	19.5	21.4
	die Dekadenummer											
	13		14		15		16		17		18	
die Größen	a	b	a	b	a	b	a	b	a	b	a	b
von - bis	21.11.	30.11.	1.12.	10.12.	11.12.	20.12.	21.12.	27.12	28.12.	6.1.	7.1.	16.1.
Δm_w [kg]	339	13332	0	13332	0	13332	0	13332	37	13369	336	13705
τ_v [St]	26	632	0	632	0	632	0	632	10	642	20	662
$V_L .10^{-6}$ [m³]	0.09	1.51	0	1.51	0	1.51	0	1.51	0.08	1.59	0.11	1.7
ϑ [g.m⁻³]	3.8	8.8	0	8.8	0	8.8	0	8.8	0.5	8.4	3.1	8.1
m_w [kg.St⁻¹]	13.0	21.1	0	21.1	0	21.1	0	21.1	3.7	20.8	16.8	20.7
	die Dekadenummer											
	19		20		21		22		23		24	
die Größen	a	b	a	b	a	b	a	b	a	b	a	b
von - bis	17.1.	1.2.	2.2.	15.2.	16.2.	25.2.	26.2.	7.3.	8.3.	17.3.	18.3.	27.3.
Δm_w [kg]	666	14371	717	15088	481	15569	944	16513	0	16513	0	16513
τ_v [St]	48	710	52	762	34	796	64	860	0	860	0	860
$V_L .10^{-6}$ [m³]	0.22	1.92	0.22	2.14	0.18	2.32	0.39	2.71	0	2.71	0	2.71
ϑ [g.m⁻³]	3.0	7.5	3.3	7.1	2.7	6.7	2.4	6.1	0	6.1	0	6.1
m_w [kg.St⁻¹]	13.9	20.2	13.8	19.8	14.1	19.6	14.8	19.2	0	19.2	0	19.2
	die Dekadenummer											
	25		26		27		28		29		30	
die Größen	a	b	a	b	a	b	a	b	a	b	a	b
von - bis	28.3.	6.4.	7.4.	16.4.	17.4.	26.4.	27.4.	6.5.	7.5.	16.5.	17.5.	26.5.
Δm_w [kg]	0	16513	0	16513	215	16728	0	16728	0	16728	0	16728
τ_v [St]	0	860	0	860	0	860	8	868	0	868	0	868
$V_L .10^{-6}$ [m³]	0	2.71	0	2.71	0	2.71	0.04	2.75	0	2.75	0	2.75
ϑ [g.m⁻³]	0	6.1	0	6.1	0	6.1	5.4	6.1	0	6.1	0	6.1
m_w [kg.St⁻¹]	0	19.2	0	19.2	0	19.2	26.9	19.3	0	19.3	0	19.3

Tab. č. 1 – Die Nummer des Wertes den Parameter AB LR 33 L (1985 – 86)

Abb. 1) DIE TEMPERATUREN IN LR 33 L

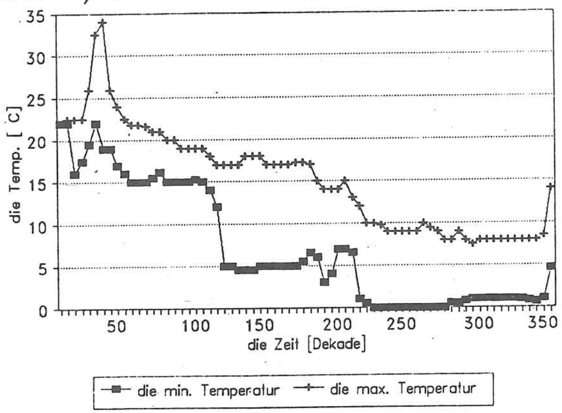
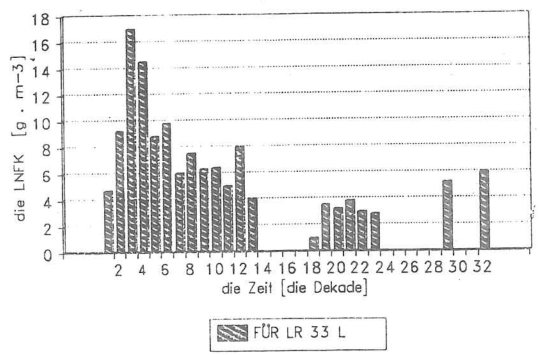


Abb. 2) DIE LUFTAUFNAHMEFÄHIGKEIT (DURCHSCHNITTLICHE)



TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

DIE ENTWINCKLUNG DER SENSOREINHEIT FÜR GETREIDESILOS.

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A draft design of a new intelligent sensor unit described for measuring of temperature and filling level of deep storage bins. The excellent quality of sensor unit has been reached using new design of convertors and by using of microcomputers. The idea of linearization of convertor's characteristic R/f (resistance / frequency) which was used for digitization of thermistor's signal. Experimental measurments confirm the perfect function within the temperature range from -10 to 40 °C.

Intelligent sensor unit; measuring of filling level and temperature of loose materials; microcomputer

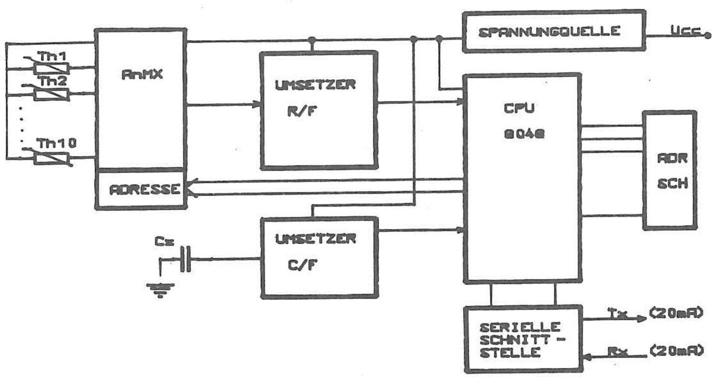
1. Vorwort

Die Grundteile der Meßanlage für Überwachung der Änderungen im Tiefbunker von Getreidesilos bestehen aus der automatischen Temperaturüberwachung und der kontinuerlichen Füllstandmessung. Das Referat legt die Lösung der Sensoreinheit vor, welche in 3. Generation der intelligenten Senzoren einzuführen möglich ist.

Die Entwicklung der Senzorseinheit wurde zur Erfüllung dieser Eigenschaften und Funktionen gezielt: automatische Umschaltung der Sensoren, Autokalibrierung, Autodiagnostik, Digitalisierung und Linearisierung der Meßdaten, serielle Datenübertragung und seine automatische Steuerung. Mit diesen Funktionseigenschaften unterscheidet sich die Sensoreinheit sehr positiv von bekannten Einrichtungen. Das Referat präsentirt bündige Beschreibung der Sensoreinheit und Lösung der Datendigitalisierung, Datenlinearisierung aus Temperatursensoren.

2. Die Struktur und Funktion der Senzoreinheit.

Die Einrichtung führt kontinuerliche Füllstandmessung bei Tiefbunker nach Kapazitätsprinzip und Temperaturmeßung an zehn Orten der Bunkerhöhe durch. Die Anlage nützt den Termosensorträger (ein hohles Stahlseil) gleichzeitig als eine Elektrode bei Kapazitätsmeßung. Die Senzoreinheit ist durch serielle Schnittstelle mit fortlaufendem Rechner IBM XT/AT verbindet. Durch diesen Weg wird der Meßbefehl übernommen und zurück werden digitalisierte Messdaten gesendet. An die Serielle Schnittstelle ist es möglich bis 256 Senzoreinheiten zu binden, weil die Auswahl der Einheit mit dem Adressbefehl gesteuert ist. Der Zentrallsteuerglied ist realisiert mit dem Einchipmikrorechner (Reihe-8048), und deshalb werden zumeist die Funktionen der Einheit durchProgramm (resp. Software) gelöst. Vor allem für höhere Sicherheit, niedrigere Preise und kleine Ausmasse wurden weitere elektrische Kreise gelöst. Das Blockschema (Abb.1) zeigt die Struktur der Senzoreinheit.



An.MX - ANALOG. MULTIPLEXER
ADR.SCH - UMSCHALTER DER SENSOREINHEITADRESSE
Cz - EL.KAPAZITAT DER BEHALTERS

Abb.1

3. Untersystem der Kapazitäts-Füllstandmessung.

Die Messmethode nützt die bekannte Tatsache aus, dass der Behälter mit leitenden Wänden, ergänzt durch isolierten Elektrode, einen Kondensator bildet. Bei Füllung des Behälters mit Getreide ändert sich das Permitivitätsverhältnis des Kondensators und die Abhängigkeit der Kondensatorkapazität an der Getreidehöhe ist linear. Die Ausnutzung dieser Methode für Füllstandmessung in Tiefbunkern von Getreidesilos beschreibt der Autor in /1/,/2/. Es handelt sich um die Problematik der Getreidepermitivität, der Linearumsetzer Kapazität/Frekvenz und weitere Mikrorechnersteuerung. Diese Erkentnisse wurden beider Lösung von Sensoreinheit voll genützt.

4. Untersystem der Temperaturmessung mit dem Termistorfühler.

Hohe Empfindlichkeit, kleine Ausmasse und Gewicht, niedriger Preis und einfache Lösung des Umsetzers R/F (Widerstand/Frekvenz) waren die Gründe zur Benützung des Thermistors. Die bekannten Mängel von Thermistoren, zum Beispiel die Parameteränderung durch die Alterung und grosse Parameterzerstreuung (Dispersion) sind in dieser Zeit durch Fortschrift in Erzeugung fast beseitigt /3/. Gleichzeitig wurde der Bedarf an der Umbau heutiger Einrichtungen respektirt, wo die Thermistoren benützt werden.

Unlineare Abhängigkeit des Thermistorwiderstandes an der Temperatur, welche durch die Gleichung (1) angegeben wird

$$R(T) = A\,e^{B/T} \qquad (1)$$

A /Ω/....Material und Formkonstante
B /K/....Temperaturkonstante des Thermistors
T /K/....Temperatur,

kann man in bestimmtem Bereich eliminieren.

Die Linearisierung der Übertragungscharakteristik von Thermistorthermometer kann man durch die Linearisierung des Stromverlaufes im Kreis oder durch die Linearisierung eigenes Widerstandverlaufes durchführen. Die einfachste Lösung, zumeist genügend, ist Linearisierung mit seriellen oder parallelen Schaltungen eines Widerstandes (Rs) zum Thermistor, wie die Abbildung 2.a,b zeigt.

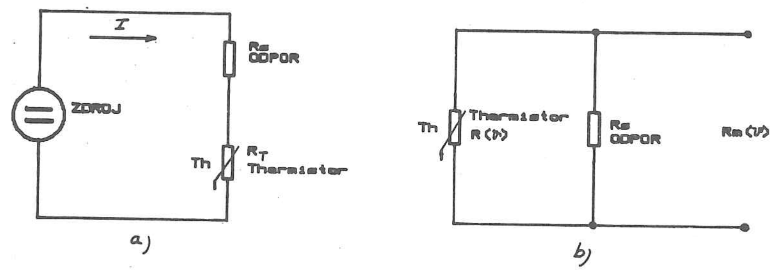


Abb.2.a,b

Strömt der Strom durch den Kreis nach Abb.2a, dann bestimmt die Lösung der Gleichung (2) der Abhängigkeit I=f(T) für gewählte Temperatur T_i den Inflexpunkt. Die Temperatur T_i ist gewählt als Mittelwert des Temperaturbereichs.

$$\left(\frac{d^2 I}{dT^2}\right)_{T_i} = 0 \Rightarrow R_s = \frac{B - 2\,T_i}{B + 2\,T_i} \cdot R_{T_i} \qquad (2)$$

T_i /K/....Mitte des Temperaturbereiches
R_{T_i} /ohm/..Widerstand des Thermistors bei Temperatur T_i
Rs /ohm/..linearisierter Widerstand

Bei der Schaltung des Widerstandes Rs zum Thermistor Th (siehe abb.2b), kann man die Linearisierung des Widerstandverlaufes $Rm(\vartheta)=f(\vartheta)$ ableiten, wenn diese Grundebedigung gilt: bei drei equidistanten Temperaturen $\vartheta_1 - \vartheta_2 = \vartheta_2 - \vartheta_3$ werden resultirende Widerstände $Rm(\vartheta)$ auch equidistant.

Es muss also die Gleichung gelten :

$$Rm(\vartheta_1) - Rm(\vartheta_2) = Rm(\vartheta_2) - Rm(\vartheta_3) \qquad (3)$$

wobei

$R(\vartheta)$ ...Thermistorwiderstand bei Temperatur ϑ ../ohm/

ϑ ...Temperatur .. /°C/

$Rm(\vartheta)$ ...paralelle Kombination $R(\vartheta)$ + Rs ../ohm/

Wenn in die Gleichung (3) die Beziehung für paralelle Kombination des Widerstandes $R(\vartheta)$ mit Rs eingesetzt wird und einfache Regelung durchgeführt wird, dann bekommt man die Beziehung für die Ausrechnung Rs :

$$Rs = \frac{R2\ (R1+R3) - 2\ R1\ R3}{R1 + R3 - 2\ R2} \quad /ohm/ \qquad (4)$$

wobei $R1=R(\vartheta_1)$; $R2=R(\vartheta_2)$; $R3=R(\vartheta_3)$

Für verwendeten Thermistor NRZ - 1.001 mit Konstante B=4000K und für gewählten Temperaturbereich wird mit beiden Methoden fast übereinstimmender Widerstand errechnet. Mit der ersten Methode war der Wert Rs = 2221 ohm und mit der zweiten Rs = 2232 ohm. Equidistante Temperaturen für die zweite Ausrechnungsweise wurden auf 10% und 90% des Bereiches festgesetzt. Der Verlauf des Thermistorwiderstandes und linearisierte Charakteristik mit dem Widerstand Rs in Temperaturabhängigkeit zeigt Abb.3.

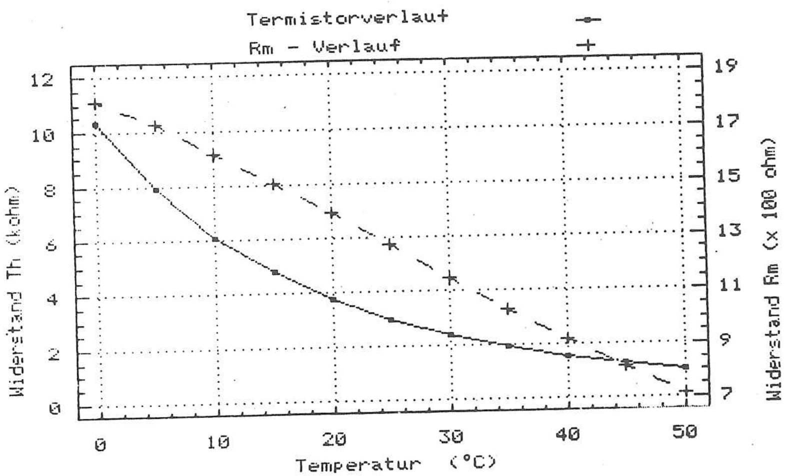


Abb.3

Serielle Anschaltung des Widerstandes Rs zum Thermistor Th wurde weiter in der Kreislösung des Umsetzers R/f (Widerstand/Frekwenz) geltend gemacht, welcher einfache Signaldigitalisierung ermöglicht. Die Lösung nüzt Timer "555" mit der originalen Anschaltung an die Kombination des Widerstandes $R(\vartheta)$ mit Rs aus. Der Thermistor muss noch dazu im Gleichstrombetrieb arbeiten, weil er zum Kreis durch lange Zuleitungen (bis 45 m) mit parasitäts - Kapazität (bis 3000 pF) angeschlossen ist. Die ganze Schaltung ist einfach und hat befriedigende Übertragungslinearität. Die Charakteristik des Umzetzers wird auf Abb.4 gezeigt. Die maximale Unlinearität des Verlaufes ist 2%. Beim Bedarf an kleinerer Unlinearität ist weitere digitale Linearisierung mit dem eingebauten Mikrorechner, resp. mit seinem Programm, möglich.

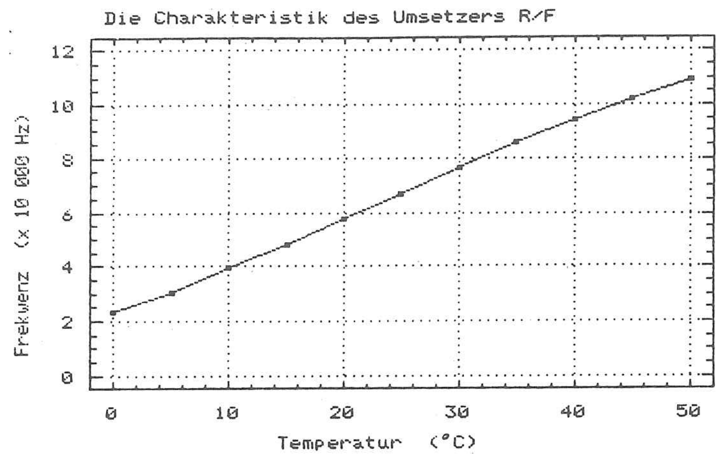


Abb.4

5. Die Prüfungen des Parameters der Senzoreinheiten.

Die Messungen wurden mit zwei Prototypen der Senzoreinheiten durchgeführt, welche wurden mit inländischem Mikrorechner MHB 8748 ausgerüstet wurden. Die Prototypen wurden an serielle Schnittstelle RS 232C des Rechners IBM PC/AT durch den Wandler RS 232C / 20mA Current Loop angeschaltet. Bei der Entfernung 300 m zwischen dem Rechner und Senzoreinheit und bei der Geschwindigkeit der Übertragung 2400 Bd war die Komunikation fehlerlos, was befriedigend ist. Mit weiteren Prüfungen wurden die Temperaturstabilität der Übertragungscharakteristik der Senzoreinbeit untersucht, resp. der Einfluss auf drei gewählte Temperaturen und ein Messwert des Kapazitätssensors. Die Wichtigkeit dieser Prüfungen erklären die Temperaturbedigungen (-10 bis +40 °C) in welchen die Einrichtung arbeiten wird. Die Simulation dieser Bedingungen wurde in der Klimaanlage durchgeführt und die drei gemessenen Temperaturen (0; 20; 40 °C) in der Ölflüssigkeit wurden mit den Thermostaten OP7 festgehalten. Die Genauigkeit der Regulierung war +0,05 °C. Die Toleranz der gemessenen Werte der Kontrolltemperaturen hatte die absolute Temperatur 0,3 °C nicht überschritten. Die Angabe aus Kapazitätsensor hat die Toleranz 0,1% (aus gemessenem Wert) nicht überschritten.

6. Zusamenfassung.

Die vorgelegte Forschungslösung der intelligenten Sensoreinheit mit Kapazitäts und Temperatursensorem synthetisieren spezielle Anwendung von neuen mikroelektronischen Elementen und originale Kreislösung. Der Ausgang ist ein Sensormodul, welcher die automatische Messung aus 10 Temperatursensoren und einem Kapazitätssensor in Verbindung mit Rechner IBM PC durchführt. Zum Rechner kann man bis 256 Senzoreinheiten anschalten. Im Referat ist ausführlich die Linearisirungmethode und Datenumsetzung aus den Thermistorsensoren beschreiben. Praktische Ausnützung der Resultate belegen die positiven Prüfungen der Prototypen-Sensoreinheiten.

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TRENDS IN AGRICULTURAL ENGINEERING

PRAGUE 15 - 18 SEPTEMBER 1992

STORING OF CORNCOBS IN VERTICAL BINS

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This paper presents the results of research of storing and low temperature drying of corncobs in vertical metal round bin and conventional horizontal wooden crib. Based on the obtained results it has been found that the vertical bins occupy less space in the economic yard, they are fully mechanized, equipped with the device for active ventilation by surrounding air and thus the quality grain of natural odour and taste is obtained. Finally, it has been concluded that the vertical bins will be profitably used for storing and low temperature drying of wet corncobs.

Key words: corncob, vertical bin, low temperature drying, storing, resistance layer

1. INTRODUCTION

The conventional way of storing the corncobs in horizontal wooden cribs with the natural drying by the surrounding air, in addition to the certain advantages, showed some deficiencies. Due to the insufficient intensity of wind the cribs are to be narrow (1,5 to 2 m max.). In order to store larger quantity of corncobs, the cribs are to be placed in the length of 10 to 15 m. The height of these cribs will be 2 to 3 m. In spite of this, they have relatively small capacity 15 to 30 tons, expressed in relation to the wet corncob. Such type of cribs can hardly be oriented towards the wind rose, i.e. to be placed in the economic yard transversally to the most frequent direction of wind blowing. In the economic yard they are mostly located on the free spaces, built in groups or together with some other building structures. Therefore they are sheltered and prevented from the wind effect. In such cribs (every fourth year on an average) the corncobs deterioration (covering with mould) frequently appears, especially if the corncobs put into the crib have the moisture content higher than 30%. In addition, the corncobs in the crib are attacked by various rodents and birds. Also, the mechanized loading and unloading of corncobs are not adequately solved and it is necessary to engage the additional labour. In consideration of relatively large surface to the volume of crib, the capital expenses of these structures per 1 cu.m. of storage space are high. Namely, the cribs are high duty, i.e. they occupy the large space in the economic yard.

High yields of hybrid corn and the high content of moisture created in the 60s particularly large problems in storing both at the social and the private estates. The lack of labour and the sufficient number of cribs resulted in changing over to the new technology of mechanized harvesting of corn grain and their storing into silo centres. This technology required the application of high temperature gravity-flow driers of high performances in order to store the wet grain as shortly as possible. The modern technology was economically justified until the oil crisis in 1974. Today we are coming across the poor quality of final product (high percentage of damages and grain breakage). But in addition to the certain quality the market also requests the healthy product, safe food for men and animals.

For the purpose of solving the above problems all efforts in this research work are directed to the application of modified technology of the natural way of corncob drying and storing. This is so called low temperature drying of corncobs by the surrounding air or slightly heated air in metal or concrete vertical round bins (cells), with built-in device for active ventilation of corncobs. This procedure would enable the maintenance of biological quality of corn grains, without high consumption of thermal energy and with the minimum consumption of electric energy.

2. LITERATURE SURVEY

After Bošnjaković and Brkić (1991)the consumption of energy for the operation of field mechanization in the production of corn amounts to 109,4 lit/ha (or 9,7%), fuel oil, for artificial drying and storing of grain in the silo 524,0 lit/ha (or 46,3%) and for the production of grain, fertilizer, protection means, machinery and equipment (so called indirect energy consumption) 498,8 lit/ha (or 44,0%) at corn grain yield of 8 tons/ha. Today we are coming across the poor quality of final product, i.e. high percentage of grain damage and breakage. Namely, in the system of fast drying and rapid grain cooling, as well as during the transport of "glassy" grain in the silo, the percentage of external grain cracks reached the value of 11%, internal cracks 87% and the grain breakage increased to 28% (after Alimpić and Brkić, 1974).

The most efficient way of corncob drying by the surrounding air is at the air temperature of 20°C. The good results were obtained with the air of the relative humidity not higher than 60% (after Jakovenko,1972) and 70% (after Černjih,1973). If the corncob layer is ventilated with the surrounding air at the temperature of 20°C and relative humidity of 60%, at the specific air flow of 300 m³/h per ton of corncobs, then the corncobs under these conditions may be dried to the moisture content of 13 to 14% in seven days and nights (after Jakovenko,1972).

After Jakovenko (1972), the following regime of active ventilaiton of corncobs by the surrounding air is recommended: for moisture content 18% minimum air flow of 30 m³/h per ton of corncob and the maximum thickness of corncob layer 3,5 m, for moisture content 35% air flow 55 m³/h per ton, layer thickness 1,8 m. Similar values are recommended by Meljnik (1970).

The density of wet corncob layer amounts to 0,469 t/m³ (after Telengator,1972), 0,462 to 0,480 t/m³ (after Golik, cited at Telengator,1972) and 0,450 to 0,480 t/m³ (after Ukolov,1964).

Mass ratio of grain and cob is 78:22 (after Ukolov,1964). The mass of grain may vary from 70 to 82. The lower content of moisture in cobs, the larger portion of grain.

The resistance layer of corncobs to the air stream was analized by several authors. For instance, at the forced velocity of 0,5 m/s, the resistance layer is 100 Pa/m of layer thickness (after Hukill, 1974), 71 Pa/m (after Jakovenko,1972), 50 Pa/m (after Ukolov, 1964) and Černjih 1973) and 108 Pa/m (after Ukolov,1974).

The various values of resistance layer are mainly obtained due to the various types of tested varieties and hybrid corn. By comparing the values of corncob resistance layer with the grain resistance layer by the same authors it may be concluded that the corncob resistance layer is less by 30 to 60 times than the grain resistance layer.

The moisture of corncob gradually drops during the storing in autumn, winter and spring months. So for instance, after Alimpić and Brkić (1974) during the corncob harvesting (the end of September, beginning of October) the moisture content in corncobs amounts to 25 to 30%, at the beginning of November the moisture content drops to 22 to 23%, at the beginning of December 21 to 22%, at the beginning of January 19 to 20%, at the beginning of February 18% and in April drops to 16%.

3. MATERIAL AND METHOD OF WORK

During the storing season in 1990 and 1991 the testing of storing the wet corncobs in the vertical metal twelve angle ("round") bin produced by RO "Čelik" from Bački Jarak was made. The bin was located at the farm Feher near Temerin. The project of bin has been elaborated by the Instutute for agricultural technique, Agricultural Faculty in Novi Sad.The schematic view of the bin is shown in Fig.1. The technical characteristics of the bin are: diameter 4,2 m, height 6 m, width of the side of the internal triangular pipe 0,5 m,dimensions of horizontal square connecting pipe for active ventilation 0,35x0,35 m, volume of bin useful space 78 m³. To the bin is attached the axial fan AL 630 type 013, manufactured by "Klima" Celje, of the following working characteristics: air flow 3,78 m³/s and strain 160 Pa (working point).

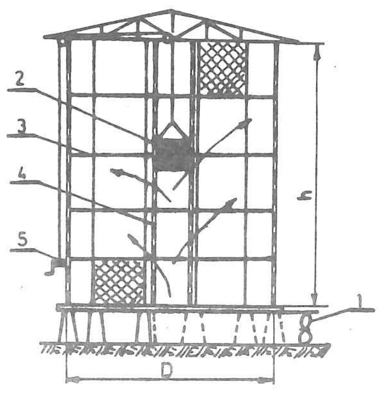

Fig.1 Vertical bin
1-fan, 2-movable piston, 3-bin, 4-perforated pipe,5-reel

"Volga" hybrid (FAO group 500) was thrown into the bin by means of the inclined belt conveyer on 10th October,1990., with the initial moisture content of 23,7%. The weight of corncob was 38,22 tons. The corncob was shelled by the tractor sheller on 17th September,1991. An eye was kept on the storage of corncobs during 11 months. The samples of corncobs were submitted to the Technological Faculty in Novi Sad for further laboratory testing of quality features of storing process.

Simultaneously the comparative testings of corncob storing in the conventional horizontal crib were made. The crib was built earlier at the same farm. The crib dimensions are: width 1,9 m, height of lateral sides 2,2m height of gable 3,2 m and length 10 m. The crib was located at the height of 1 m. On the north side there is a shed near the crib. The shed shaded the crib. The crib volume is 48 m³. "Dekald" hybrid (Fao group 500) was stored into the crib with the initial moisture content of 23,8%. The weight of corncobs was 23,5 tons. The corncob was shelled on 19th September,1991.

On 16th December, 1991 the laboratory testing of corncob resistance layer to the air stream was made. Hybrid ZP SK 704 was tested on the device for fluidization of grained (granular) material which was located in the laboratory of the Institute for agricultural technique in Novi Sad.

4. RESULTS OF RESEARCH WITH DISCUSSION

Based on the initial indices of wet corncob, "Volga hybrid", it has been found out that the bulk density of corncob in the vertical bin was 490 kg/m³. The mass ratio of wet grain and cob was 81,7:18,3, expressed in percentages. The calculated quantity of wet grain was 31.226 kg and cobs 5.714 kg. The quantity of the obtained dry grain was 27.386 kg with the moisture content of 13%. The quantity of dry cobs was 4.400 kg. The mass ratio of dry grain and cobs amounted to 86,15:13,85, expressed in percentages. The bulk density of dry cobs was 466 kg/m³.

Due to the favourable weather conditions during the storing of medium early hybrid with satisfactory initial moisture content (23,7%) it was not necessary to apply the active ventilation of corncobs in the vertical bin with the surrounding air. Namely, the bin was built like a chimney with the natural vertical air draught. During the wind blowing, the horizontal bin draught became stronger, since the thickness of corncob layer in the bin was 1,75 m. Based on the above facts it may be concluded that the corncob with the moisture content from the first critical point may be naturally dried in the vertical round bin.

Diagram, Fig.2 shows the results of testings of moisture content drop in the corncob stored in the vertical bin. (position 1). It can be seen from the diagram that the flow of corncob drying curve (position 3) depends on the weather conditions during autumn, winter and spring, as well as on the technical characteristics of storage. The favourable characteristic of curve (position 1) resulted from the favourable weather conditions and corncob storing in the vertical round bin with natural draught.

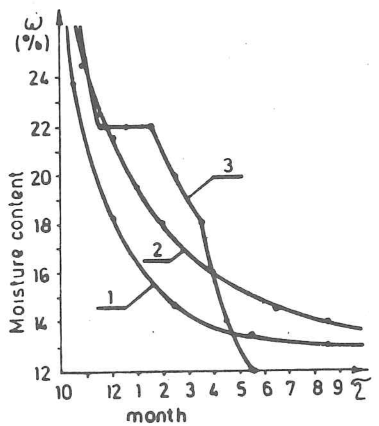

Fig. 2: Cob drying curve
1-Temerin, 2-Alimpić/1/, 3-Patarčić/5/

The results of testing the corncob resistance layer to the air stream are shown in diagram, Fig.3 (position 4). The data of our tests mainly coincide with the data of Ukolov (1964). What is important to point out, it may be stated that the values of corncob resistance layer are 40 times less than the values of resistance layer of corn on the cobs, for the same apparent velocities of the air in the layer. This practically means that the consumption of electric energy for active ventilation of the wet cob in the bin would be very low.

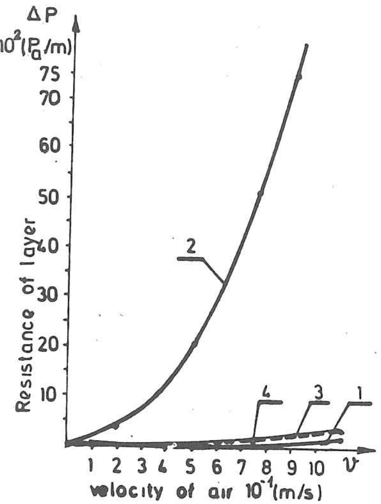

Fig.3: Resistance layer of grain and cob
1-cob/6/2,-grain/6/3-cob/7/4-cob

By following up the storing of corncobs in the conventional crib it was found out that the obtained quantity of dry grain was 16,9 tons with the moisture content of 13,1%. The mass ratio of dry grain and cob was 83,6:16,4, expressed in percentages. The bulk density of dry grain is 468 kg/m³.

The results of testings of the quantity of moulds, yeast and bacteria on the corncob in the vertical bin and in the conventional crib point out to the conclusion that the significantly less number of microorganisms were found in the vertical bin. For instance, it has been found out that the same number of microorganisms appeared in May in the conventional crib and in August in vertical bin in spite of favourable weather conditions.

In addition, the corncob from the conventional crib smelt after mould, rotteness, rats and mice, while the corncob from the vertical bin was without any odour and taste. This resulted from the natural air draught in the vertical bin.

5. CONCLUSION

Based on the literature and the results of testing the following may be concluded:

- drying of corncob with the moisture content at the first critical point (22 to 24%) may be done naturally in the vertical bins, without active ventilation of cobs by the surrounding air,
- if the moisture content exceeds 28%, it is necessary to apply the active ventilation by the surrounding air to the moisture content at the first critical point (22 to 24%),
- in order to use the active ventilation maximally the recommended air flow is 50 to 55 m³/h per ton of corncob. It would result in the lowest electric energy consumption. It is estimated that the electric energy consumption would be approx. 250 kW for drying of 40 tons of wet corncobs by the surrounding air,
- the resistance layer of corncob is lower for about 40 times than the resistance layer of corn grain to the air stream flow. Having in mind this fact it may be concluded that the drying of corncobs in the vertical bins will be profitable,
- the quality of stored and dried cob in the vertical bin is significantly better than in the conventional crib. From the vertical bin you obtain healthy food for men and animals,
- vertical bins occupy less space than the conventional structures in the economic yard. The investment expenses expressed per 1 m³ are less than for crib. These bins are fully mechanized and do not require the engagement of additional labour.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

EFFECTIVE NATURAL VENTILATION OF CATTLE HOUSES

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This article describes the experience with the utilization of the new natural ventilation system in a cow houses. Resultes of measurements of air temperatures, humidity, air velocity, globe temperature and other criteria show that microclimatic conditions in the stables with this type of ventilation are rather good during the all tested periods.

natural ventilation; cow house; microclimatic conditions; measurement

1. INTRODUCTION

During the last twenty years primarily forced ventilation has been used in animal husbandry houses in Czechoslovakia. The forced ventilation is necessary mostly in the houses with a great concentration of animals in a breeding space, namely poultry and pig houses. But the forced ventilation systems were also designed for cattle houses, where these systems had not been used correctly and the maintenance had not been sufficient.

This is why the natural ventilation systems were again introduced for use in this country. However, the natural ventilation of newly-built stables was not tested thoroughly and was in many cases, simultaneous with the testing of uninsulated stables and unsuitable types of stalls. The results of those experiments were not reliable. It was caused mostly by faulty evaluations of the effects of wind and the unsuitable construction of ridge slots and holes for inlet air.

The aim of this article is to describe the testing procedure for system of natural ventilation constructed according to the patent /1/, named a as a system BS. This system has been tested in a reconstructed four-row stable with 174 dairy-cows.

2. METHOD

Construction of the roof with natural ventilation has the following characteristic features:

- simple saddle roof with timber beam lattice, connected by pressed-in Gang-nail type board,
- oblique slope of insulated roof construction ($15-17^o$) with planning modulus 1,5 m,
- possible width of construction to 25 m,
- low ceiling made from panels BIOS with thermal resistence 1,29 m^2kW^{-1},
- continual ventilation of roof by draught (roof slot),
- intake of fresh air through cornice slot,
- inlet of air in the breeding space through the ventilating inlets with adjustable flaps situated at suitable distances from the walls,
- air outlet through the ridge ventilating slot with adjustable revolving flaps,
- ridge ventilating slot covered from above by small, translucent roof and protected against wind from both sides by screen plates.

Furthermore, long-term measurements of air temperature and humidity have been made by registering the apparatus THG during the winter, spring and summer periods. Intermittent measurements of air temperatures, humidity, air velocity, globe temperature, dust content, CO_2 and H_2S content and noise also were taken. The air flow patterns were visualized by smoke tests.

The check points for measurement were chosen with the aim of finding the representative places for all microclimatic areas (centre, ridge, etc.).

Obtained results were tested according to " Regulations of Use of Ventilation and Heating Systems in Agricultural Houses "/2/ and according to the following criteria:

- Effective Temperature of Surrounding Surfaces t_u

$$t_u = 100\sqrt[4]{\left(\frac{T_g}{100}\right)^4 + 2{,}85\,(t_g - t_s)\sqrt{w}} - 273{,}15$$

- Temperature Humidity Index THI

$$THI = t_s + 0{,}36\, t_m + 41{,}5$$

- Black Globe Humidity Index BGHI

$$BGHI = t_g + 0{,}36\, t_m + 41{,}5$$

- Wet Bulb Globe Temperature WBGT

$$WBGT = 0{,}2\, t_g + 0{,}1\, t_s + 0{,}7\, t_m$$

where: t_g, T_g - globe temperature /^oC, K /,
t_s - temperature of dry bulb /^oC/,
t_m - temperature of wet bulb /^oC/.

3. RESULTS

Table 1. Temperatures of winter, spring and summer

Period	$t_i < t_{opt}$	$t_i \cong t_{opt}$	$t_i > t_{opt}$	$\bar{t}_e$	σ_e	$\bar{t}_i$	σ_i
	% of time	% of time	% of time	^oC	^oC	^oC	^oC
20.-27.2.	0	79,5	20,5	2,9	3,9	13,5	3,5
14.-21.3.	1,2	63,4	35,4	8,1	4,5	13,0	2,7
9.-16.4.	2,4	32,5	65,1	7,7	5,1	13,0	3,0
3.-10.5.	1,2	73,8	25,0	7,1	3,8	12,8	2,4
3.-10.6.	41,5	56,1	2,4	13,5	4,8	15,8	3,6
20.-24.6,	21,6	60,8	17,6	17,5	5,2	18,7	3,5

Table 2. Humidity of winter, spring and summer

Period	$\varphi_i < \varphi_{opt}$	$\varphi_i \cong \varphi_{opt}$	$\varphi_i > \varphi_{opt}$	$\bar{\varphi}_e$	σ_e	$\bar{\varphi}_i$	σ_i
	% of time	% of time	% of time	%	%	%	%
20.-26.2.	0	88	12	89	10	67	3
14.-21.3.	1,2	41,5	57,3	81	17	67	7
9.-13.4.	0	51	49	73	19	68	7
3.-10.5.	0	42,9	57,1	71	19	69	7
3.-10.6.	2,1	64,6	33,3	67	15	66	8
20.-24.6.	2,0	41,2	56,8	68	19	71	10

Table 3. Average temperatures and criteria in winter, spring and summer period

t_e	t_s	t_g	t_u	THI	BGHI	WBGT
^oC	^oC	^oC	^oC	-	-	-
1,4	7,6	9,5	12,0	51,2	53,0	6,6
17,1	19,5	19,9	20,1	66,5	66,7	16,3
27,6	26,6	25,9	25,0	75,9	75,2	23,2

4. CONCLUSION

Obtained results of measured temperatures show that the stables with this type of ventilation system enable rather good preservation of air temperatures during all measured periods. Relative humidity of the stable air had been about half of measured periods time higher than optimum, which show necessity for a more intensive ventilation.

The microclimatic conditions given by affect of temperature, humidity, air velocity and temperatures of surrounding surfaces are in majority of the stable stalls favourable.

The lengthwise air flow through the stable and bad regulation of slot flaps for inlet and outlet of air has rather negative influence on the microclimatic conditions (temperature). For this type of natural ventilation is necessary to use precise doors, windows and exact regulation according to indoor and external climate conditions.

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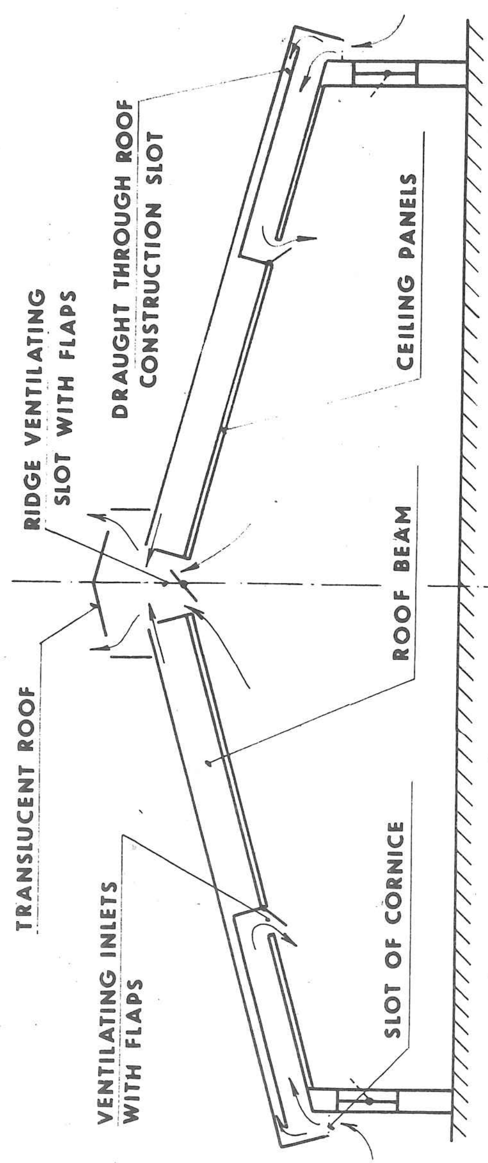

FIG. 1 ROOF CONSTRUCTION 'SYSTEM BS'

TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

TEST RESULTS OF FORCING-OUT SCREWES

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The article deals with the test results of forcing-out screwes in veterinary decontamination stations. The extruder screw segments, made from high-tensile cast steel type VP7, VPH and VPH EXTRA, were put into operation. The tests were carried out on extrusion presses of the Dutch firm STORK-DUKE in the veterinary decontamination station in Medlov and on extrusion presses of the Czech firm TMS Pardubice in Žichlínek. In the course of tests the changes in geometrical size of extruder screw segments and changes in size and form of extruder screw segment threads were determined.

veterinary decontamination; render:ng plant extrusion press; extruder screw; high tensile cast steel

1. EINLEITUNG

Bei der Verarbeitung der sekundären Rohstoffe und der biologischen Abfälle für Futter ist es außer der Sterilisation nötig den Rohstoff zu desintegrieren - konsistenten Eiweißstoff, Fette und Wasser auf selbständige Fraktionen separieren. Der ganze Prozess ist ein kompliziertes technologisches Problem anspruchsvoll auf die Maschinenausstattung, namentlich die Fettseparierung, wie in direkten energetischen Ansprüchen, so auf die in der maschinellen Ausrüstung versteckte Energie. Die Kafilerienschneckenpressen sind ein typisches Beispiel. Die Arbeitsteile - Schnecke und Seiherstäbe - arbeiten in sehr ungünstigen Press- und Abnutzungsbedingungen. Anspruchsvolle Bedingungen charakterisieren die Lebensdauer, die sich nach der Rohwarenzusammensetzung von 400 bis 800 Betriebsstunden ändern /1/.

Die Herstellung neuer Schneckensegmente erfolgt durch klassische Technologie - Zerspanung, Einsetzung des Gewindes und Aufschweißung der verschleißbeständigen Schichten auf die aktive Flächen. Mit Rücksicht auf die relativ kleine Lebensdauer der Segmenten wurden in letzten Jahren verscheidene Arten von Zubereitung entworfen um die Lebensdauer zu verlängern. Es wurde ganze Reihe von Technologien geprüft, zum Beispiel

Renovierung der abgenutzten Segmente durch Aufschweißung der abnutzungsbeständingen Zusatzwerkstoffen, Plasmaauftragen der nichtmetallischen Schichten und Einbau des Schneckengewindes aus abnutzungsbeständigem Werkstoff.

2. PRÜFUNGSMETHODIK

In der Zusammenarbeit des Lehrstuhls "Werkstoff und Maschinenbautechnologie" der Landwirtschaftlischen Hochschule in Prag, SVÚM Praha-Běchovice, SVÚM Brno und TMS Pardubice wurde zum Experiment neue Technologie entworfen - abgegossene Schneckensegmente. Aus möglichen Werkstoffen wurden die Gußstähle hoher Festigkeit VP7, VPH und VPH EXTRA gewählt. Das Gießen wurde in SVÚM Brno, die Wärmebehandlung in TMS Pardubice durchgeführt. Für Experimente wurde ein Satz der Segmente für die Schneckenpresse TMS Pardubice, Typ LS 250, und ein Satz der Segmente für die hollandische Presse STORK-DUKE verbereitet.

2.1 Verfolgte Parameter

Beim Messen wurde die Änderung der geometrischen Größen jedes bei der Demontage zugänglichen Segmentes festgestellt. Die Bezeichnung der Segmente zeigt Bild 1. Das Messen wurde

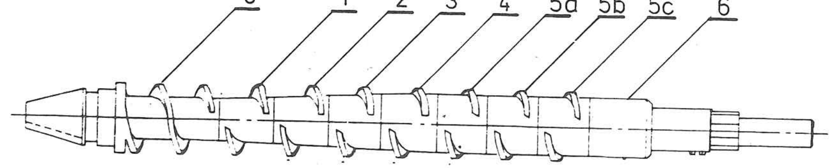


Bild 1. Bezeichnung der Segmente

mittels dem Außentaster und dem Maßstab durchgeführt. Weiter wurden die Maßen und die Gewindeform jedes Segmentes gemessen. Messungsschema zeigt Bild 2.

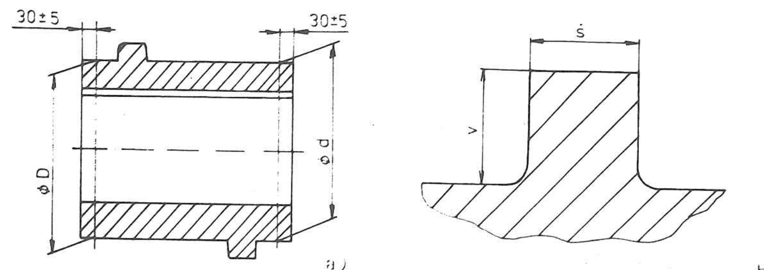


Bild 2. Messungsschema der Maßen des Segmentes (a) und des Profils des neuen Gewindes (b)

Die Durchmessergrößen der Segmente zeigen ihre fortschreitende Verminderung. Graphisch wird diese Abhängigkeit nicht dargestellt, weil die Durchmesser- und Längenabnützung der einzelnen Segmenten nicht linear war. Aus gemessenen Größen ist aber die schnellere Abnützung am Anfang und zum Ende der

Lebensdauer merkbar. Zwischen diesen Phasen läufte die Abnützung langsamer durch.

Näher wurde die Schneckengewindeabnützung verfolgt. Für die Auswertung wurde immer nach gewisser Zeit das Seihergestell demontiert und mittels Gipsabzüge wurden die Gewindeprofile der einzelnen Segmente abgenommen.

Jeder Gipsabzug wurde zersägt und so geschliffen, daß ein radialer Schnitt senkrecht auf die Richtung der Gewindesteigung entstand. Durch Überlagerung der Schnitte wurden die Verschleißverläufe einzelner Segmente gewonnen.

2.2 Messung an der Schneckenpresse TMS Pardubice

Die Betriebsprüfungen wurden in dem Assanierungsanstalt in Žichlínek durchgeführt. Die Segmenten wurden aus Gußstählen VPH und VP7 hergestellt, ihr Einsatz wird in Tafel 1 angeführt.

Tafel 1. Geprüfte Werkstoffe in der Schneckenpresse TMS

Segmentbezeichnung	Werkstoff
3	VPH
4	VPH
5a	VP7
5b	VP7
5c	VPH

Bemerkung: Segmente Nr. 0, 1 und 2 und die Buchse 6 (Bild 1) werden nicht angeführt, weil sie im Betrieb nur kleinen Verschleiß ausweisen und für die Schneckenlebensdauer nicht limitierend sind.

Die Verschleißverläufe der Segmente 3, 4, 5a, 5b und 5c in Abhängigkeit auf den Betriebsstunden zeigen Bilder 3 bis 7.

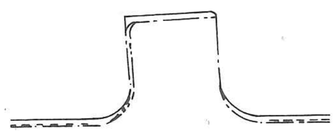


Bild 3. Verschleißverlauf des Gewindes des Segments 3 (TMS)

———— 0
- - - - - 92
—·—·— 169
—··—··— 550

Betriebsstunden

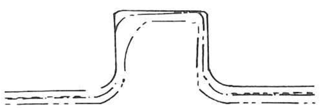


Bild 4. Verschleißverlauf des Gewindes des Segments 4 (TMS)

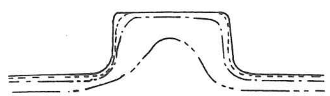


Bild 5. Verschleißverlauf des Gewindes des Segments 5a (TMS)

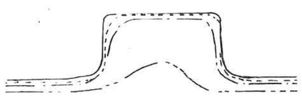


Bild 6. Verschleißverlauf des Gewindes des Segments 5b (TMS)

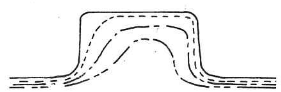


Bild 7. Verschleißverlauf des Gewindes des Segments 5c (TMS)

Oben angeführte Bilder zeigen die fortschreitenden Formänderungen jedes Segmentes. Für die Fettverdrängung ist es aber nicht nur die Änderung der Gewindehöhe, sondern auch die Winkeländerung der Druckseite des Gewindes wichtig.

Die Gewindeprofile wurden planimetriert und es wurde die Gewindeprofilabnahme mit Bezug auf den ursprünglichen Querschnitt ermittelt. In Tafel 2 werden die perzentuellen Verhältnisse der Querschnitte für bestimmte Betriebsstunden zum Querschnitt des neuen Gewindes angeführt.

Tafel 2. Gewindequerschnittabnahme der Segmente TMS /%/

Segment Nr.	Betriebsstunden			
	0	92	169	550
3	100	97,9	94,8	90,2
4	100	96,1	92,1	67,0
5a	100	93,5	81,2	25,8
5b	100	91,4	78,8	7,0
5c	100	80,3	58,3	21,3 x)

Bemerkung: Segment 5c wurde nach 275 Betriebsstunden ausgetauscht.

Graphische Darstellung der Werte aus der Tafel 2 zeigt Bild 8.

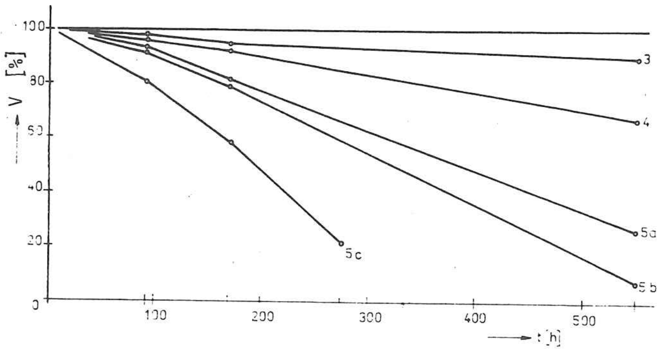


Bild 8. Verhältnis des Gewindequerschnittes zum Querschnitt des neuen Gewinde (V) in Abhängigkeit von den Betriebsstunden (t)

2.3 Messung an der Schneckenpresse STORK-DUKE

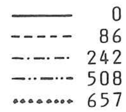
Die Betriebsprüfungen wurden in dem Assanierungsanstalt in Medlov durchgeführt. Die Segmente wurden aus Gußstählen VPH und VPH EXTRA hergestellt, ihr Einsatz wird in Tafel 3 angeführt.

Die Verschleißverläufe der Segmenten 3, 4, 5a, 5b und 5c in Abhängigkeit auf den Betriebsstunden zeigen Bilder 9 bis 13.

Weiter wurde analogisch wie in Tafel 2 die Gewindequerschnittabnahme der Segmente STORK-DUKE festgestellt.

Tafel 3. Geprüfte Werkstoffe in der Schneckenpresse STORK-DUKE

Segmentbezeichnung	Werkstoff
3	VPH
4	VPH
5a	VPH EXTRA
5b	VPH
5c	VPH



Betriebsstunden

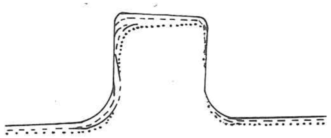


Bild 9. Verschleißverlauf des Gewindes des Segments 3 (STORK-DUKE)

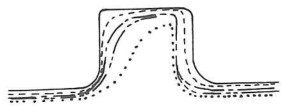


Bild 10. Verschleißverlauf des Gewindes des Segments 4 (STORK-DUKE)

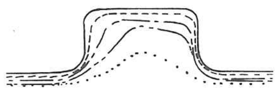


Bild 11. Verschleißverlauf des Gewindes des Segments 5a (STORK-DUKE)

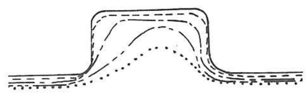


Bild 12. Verschleißverlauf des Gewindes des Segments 5b (STORK-DUKE)

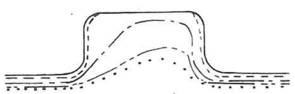


Bild 13. Verschleißverlauf des Gewindes des Segments 5c (STORK-DUKE)

Tafel 4. Gewindequerschnittabnahme der Segmente STORK-DUKE /%/

Segment Nr.	Betriebsstunden				
	0	86	242	508	657
3	100	95,4	87,7	84,8	83,4
4	100	89,0	70,5	60,2	36,3
5a	100	84,8	67,0	47,4	10,1
5b	100	90,6	75,7	43,8	19,1
5c	100	95,6	62,7	18,8	7,7

Graphische Darstellung der Werte aus der Tafel 4 zeigt Bild 14.

3. AUSWERTUNG DER EXPERIMENTE

Die Verschleißgeschwindigkeit wird bedeutend durch Rohwarenzusammensetzung beeinflußt (Tierkörper, Konfiskate, Knochen, Schlachtabfälle usw.). Die Assanationsanstalten müssem

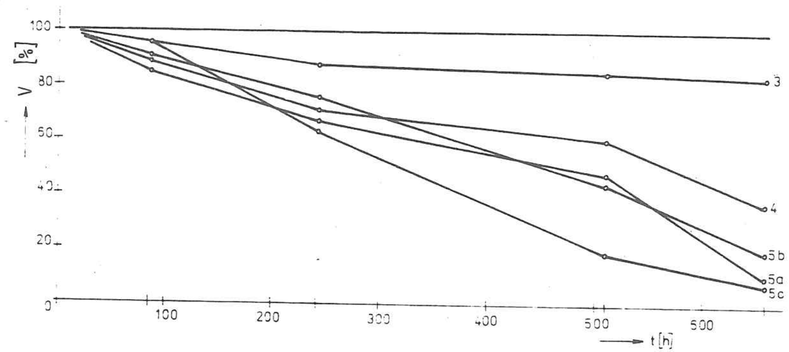


Bild 14. Verhältnis des Gewindequerschnittes zum Querschnitt des neuen Gewinde (V) in Abhängigkeit von den Betriebsstunden (t)

diese Rohwaren im kurzen Zeitraum verarbeiten und die Rohwaren kann man nicht aufbewahren. Daraus folgt, daß Beeinflussung der Lebensdauer durch Regulierung der Rohwarenzusammensetzung nicht möglich ist.

Weiteres Problem ist die Lebensdauerbeurteilung der von uns geprüften Segmenten. Literaturangaben sind sehr verschieden, was wahrscheinlich durch oben angeführte Rohwarenzusammensetzung verursacht wird. Nach der Angaben der Arbeiter in Žichlínek bei Benutzung von aufgeschweißten Segmenten wurde die Lebensdauer von etwa 300 bis 360 Betriebsstunden erreicht. Etwas höhere Angaben führt die Arbeit von VETAS Dobřejovice an, und zwar 516 Betriebsstunden. Die Arbeit macht aber aufmerksam auf die Probleme der Auftragsschweißungsqualität, Formänderungen und Rißbildung. Die Lebensdauerangaben der Assanierungsanstalten in der Slowakei sind bis 1253,6 Betriebsstunden, was sich als nicht real zeigt.

3.1 Auswertung der Experimente für die Schneckenpresse TMS

Die Lebensdauer der Segmente war 550 Betriebsstunden. Bei dem Vergleich ist es klar, daß die von uns geprüfte Schneckensegmente aus Gußstahl hoher Festigkeit gleiche oder höhere Lebensdauer aufwiesen als die aufgeschweißten Segmente. Es wurden dabei nach 550 Stunden nur Segmente 4, 5a, 5b und 5c ausgetauscht, weitere Segmente blieben im Betrieb.

3.2 Auswertung der Experimente für die Schneckenpresse STORK-DUKE

Die Lebensdauer der Segmente war 657 Betriebsstunden. Es wurden dabei, ähnlich wie bei der Schneckenpresse TMS, nur die Segmente 4, 5a, 5b und 5c ausgetauscht, weitere Segmente blieben im Betrieb.

Der markante Beitrag bei Benützung der gegossenen Segmente ist die Möglichkeit die abgenutzten Segmente als Rohstoff für die Herstellung neuer Segmente zu benutzen. Das könnte nicht nur Materialersparnis bringen, sondern auch die Beseitigung der Schwierigkeiten bei der wiederholter Reparatur durch Aufschweißung. Erfahrungsmäßig kann man die Aufschweißung auf dieselbe Oberfläche höchstens dreimal wiederholen. Weitere Aufschweißung ist mit Rücksicht auf große Formänderungen der inneren Bohrung und der Nabennut nicht mehr möglich.

4. SCHLUßBEMERKUNGEN

Man kann feststellen, daß die Betriebsprüfungen neuer Segmente, die aus Gußstählen hoher Festigkeit Typ VP7, VPH und VPH EXTRA hergestellt wurden, manche neue positive Erkenntnisse gebracht haben.

1. Lebensdauer der abgegossenen Segmente ist vergleichbar oder höher als der durch Aufschweißung reparierten.
2. Im Falle der Serienfertigung würde es zur Materialersparnis kommen durch Ausnützung der abgenutzten Teile als Rohstoff.
3. Lebensdauer der Schneckensegmente aus Gußstahl könnte durch Erhöhung der Härte gesteigert werden.
4. Durch Ausnützung der abgegossenen Segmente für die Schneckenpresse STORK-DUKE könnte ihr Mangel in Assanierungsanstalten beseitigt werden /2/.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

TECHNOLOGICAL VALUE OF SUGAR BEET

(Polarimetric Determination of Sucrose)

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The article deals with replacement of toxic lead clarification agents which are polluting waters and streams with another less toxic aluminium agents. A method of using HPLC for carbohydrates analysis is also briefly mentioned.

water pollution; clarification; lead replacement; aluminium clarification agents; polarimetric determination

Sugar beet is the basic raw material for sucrose production. The beet is evaluated according to its technological value. The value is determined by the ratio of the amount of sugar content in the beet to the amount of sugar that can be obtained when the beet is processed. Among of the main technological quality indicators are the content of sucrose in the beet, the content of ash, Na, K, α-amino N, invert sugar and others.

The content of sucrose is determined by polarization. The polarization is an optical method based on substances abilities to turn the level of polarised light. For that method of determination, it is necessary to obtain a clear extract from the beet from which optically active substances, with the exception of the sucrose, have been removed. An accessible method of obtaining the clear extract is to clarify the prior-to-filtration solution by addition of a relevant salt and then separate the precipitate by filtration.

In Czechoslovakia so far lead acetate and other lead salts have been widely used for clarification of solutions for the purposes of polarimetric determination of the sucrose content in the beet. Laboratory sludges containing lead substances are not treated and they are discharged into waste water. In the course of one sugar campaigne about 0,7 kg of lead may be discharged into waste water as a result of beet analyses by one sugar factory. Czechoslovak norm (ČSN) no. 75 7111 on Potable water states that the maximum permitted concentration of lead in potable water sources is 0,05 $mg.l^{-1}$. Based on that it is clear that the above-mentioned amount of lead might pollute up to 14 M liters of potable water sources water. With respect to high toxicity of lead, it would be useful to replace lead salts with other nontoxic substances, or at least with less toxic substances than lead is.

Based on the recommendations by ICUMSA /1, 2/, an organization active in the field of sugar analysis, we have verified the solution $Al_2(SO_4)_3.18\ H_2O$, $AlCl_3.6\ H_2O$ for the purpose of solution clarification for the determination of the content of the sucrose in the beet. Further on, we have tested whether the powder agent (Baddley Chemicals, Inc. Baton Rouge , LA, USA) may be used for the above-mentioned clarification. The agent comprises of $Al_2Cl(OH)_5$, $Ca(OH)_2$ and flocculant RM 10-NKT (American Colloid Comp.) mixed in the ratio 10:1:2 /3/.

We have found out that the polarisation results of clarification by compounds on the Al^{3+} salts base are in average by 0,05 % lower than with lead acetate.

With the above-described polarimetric method, all optically active substances that turn the level of the polarised light are determined in the result. In order to eliminate that, methods of sucrose determining based on a different principle are searched for. One of such methods is high pressure liquid chromatography (HPLC). The advantage of this method is that in one analysis contents of sucrose, glucose, fructose, raffinose can be determined as well as a content of betain (N-substance). This methods reproducibility is 1,5 %. The HPLC way of determination

is fit to replace classical empirical methods of invert determination in the sugar making industry.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

CHOICE OF MATERIAL FOR WIRES IN HOP GARDENS

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The text refers about choice of material and construction study of steel wire in hop-frama. In addition to the most spread soft steel, such as low carbon steel under Czechoslovak standard 11 343, there were tested elements made from wire hope. Corrosion effect decreases useful section, strength and plasticity of wires of soft steel. At the recent time there started experiments with low alloy steel Atmofix, which is similar to steel Corten. In this case is supposed from layer of patina, which protects then the steel against further corrosion.

atmospheric corrosion; hop-frame; strain hardening of steel wire.

1. EINLEITUNG

Die Beschädigung der Hopfengartenkonstruktionen von ungünstigen Naturerscheinungen (besonders mittels dem Sturmwind) verlangte sich komplexe wissenschaftliche Prüfen der Belastung der Hopfengartenkonstruktion im Bezug zur Dimensionierung einzelnes Elementes. Die Ausnutzung der Ergebnisse unserer Prüfungen trägt zum Erhöhung der Zuverlässigkeit der Hopfengartenkonstruktionen bei und es könnte die Verluste bei den Fällen der Hopfengartenkonstruktionen erniedrigen.

Die Hopfengartenkonstruktion wird einem Grundsystem der Längst- und Querverbindung geschafft, welches die Beetdrähte trägt /3/. Das Deckensystem der Hopfengartenkonstruktion wird mit den inneren und äusseren Säulen unterstütz und am Rand wird mit dem Ankersystem in den Boden befestigt. Das Deckensystem der Hopfengartenkonstruktion schaffen die Fadenelemente, die die Belastung vorallem ihrer Tragfähigkeit im Zug übertragen.

Als die Fadenelemente brauchen man am meisten gezogene und glühene Drähte aus dem Stahl 11 343 (entspricht DIN 17 100-80) nach den tschechoslowakischen Normen ČSN 41 1343 und 42 6410. Für das Deckensystem werden die Drähte mit einem Durchmesser von 5 bis 12,5 mm benutzt.

Für die Fadenelemente können auch Materiale mit hoher Festigkeit benutzten sein. Es wurde eine Hopfengartenkonstruktion

mit den Stahlseile diesen Parametr gebaut /2/:

- das einlitzele Seil (1 + 6) mit dem Durchmesser 7,1 mm ČSN 02 4310
- das einlitzele Seil (1 + 6 + 12) mit dem Durchmesser 15 mm ČSN 02 4311
- der Nominalwert der Festigkeit 1 270 MPa.

An den Seilenden sind die Augen geschafft, welche mit den Bleichertklemmen sichergestellt wurden. Es wurden die Seile aus den verzinkten Drähte benutzt. Die Hopfengartenkonstruktion aus der Seile wird schon 11 Jahre benutzt und Elemente aus der Stahlseile sind entsprechend. Die Benutzung des Materials mit hoher Festigkeit führt zur Erniedrigung die Stofflichkeit, aber es bringt zur komplizierten Weise der Festigung des Fadenelementes.

2. DIE METHODIK DER PRÜFUNGEN DER STAHLDRÄHTE

Das Ziel unseres Arbeits war erkennen, wie sich die Eigenschaften der Drähte aus Stahl 11 343 im Lauf der Lebensdauer verändert. Bei dem Muster haben wir festgestellt:

- korrosionsbedingte Verluste
- die Stärke an der Fliess- und Festigkeitsgrenze
- die plastische Eigenschaften des Drahtes (Formbarkeit und relative Verlängerung).

Die korrosionsbedingte Verluste wurden wie Veränderung der Länge oder die Gewichtsverluste auf der Flächeneinheit angegeben. Bei den Drähten des Ringquerschnittes ist passend Ausdruck des Korrosionsverlauf durch dem Tragquerschnitt des Drahtes. Die einfache und genaue Methode ist die Ermittlung die korrosionsbedingte Verluste durch dem Wägen. Die Muster der Drähte etwa 100 mm lang wurden von den Rost durch Beizmittel befreiet und nach dem Wägen konnte es den mittleren Durchmesser des Drahtes rechnen.

Für den Vergleich haben wir die Methode der Auswertung der Längs- und Querschnitte benutzt. Diese Methode stellt die Fläche des Tragquerschnitts fest und gleichzeitig ermittelt man auch die Ungleichmässigkeit des Korrosionsverlaufes.

Bei der Zugprüfung nach ČSN 42 0310 bestimmt man:

- die Kraft an der Bruchgrenze F_m
- die Kraft an der Fliessgrenze F_e
- Formbarkeit A
- relative Verlängerung B.

Die Formbarkeit A und relative Veränderung B rechnet man nach die Formel:

$$A\ (B) = \frac{L_r - L_o}{L_o} \cdot 100 \qquad [\%]$$

L_r .... die Länge bezeichnetes Prüfabschnittes nach der Prüfung

L_o .... die Länge bezeichnetes Prüfabschnittes vor der Prüfung.

Der Unterschied zwieschen der Formbarkeit und der relative Verlängerung ist im Prüfabschnitt. Die Formbarkeit bewertet die Umgebund des Platzes, in dem zum Bruch des Musters kommt. Die relative Verlängerung wertet die Abschnitte ausser des Bereiches des Bruchpunktes. Die Formbarkeit wurde auf die Länge 5 D (5-mal Durchmesser des Drahtes) ermittelt. Die relative Verlängerung wurde auf die Prüfabschnitte der Länge vor der Prüfung 25 mm ermittelt.

3. VERSUCHSERGEBNISSE

In Tab.1 werden die Werte der korrosionsbedingte Verluste beim Draht des Durchmessers 5 mm eingeführt /1/. Die Tabelle 1 führt gerechneter Durchmesser des Drahtes auf den Grund der Wägen an und vergleicht auch diese Werte mit den Werten aus der Längst- und Querschnittemethode. Tabelle 2 führt die Ergebnisse der Zugprüfung der Drähte mit dem Durchmesser 5 mm. Auf dem Bild 1 wird Korrosionsverlauf in der Abhängigkeit auf das Gebrauchszeit der Drähte. Der volle Strich verbindet die Werte korrosionsbedingte Verluste mit der Wägen ermitteln. Mit dem öfters unterbrochenen Strich werden die Werte mit der Längsschnittemethode ermittelt verbindet. Der punktierte Strich verbindet die Werte mit der Querschnittemethode ermittelt. Diese Striche bezeichnen die obere und untere Grenze.

Tab.1 Die korrosionsbedingte Verluste der Drähte mit dem Durchmesser 5 mm

Gebrauchszeit der Drähte [Jahr]	Die korrosionsbedingte Verluste (an Halbmesser) [mm]				
	ermittelt durch Wägen	ermittelt Querschnittemethode		ermittelt Längsschnittemethode	
		arithmetis. Mittel	Grenzeintervall	arithmetis. Mittel	Grenzeinterval
7	0,27	0,24	0,05-0,45	0,16	0,05-0,30
12	0,39	0,39	0,15-0,60	0,34	0,20-0,55
18	0,67	0,63	0,35-0,85	0,66	0,45-0,75

Tab.2 Die Ergebnisse der Zugprüfung der Drähte mit dem Durchmesser 5 mm

Gebrauchszeit der Drähte [Jahr]	Kraft an der Bruchgrenze $\bar{F}_m$ [N]	Kraft an der Fliessgrenze $\bar{F}_e$ [N]	Formbarkeit 5_D $\bar{A}$ [%]	relative Verlängerung $\bar{B}$ [%]
0	6 087	3 650	51,6	27,4
7	5 270	3 917	30,1	11,2
12	4 520	3 077	32,6	12,8
18	3 400	2 650	28,3	10,7

4. DIE DISKUSSION

Bild 1 zeigt fast linear Korrosionsverlauf. Tab.3 und Bild 2 vergleichen die Verringerung des Tragquerschnittes mit dem Sinken die Kraft an der Bruchgrenze. In ganzen Bereich sinkt der Festigkeit des Drahtes weniger als der Tragquerschnitt des Drahtes. Während des Benutzungszeites kommt zur Verfestigung der Drähte und zum Sinken der plastischen Eigenschaften (Formbarkeit und relative Verlängerung,Tab.2). Die Kraft an der Fliessgrenze sinkt weniger als die Kraft an der Bruchgrenze (Bild 3), es bedeutet die Verkleinerung des Bereichs der Materialumformung im Zugprüfungdiagram. Auch bei Beanspruchung, welche die Fliessgrenze nicht überschreit, kommt es zur Verfestigung der Drähte.

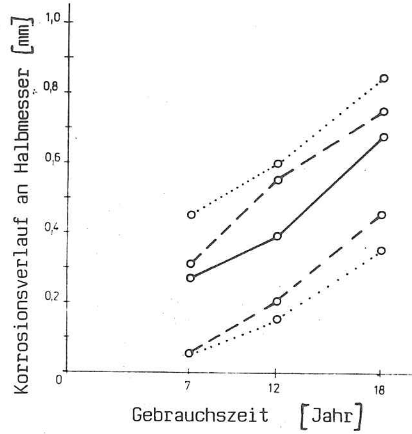

Bild 1 Korrosionsverlauf des Beetdrahtes mit Durchmesser 5 mm

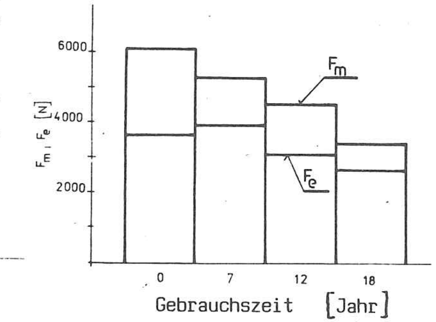

Bild 3 Verlauf der Kräfte an der Bruchgrenze (F_m) und Fliessgrenze (F_e)

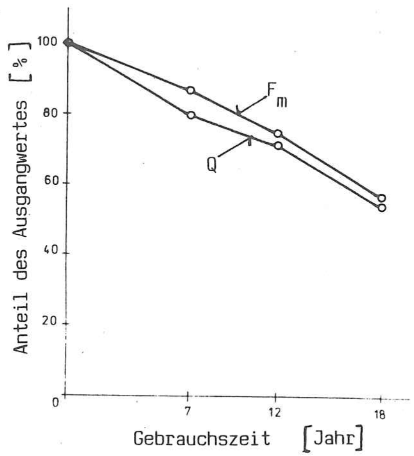

Bild 2 Vergleich der Verringerung des Tragqeurschnittes (Q) mit dem Sinken der Kraft an der Bruchgrenze (F_m)

Tab.3 Verringerung des Tragquerschnittes und Sinken die Festigkeit des Drahtes

Gebrauchs-zeit der Drähte [Jahr]	Durchmesser des Drahtes [mm]	Tragquerschnitt		Kraft an der Bruchgrenze	
		Fläche [mm^2]	Anteil des Ausgangwertes [%]	F_m [N]	Anteil des Ausgangwertes [%]
0	5,00	19,64	100,0	6 087	100,0
7	4,46	15,62	79,5	5 270	86,6
12	4,22	13,99	71,2	4 520	74,3
18	3,66	10,52	53,6	3 400	55,9

5. SCHLUSSBEMERKUNG

Durch dem Auswertung der Hopfengartenkonstruktionsdrähte nach Benutzungzeit 7; 12 und 18 Jahre wurde die korrosinsbedingte Verluste und Veränderung der Festungs- und Plastischeeigenschaften festgestellt. Die korrosionsbedingte Verluste ausweisen fast linear Verlauf mit durchschnittlichem Verlust 0,035 mm pro Jahr und es bedeuted die Verkleinerung des Drahtdurchmessers um 1,4 mm nach 20 Jahren.

Bei dem Kräften an der Fliessgrenze und an der Bruchgrenze kommt es zum Sinken, welcher kleiner ist, wie die Verringerung des Tragquerschnittes. Bei den Drähten kommt es zur Verfestigung und gleichzeitig zum Sinken der plastischen Eigeinschaften.

Die korrosionsbedingte Verluste kann man mit der Benutzung des Stahles ATMOFIX bedeutend vermindert sein. Die Drähte aus ATMOFIX werden jetzt auf der experimentalen Hopfengartenkonstruktion geprüft.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

THE COUNTER-ROTATING PK 700 CUTTER BAR WITH CAM DRIVE

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The principle of a cam drive mowing machine with counter-rotating scythes and its testing in a functional model of PK 700 cutter bar is introduced in the study. Solving of basic construction units together with results reached during testing at work is described.

Key words: mowing machine, counter-rotating scythe cam drive, scythes knife

INTRODUCTION

The first testing of the functional model of the PK 700 counter-rotating cutter bar with the new type of scythe drive was introduced in the year 1991 /1/. The driving mechanism consisted of two cams, mutually turned through an angle of 90° Both scythes were provided on one end with rotating rollers, which were pressed to the cams with two springs. The lifting of each scythe was done by the cam and two springs. The scythe was driven with the cam and the back motion was evoked with the force from loaded springs. The scheme of the drive is demonstrated in Fig. 1.

MATERIAL AND METHODS

The functional model of the machine with the PK 700 designation for verifying the cam drive function of counter--rotating scythes was designed and subsequently produced. The mowing machine consisted of two basic parts: cutter bar and mobile mechanism with the motor.

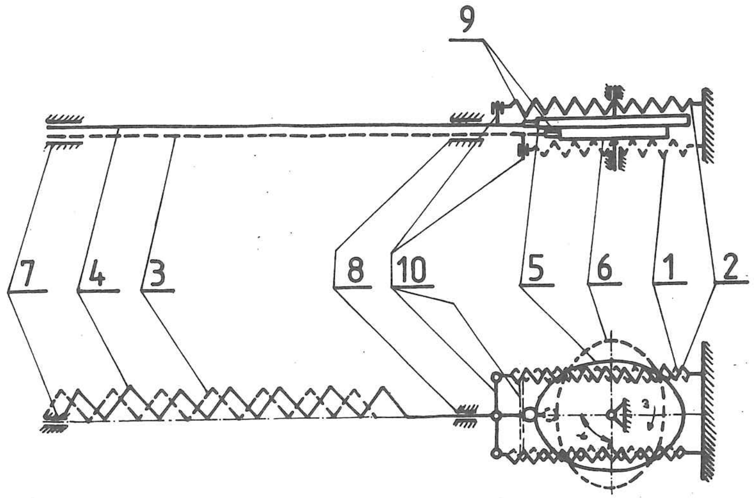

FIG.1: Scheme of cutter-bar drive
1,2 - stretched spring - 3,4 - scythes, 5,6 - cams
7,8 - lines, 9 - rollers - 10 -arms

CUTTER BAR

The engagement of the cutter bar was designated at 700 mm. Two types of sickle knives with 50.8 mm pitch were used for scythes production. The knives of the upper scythe had smooth cutting edge and the knives of the lower scythe had knurl cutting edge. The mounting of both scythes is illustrated in Fig. 2. The knives of both scythes were riveted on beams 3 and 4. Beam 4 was of rectangle profile and beam 3 of L shaped profile. Both scythes were bedded in the slot of frame 6. To decrease the value of passive resistance, the slot of frame 6 was filled with a sliding layer of Gamapest material in the point of connection with the scythes beams. The position of both scythes was secured with holder 5. The holder construction was according to /3/.

Both scythes were provided with a rotating roller with a pin on one end, and they were secured with a safety ring. Permanent connection of the roler with the cam was performed by the cylinder springs attached to the scythes´arms.

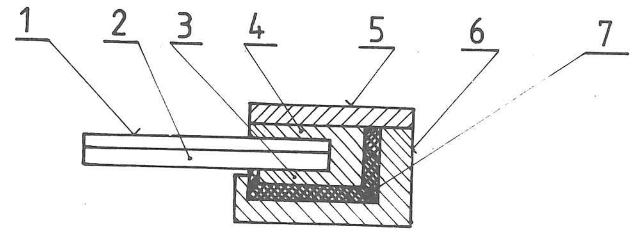

FIG. 2. Simplified transversal cut through the cutter bar
1,2 - scythe knives - 3,4 - scythes beams - 5 holder -
6 - frame,- 7 sliding layer

The springs´dimension and the shape of the cam were designed on the basis of the dynamic model of cam mechanism solved by analogous computer /4/.

MOBILE MECHANISM

The bar beam and mobile mechanism from the LB 70 mowing grass machine were used in testing the proposed cutter-bar with counter-rotating scythes, The original frontal cutter bar together with the pulley and wheel were disassembled from the LB 70 machine. The new cutter bar was fastened laterally by the holder to the beam with a few screws.The completed mechanism is demonstrated in Fig.3.

Transmission of mechanical energy from the motor to the pulley of cam shaft of scythes drive was solved with the belt drive, The applied double-cylinder type of petrol motor with power output $P = 2$ kW at crankshaft movement $n = 2\ 500\ min^{-1}$ proved suitable for this purpose.

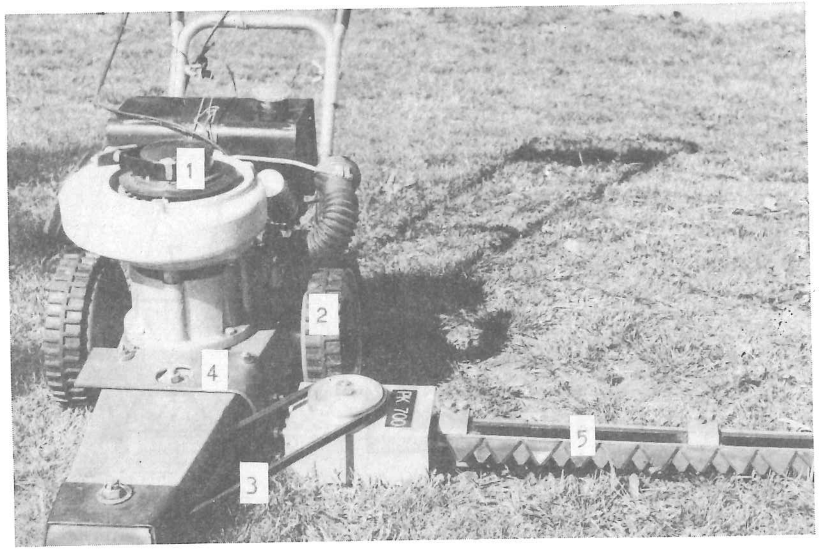

FIG.3 PK 700 cutter machine
1 - motor, - 2 - mobile mechanism, - 3. - belt drive,- 4 - holder, - 5 - cutter bar

RESULTS

The testing was carried out by the author in Pardubice and Nymburk in June 1991. Garden grass and lucerne were cut.

Imperfections were not found in the quality of the cut mass, and no uncut growth appeared. The cutter bar worked without noise and transmission of vibration on the operator, what was observed, e.g., in mowing machine LB 70.

The possibility of penetration by foreign solid objects in the cutter-bar engagement was examined. The object was caught between the knives of the scythes and then the scythes moved together. In this case the cutting mechanism did not work and it was necessary to remove the foreign object from the engagement of the scythes. It is significant that the moving mechanism remained undamaged, and it was not necessary to further protect the mechanism from cutter bar damage.

CONCLUSIONS

Development, constructions, and production of the PK 700 functional model was carried out at the Department of Technical Subjects, Faculty of Education, Hradec Králové. The results obtained in testing and in terrain show the working ability and reability of the device as well as the possibility of its application to agricultural practices in the future.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

THE COEFFICIENT OF SHEARING FRICTION OF WHEAT AT SHEAR AGAINST WERKSTOFF "S" AND MURLUBRIC MATERIALS

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SUMMARY

The results of measuring of wheat shearing friction coefficient at the shear on sliding plates, produced from Werkstoff "S" and Murlubric materials are introduced together with the description of employed testing apparatus. The shearing friction coefficient for the materials consisted of: a steel plate, spruce wood, polypropylene, and plexiglass are given for comparison.

Key words: tribometer, friction properties, coefficient of shearing friction, wheat, Werkstoff "S", Murlubric

INTRODUCTION

With current construction and development of agricultural machines one cannot avoid searching for new constructional materials. Plastic materials belong to such materials. Their application is conditioned not only by the laboratory testing but also by working conditions in agricultural pratice. The testing of constructional materials from the Murdfeldt Kunststoffe with commerce specification Werkstoff "S" and Murlubric started at the Department of Technical Subjects, Faculty of Education, Hradec Králové, in the year 1990. It is the case that materials based in plastics that have very good shearing properties have no need of lubricant application. The materials exel in their high resistance to wear and at the same time in their ability to decrease noise.

The testing was carried out in the research framework of shearing traffic systems which were determined for after-crop treatment of grains.

FIG.1: The detail of the working part of the tribometer
1. testing body - 2. sliding plate - 3. tensometric sensor - 4. tensometric apparatus

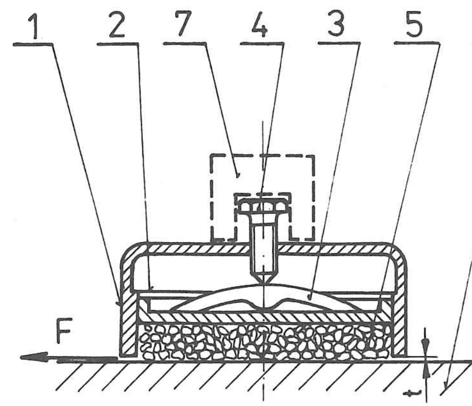

FIG.2: Testing body - 1. body of the cylinder - 2.pressure cylinder. - 3. pressure rosebit - 4. screw - 5.grains (loose material) - 6. sliding plate - 7. weight

MATERIAL AND METHODS

Experimental apparatus - the tribometer /1/ was used for testing, which allows feed movement of the testing body. The tribometer is demonstrated in Fig.1. The force of friction arising in the contact point of grains and sliding plate is registered with the tensometric sensor / 2 /. The electric signal from the tensometers connected into the Wheatstone bridge is monitored with the tensometric apparatus M 1000(4). The apparatus is completed with coordinate recorder BAK 4Tk.

The tribometer makes possible the change of shearing speed from 0 to 0.1 m.s^{-1} and the change in the load of the testing body with grain material.

The grain material is fixed in testing body /3/, whose diagram is given in Fig. 2.

The coefficient of shearing friction can be calculated from the relation

$$f = \frac{F_t}{F_N} \qquad (1)$$

where f = coefficient of shearing friction of the pair material (1)

F_N = loading of grain material (N)

F_t = friction resistance (N)

CHARACTERICTICS OF MATERIALS

Loose material (grain)

Winter wheat from the storehouse in Dobřenice, district of Hradec Králové, was used as testing material. The wheat sample was taken directly from dumping from a transporter. Wheat moisture was taken with the Feutron moisture-meter before measuring and represented 14.1 %.

Grain sample loading was determined by the calculation of the working condition of transport. Maximum value was F_n = 0.15 N.

Value of friction speed of the testing body was chosen as V=0.1 m.s-1

Sliding plates

Werkstoff "S" and Murlubric materials were obtained from the firm Murtfeldt KUNSTSTOFFE.

These materials show excellent sliding properties with negligible wear. They can bear a rather large mechanial load and are corrosion resistant. The firm delivers them for the market in the shape of plates, rods, or other products done according to the customer's detail drawing /4/. These materials have been implemented in mechanical engineering in our country, especially with regard to the slide of the steel parts on sliding lines, e.g., lines in chain tensioning, sliding plates in food industry automats, etc.

winter wheat - sliding plate
moisture V_v = 14.1 %, loading F_N = 0.15 N, shearing speed v = 0.1 m . s^{-1}
number of measurements n = 7

material of sliding plate	mean value f (1)	standard deviation	range f for the reliability p = 95 %
unpolished steel plate	0.260	0.008	0.253 - 0.266
polished steel plate	0.336	0.024	0.314 - 0.357
plexiglass	0.343	0.009	0.324 - 0.352
polypropylene	0.275	0.012	0.264 - 0.286
spruce wood	0.246	0.012	0.235 - 0.256
Werkstoff "S"	0.205	0.009	0.195 - 0.215
Murlubric	0.209	0.006	0.200 - 0.214

TAB. I

The sliding plates were produced in 350 mm x 170 mm x 10 mm dimensions.

The sliding properties of some construction materials used in the production of agricultural machines were compared with the properties of Werkstoff "S" and Murlubric materials. The following materials were chosen: unpolished steel plate (R_a = 3.6 μm), polished steel plate (R_a = 1.8 μm), spruce wood (10 % of moisture), plexiglass, polypropylene. The dimensions of the sliding plates (length and width) were the same for each material, the only difference being in thickness.

RESULTS

Statistically evaluated results of measured values from testing are given in Tab. I. Werkstoff "S" shows the lowest value of shearing friction coefficient from all the tested materials used for sliding plates. No jerking motion appeared in the movement of tested sample: on the contrary, movement was smooth. The remaining sliding plates were placed, from the point of the lowest value of the coefficient of shearing friction, as folows: spruce wood (shearing on growth rings), unpolished steel plate, polypropylene, polished steel plate, and plexiglass.

CONCLUSIONS

The results obtained from the testing of Werkstoff "S" and Murlubric sliding materials show the possibility of the application of those materials in agricultural practice. The most favourable property can be utilized effectively for the transport and manipulation of agricultural material.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

THE INVESTIGATION OF LIQUID FERTILIZER DOSAGE DURING IRRIGATION

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SUMMARY

This paper analizes the modern precise dosing units of liquid fertilizers of various constructions. The piston dosing units prevail and then the rotary and diaphragm dosing units designed in technically developed countries of the world. For better understanding of dosing units operation principles, their longitudinal sections are enclosed to this text, in particular of piston dosing units. Their basic technical data are given in tables. There are four figures and three tables in the text.

Key words: dosing unit of liquid fertilizer, irrigation device.

INTRODUCTION

For fast growing and higher yield the plants are to be top dressed several times during vegetation. The precise dosing units of various types are designed for the correct dosing of very expensive liquid fertilizers and fertilizers soluble in water. They can be divided into several groups. The most common are the piston dosing units and then the rotary and diaphragm dosing units. Some dosing units use the energy of water for their operation. Among them are known the dosing units such as: Dosatron, Promix, TMB, Diluma, Pluidor and others. However, there are some dosing units which use the electric energy for their operation such as: Dosapro, Lesaint, Baggaley, Spid injector, Cetodil and others.

Due to the limited space only the most common dosing units in the practice will be analized in this paper:

- piston dosing unit - Dosatron International
- rotary dosing unit - Promix
- diaphragm dosing unit - TMB (Israel)

PISTON DOSING UNIT - DOSATRON INTERNATIONAL

Fig.1 shows the longitudinal section of Dosatron dosing unit (France). The volumetric piston pump (2) is driven by the piston hydraulic motor, the upper and lower surface of which are alternatively connected to the inlet and outlet of water under pressure. Water acts on four-way valve and piston. The valve is connected to the spring-loaded balance which, under the water pressure, switches over by itself from one position into the other, by means of two piston rod collars. Thus the hydraulic motor under the liquid pressure achieves the alternate movement which corresponds to 5 litre water flow. The pump for dosing of fertilizer, under water pressure, sucks and allows the required volume of solution to get into the outlet pipe (4). The concentration of solution, or percentagewise portion of solution, is regulated by the decrease or the increase of the active path of the measuring valve by means of screw (7).

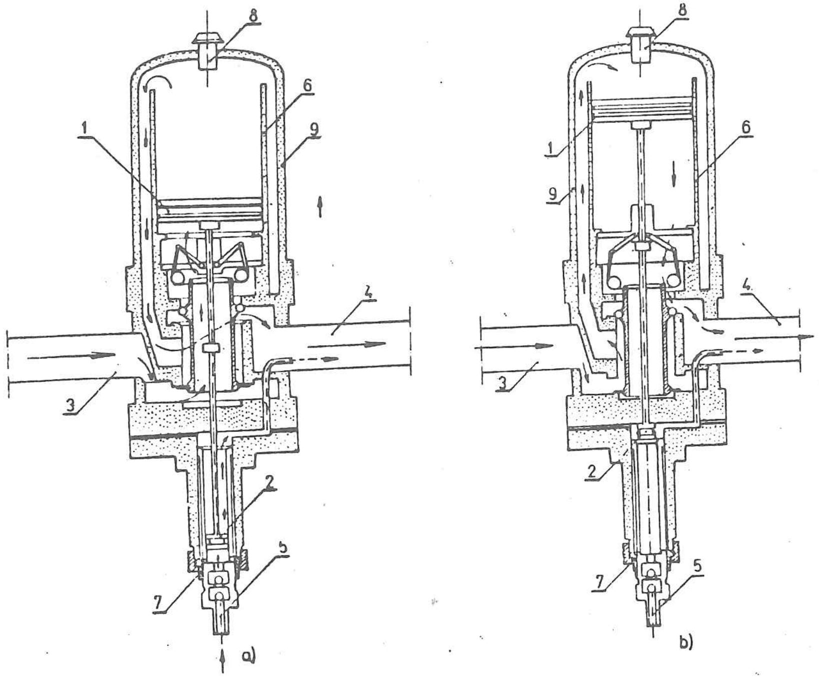

Fig.1. Longitudinal section of dosing unit-Dosatron International (France):
a-upward movement of hydraulic motor piston; b-downward movement of piston; 1- engine piston; 2- pump piston; 3 and 4- water and fertilizer inlet and outlet; 5- inlet of fertilizer solution; 6- cylinder; 7- regulating screw; 8- by-pass ; 9- dosing unit housing

For the correct operation of the dosing unit, it is necessary to install the strainer filter into the pipe through which the liquid is supplied. Also in front of the dosing unit it is necessary to install the air bell, when water impacts appear during the flow of the liquid. From time to time during operation, the dosing unit is to be cleaned from the inner side from the impurities and sedimented scale. The data on the dosing unit are shown in table 1. Fig. 2 shows the possible ways of connecting the dosing unit to the pipeline.

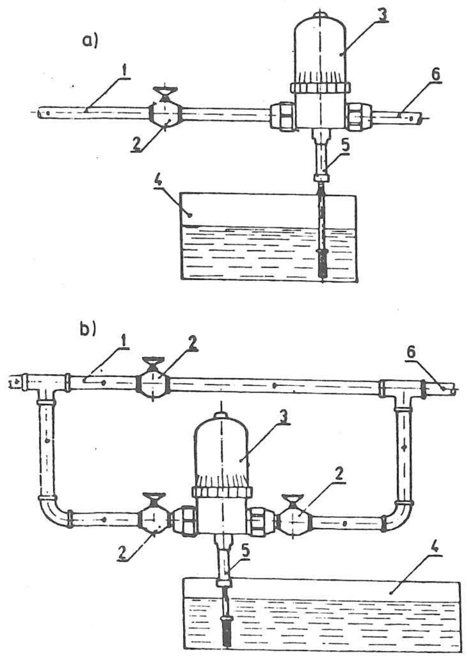

Fig. 2

Possible ways of Dosatron - dosing unit installation:

a-directly to spray boom

b-to pipeline secondary branch

1 and 6- main pipeline;
2 - valves;
3 - dosing unit;
4 - fertilizer tank;
5 - dosing unit suction pipe

Technical data on dosing unit DOSATRON INTERNATIONAL (France) 1)2)3)

TAB. 1

Achieved flow	20 m³/h;	Max pressure	10 b;
Pressure loss 0,43 b. at	20 m³/h;	Min. pressure	0,12 b;
0,21 b. at	12 m³/h;	Regulation of dosing	0,2%-2,0%;
Engine piston dia.	220 mm;	Pump piston stroke	280 mm;
Engine piston stroke	540 mm;	Weight of dosing unit	18 kg;
Water pipe dia.	51 mm;	Fertilizer pipe dia.	19 mm;

1- without electric energy
2- dosing of all kinds of water solutions possible
3- the same company manufactures the dosing units of the following flows: 3m³/h, 6 m³/h and 8 m³/h.

ROTARY DOSING UNIT - PROMIX

Fig.3 shows the principle of operation of the rotary dosing unit - Promix (France) and the table 2 shows the technical data.

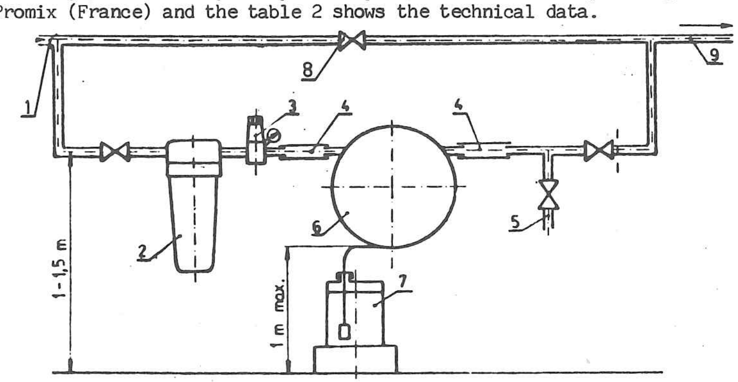

Fig.3 Scheme of operation of the rotary dosing unit Promix:

1- water supply; 2- filter; 3- pressure reducer; 4- pipe; 5 and 8- valves; 6- dosing unit; 7- fertilizer; 9 - to spray boom

Technical data on rotary dosing unit PROMIX (France) 1)2)3)4) TAB.2

Min. water flow	30 l/h;	Max. water flow	1500 l/h;
Min. pressure	1 b;	Max. water pressure	5 b;
Min. dosing	0,5-0,78%;	Max. dosing	1-2 %;

Dosing unit dimensions: length 228 cm; height 190 cm; width 123 cm;

1- dosing is proportional to rotation;
2- water energy drives the dosing unit rotor
3- in addition to adding the fertilizer into water it also serves for adding the other medicaments (vitamins) and for disinfection;
4- precision of dosing depends on flow and pressure variations

DIAPHRAGM DOSING UNIT - TMB (Israel)

TMB dosing unit of liquid fertilizer (or other fluids) with diaphragm enables the flow of 70 m³/h, what classifies it among the large dosing units. It is equipped with diaphragm pump. The concentration of fertilizer in water may be controlled, if required (Fig.4). The dosing unit is driven by the energy of water which passes through the pipeline of the irrigation device and partly through the dosing unit distributor (5) and three-way valve (7). The principle of operation of the dosing unit with diaphragm is shown in Fig.4. The technical data are shown in table 3.

It should be pointed out that in our country are used the fertilizing devices with less precise dosing, mostly in two ways:

- by connecting the pipes with fertilizer to pump suction pipeline
- by connecting the pipes with fertilizer to pump discharge pipeline

For the application of larger quantities (or dosages) of fertilizer by means of the irrigation device it is necessary to use the special tables where the agrotechnical requirements regarding the concentration of fertilizer in relation to the type of crops and quality of soil are correctly indicated.

Technical data on dosing unit - TMB (Israel) TAB. 3

Type	Flow of injection (l/h)	Water pressure (b)	Dimension of connection (mm)	Weight (kg)
WP-10	3-50	1,4-7	13	3,5
WP-60	15-250	1,8-8	19-13	11
WP-150	50-600	2-7	19	24
DP-300	100-1200	2-7	19	23

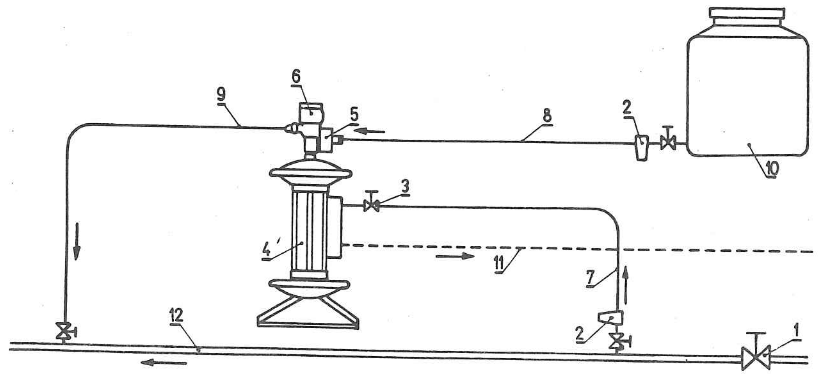

Fig.4. Proportional dosing unit of fertilizer with diaphragm pump. Producer TMB (Israel):

1-valve; 2-filter; 3-valve; 4-dosing unit; 5 and 6 - suction and discharge valve; 7-water supply; 8 and 9- suction and discharge pipe; 10-fertilizer solution; 11-waste water; 12-irrigation pipeline

CONCLUSION

For applying the fertilizer simultaneously with irrigation it is appropriate to use the precise fertilizer dosing units, thus fulfilling the agrotechnical requirements regarding the concentration of fertilizer per measuring unit of surface. For the same purpose our companies started with the serial production of precise dosing units, in particular the piston dosing units.

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TRENDS IN AGRICULTURAL ENGINEERING
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WÄRMEBESTÄNDIGKEIT DER MELKKUHSTÄLLEN

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In the present practice of designers, who are interested in calculation and designing of heating and ventilation systems for animal breading objekts, the charakteristics of individual circuit constructions from the view of nonconstante thermal transmission have been already taken into cosideration. The autor's aim was to complete the calculation methods about aplication which takes into account a stable as a collection of circuit constructions inclusive the biologic load and it's termoregulation. These procedures were verified after that with a calculation of an actual objekt and thev were compared with the measured values.

thermal stability for dairy cows; thermal absorption; fluctuatin of temperatures and heat flow

1. EINFÜHRUNG

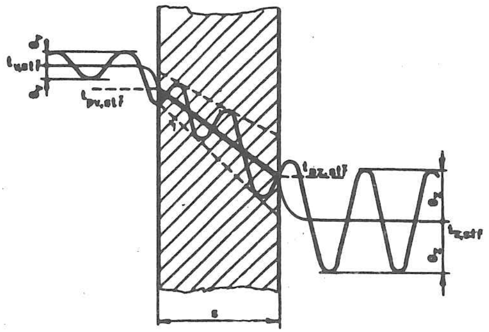
Bei einigen Objekten der Tierproduktion, besonders bei der Einstallung von den jungen Tieren, wird der Einfluß der Außenlufttemperaturschwankung mit der Heizung ausgeglichen. Bei den erwachsenen Tieren wird es meistens nicht beheizt und die wärmetechnische Eigenschaften der Umfangkonstruktionen müssen so konstruiert werden, damit auch bei der Außentemperaturschwankung die entsprechende Stallufttemperatur, Temperatur der Umfangskonstruktionsoberflächen und auch der Amplitudenschwankungswert bei dieser Temperaturen gesiechert wird.

In der bisherigen Praxis der Projektanten ist mit der Heizung und Lüftung in den Objekten für Tierproduktion nur aus Sicht der Temperaturschankungen, nur mit einzelnen Umfangskonstruktionen gerechnet worden. Das Ziel dieser Arbeit /1/ ist, die Ausrechnungsmethoden vorzuschlagen, die mit dem Stall als mit dem Komplex der Umfangskonstruktionen, Lüftung und mit der biologischen Wärmebelastung erwägen.

2. GEWÄHLTE METHODE DER VERARBEITUNG

Der Grund für die Lösung dieser Aufgabe wurde die Verarbeitung der theoretischen Beziehungen der nichtstationären Wärmeübertragung aus der Literatur /2,3/. Diese Berechnungen wurden noch mit den Beziehungen ergenzt, die ermöglichen de Temperaturstand des Stalles inklusive des Einflusses der Rücktemperaturwellen, Lüftungeinflusses und Einflusses der Wärmeausgabeänderung bei den Tieren durch Thermoregulation zu verfolgen.

Die ausgewählte Methode der Temperaturäußerung und deren Änderungen im Zusammenhang mit der Zeit, zeigt anschaulich das Bild, auf welchem die nicht stationäre Wärmebelastung durch Einschichtmauer demonstriert ist.



Die Temperatur- und Wärmeflußwerte, die nach der Methode stationären Wärmebelastung sind als "mittel" bezeichnet (z.B.: $t_{v,st\check{r}}$, $t_{z,st\check{r}}$, $Q_{st\check{r}}$ usw.). Die Amplituden der harmonischen Wärmeschwankung in der Komplexäußerung wurden als $\overline{\theta}$ und die Amplituden der Wärmeflüssen als $\overline{Q}$ bezeichnet. Die Gesamtlufttemperatur, z.B. in dem Stall, kann man mit folgender Gleichung ausdrücken:

$$t_v = t_{v,st\check{r}} + \overline{\theta}_v = t_{v,st\check{r}} + \theta_v \cos\left(360 \frac{\tau}{\tau_o} - \varphi\right)$$

Diese Gleichung gibt uns nicht nur die Übersicht über dem tatsächlichen Wert der gesuchten Temperatur (oder des Wärmeflusses), sondern auch über ihrem Zeitverlauf im verfolgten Interval τ_o (φ bedeutet Phasenvorschub der Amplitude θ_v).

Die resultierende Amplitudenwärmeschwankungswerte im bestimmten Zeitaugenblick wurden durch dem Radiusvektor $\overline{\theta}=A/\underline{\varphi}$, oder mit der Komplexnummer $\overline{\theta}$ = a + bi /K/ ausgedrückt, wobei die zweite Alternative vorteilhafter ist.

3. EXPERIMENTALMESSUNG

Die Benutzungseignung der vorgeschlagenen Ausrechnungsmethoden wurde mit den tatsächlichen Bedinungen des Temperaturstandes bei den zwei Kuhställen bewiesen. Der erste hatte ein traditionelles Außenmauerwerk aus den Vollziegeln und der zweite hate gleich dickes Mauerwerk aus dem Keramzitobeton.

Bei den beiden verfolgten Kuhställen wurden für die Auswertung je 5 Tage mit der größten Außenlufttemperatursenkung in dem kontrolliertem Zeitraum ausgewählt. Es wurden die Verläufe der Außen- und Innenoberflächentemperatur der Umfangskonstruktionen gemessen. Der abgemessene Temperaturverlauf wurde mit dem theoretisch ausgerechneten Temperaturverlauf vergleichen. Auf Grund der theoretischen Ausrechnungen wurde der Verlauf der tatsächlich gemessenen Außenlufttemperatur, der theoretisch ausgedrückt wurde als Gesamtbetrag der Mitteltemperatur und 3 harmonischen Schwankungen im Laufe des verfolgten Zeitraumes.

Die ausgerechneten Temperaturdurchläufe wurden mit den experimental abgemessenen Werten vergleichen. Als Grund der Ausrechnung ist es nötig den normierten Außenlufttemperaturverlauf und seine Schwankamplituden zu nehmen.

4. BEISPIEL DER AUSNUTZUNG DES AUSRECHNUNGSPROZESSES

Der vorgeschlagene Ausrechnungsprozeß wurde weiter für die Festlegung der Dicke der "Ersatzmauer" aus dem leichten Baumaterial bei dem Kuhstall KO - 108 angewendet. Für den Vergleich wurden auch die Ausrechnungsmethoden durchgeführt und zvar nach der Normemethode (die mit der unstationären Wärmebelastung nur bei einzelnen Konstruktionen rechnet) und auch nach der älteren Methode der stationären Wärmeleitung.

5. ERGEBNISSE

In der Arbeit wurde der Komplex der bestehenden Ausrechnungsmethoden der unstationären Wärmebelastung und ihre Lösung durch die Methode der Komplexziffern durchgeführt. Es wurden die Beziehungen für die Ausrechnung der einzelnen Größen festgelegt und wurde ihre Aplikation für die Ausrechnung des Stallobjektes durchgeführt.

Es wurde weiter die Gleichung für die Ausrechnung des Koefizientes der Stallwärmebeständigkeit deduziert. Diese Gleichung erwägt mit dem Einfluß der Stallüftung, mit der Wärmeausgabeschwankung der Tieren und mit dem Stall als Garnitur aller Umfankonstruktionen. Der Koeffizient der Stallwärmebeständigkeit ergibt die Wärmemenge, die für die Temperaturstallluftänderung nötig ist. Der Ausrechnungsprozeß wurde durch Experimentalmessung in 2 objekten überprüft. Die Meßungergebniße haben gezeigt, daß der vorgeschlagene Prozeß für von dem tatsächlichen Temperaturstand in den verfolgten Ställen genug präzis ist.

Auf dem Beispiel der Ausrechnung der Dicke der "Ersatzmauer" wurde der Vorteil der vorgeschlagenen Ausrechnungsmethode für die Praxis nachgewiesen, in diesem Falle durch eine erhebliche Volumensparung des Keramzitobetons.

Die Benützung der vorgeschlagenen Ausrechnungsmethode ermöglicht gleichfalls die genauere Festlegung der erwünschten Leistung der Lüftungs- ev. Heizungsgeräte in den Stall- und anderen Objekten aus den leichten Baumaterialen mit Rücksicht auf die Außenlufttemperaturschwankungen unter den Winterbedingungen und mit Rücksicht auf den Luftaustausch und die Thermoregulation der Tiere.

Es ist nötig, die Ausrechnungsmethoden der unstationären Wärmebelastung, besonders im Zusamenhang mit den Ställenaufbau aus den leichten Umfangkonstruktionen auch auf den Sonnenzeitraum zu aplizieren, was genauer als bisher auch die Wärmeströmeinflüsse von den Sonnenstrahlen nachzurechnen ermöglicht.

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TRENDS IN AGRICULTURAL ENGINEERING
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DIAGNOSTIC CHECK-UP OF THE HYDRAULIC CIRCUIT SERVOCONTROL MECHANISM OF TRACTORS

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The aim of this contribution is a methodical check-up of the technical state of the servocontrol mechanism and its hydraulic circuit tractors. In case of bed performance servocontrol booster the safety of operation is decereased end higher demands are set on operator. Out of the main groups in the circuit it is necessary to check the hydrogenerator and the entire body of the servocontrol booster. Because both groups are of cumbersome accessibility, their direct access is bound with a series of elemental dismantling, therefore a check-up without dismantling is proposed. In case diagnosis of failure repair have to be done. In case diagnosis of failure-free state it is necessary to performe the repair of servocontrol booster.

tractor; technical diagnostic; hydraulic circuit; hydrogenerator; servocontrol booster

1. INTRODUCTION

During the investigation of the selected tractors Zetor 8011 performed adequatly under farming conditions it was discoverad that the hydraulic circuits present the second highest failured component. There are proposed for the technical diagnostics of the hydraulic systemsunits with orientation on their reliability characteristics. The article deals with the hydraulic circuits of the servocontrol steering of the tractor Zetor of the second unified lines with the original booster. In the connection with this hydraulic circuits exist very important questions - operation safety and the work conditions for the tenders.

2. HYDRAULIC CIRCUIT

The hydraulic mechanism of servocontrol is placed in one

block with steering gear, under the radiator on the tractor front axle bracket. The independent hydraulic circuit of servocontrol consist of gear ZC-16 T hydrogenerator, oil tank with coarse sieve, low-pressure gause filter and connecting pipeline. Oil is supplied by the hydrogenerator with the performance of 20 l per min at the engine rated speed. The hydrogenerator is placed in the middle box on the right side and is actuated by the gear drive of the power take-off shaft at the speed of 1000 rpm. The drive cannot be disengaged. At the engine rated speed of 2200 rpm the hydrogenerator speed is 1870 rpm.

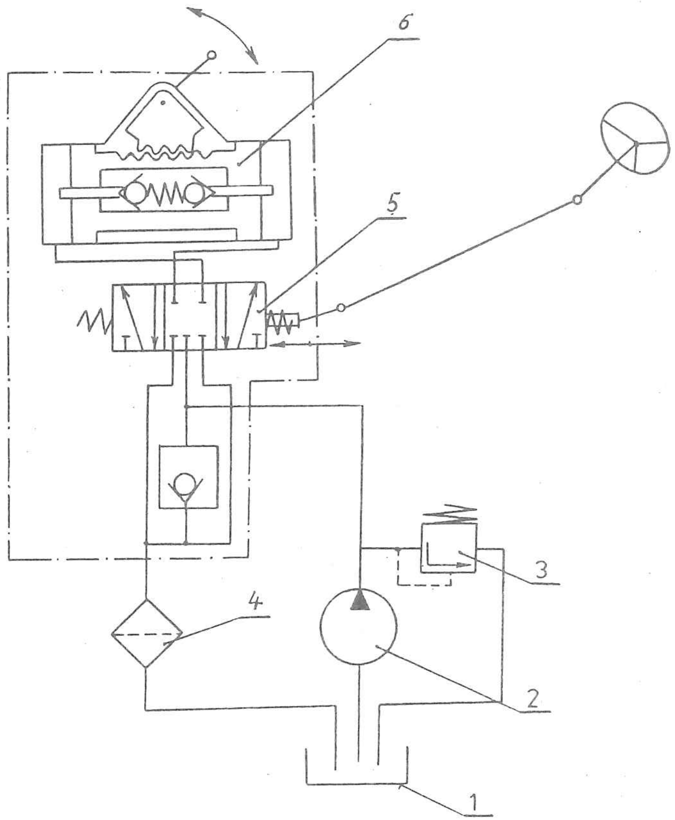
The oil tank of servocontrol circuit is placed on the right side of the engine, its volume is 7 l. In the tank bottom there is a drain plug with magnetic packing. In the upper part of tank there is a filler with vent plug and filling sieve with an oil gauge. In the upper part of tank there is also a safety valve. The low-pressure gauze filter is fitted to the front wall of oil tank. Hydraulic circuit is presented in Fig.1.

3. REASONS FOR THE APPLICATION OF THE DISMANTLING-FREE DIAGNOSTICS

The both main units of the circuits - the hydrogenerator and the booster body are not easy available. The hydrogenerator, as above mentioned, is placed in the middle box of the tractor, the booster body is placed under the radiator on the fore axle holder. If we want practice the direct check-up of the servocontrol steering, it would be necessary perform the folowing dismantling (and after checking-up assembling again) operations:
- dismantle the hood, weights, radiator and air filter,
- disconnect the tranverse steering rod, take the knuckles out of the steering arm,
- dismantle the left side girder of the toolbar,
- disengage the steering shaft,
- from the servocontrol system diconnect the overflow piping, discharge piping and hydrogenerator piping; then disconnect the piping from the low-pressure gauze filter and from the oil tank,
- take off the clip and piping on the right side of the front bracket,
- dismantle the servocontrol mechanism from the axle bracket, lift it up by levers, disengage from the centring tubes and take it out.

Provided the servocontrol was found trouble-free during the workshop check-up, its assembling is performed and it is necessary to check-up the hydrogenerator. If we were forced to check-up again the function directly, following operations would be necessary:
- screw off the drain plug and discharge oil from the hydraulic circuit,
- disconnect the suction piping and pump piping from the hydrogenerator and oil tank,
- screw off the vent plug from the middle box,
- through a hole in the middle box screw off two bolts fixing the hydrogenerator,
- unfix the hydrogenerator from groowing and take it out of the hole in the middle box.

As the both procedures are laborious, time-consuming and



1. Diagram of the hydraulic circuit servocontrol mechanism of tractors
1 tank, 2 hydrogenerator, 3 safety and control valve, 4 oil filter, 5 distributor, 6 booster piston

need a skilled repair worker, dismantling-free check-up of the technical state and function of hydrogenerator is being designed. The decrease of the risk of fouling and errors connected with the assembling is its further advantage.

Provided a failure or a deterioration of the technical state of the hydrogenerator have been detected, there is no more need to perform a number of operations related to the direct check-up of the proper booster body. These should be performed only in case the hydrogenerator was found in a good technical state and fulfiling its function.

4. DISMANTLING-FREE CHECK-UP OF THE TECHNICAL STATE OF HYDROGENERATOR

Performance, or loss of performance due to the wear of functional surfaces, can be chosen as a parametr of the technical state of hydrogenerator. Therefore this can be a parametr of gradually increasing wear, and also of potential failure. On the basis of an estimate of the hydrogenerator life prior to the use of tracrors it can be decided if the hydrogenerator will be left in the tractor or if it will be renowed - replaced or repaired. The worse parameter of the technical state of hydrogenerator can also signalize in time that it is necessary to provide for a spare part or whole assembly. That means it is possible to apply preventive diagnostics, and also subsequent diagnostics in the case of failure occurrence.

At present, the agricultural enterprises do not possess any devices for the check-up of the hydrogenerator technical state; this is the reason why a simple and reliable device has been designed and tested which will fully suit for the purposes of technical diagnostics. The design and function of this device in the corse of check-up of the servocontrol booster can be seen in Fig. 2.

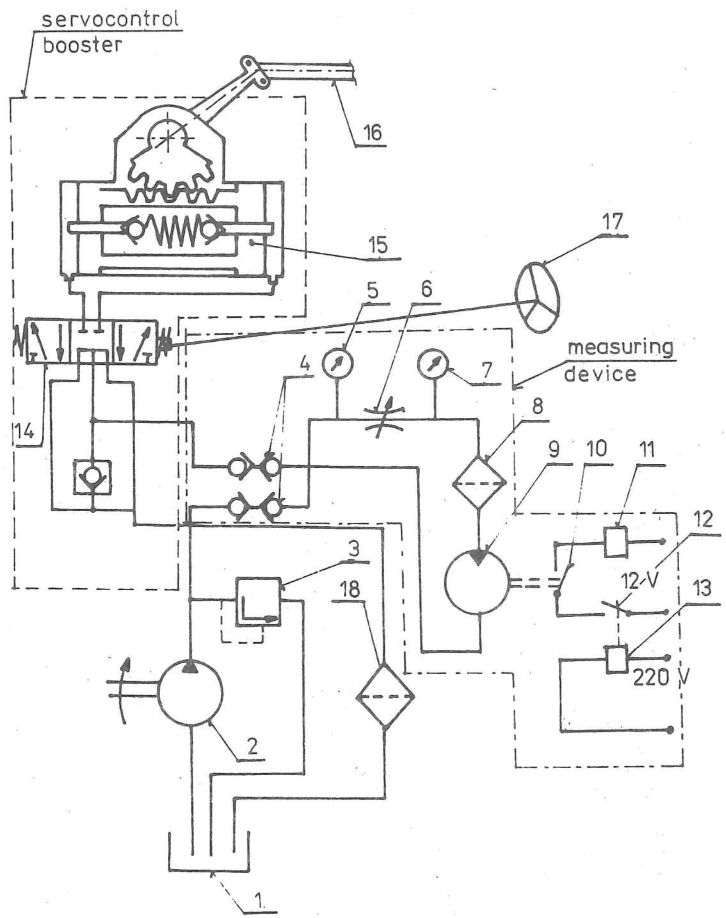
The designed device is attached to tested hydrogenerator 2 with safety valve 3 through reduction components with quick couplers. The measuring device consist of pressure gauge 5, throttle valve 6, control thermometer 7 and hydraulic engine 9 with oil filter 8. Revolution counter 11, controlled by button 12 by means of switch clock 13, is attached to the hydraulic engine through switch 10.

It can be seen in Fig, 2 that in the delivery line there is a control valve and pressure gauge; the pressure gauge which is not available in the home market, is replaced by a hydraulic engine. The hydrogenerator performance at the given nominal liquid pressure can be determined from the equation

$$P = p \cdot Q$$

where: P...hydrogenerator performance /W/,
p...nominal liquid pressure /Pa/,
Q...volume discharge per unit time/$m^3 \cdot s^{-1}$/.

The increasing untightness of piping brings about in the course of machine operation a partial loss of performance; the value of performance loss is a parametr of the hydrogenerator technical state. The measured performance of hydrogenerator P represents the value of performance reduced by the bypass loss in the hydrogenerator. This loss means the sought-for signal ΔP. The loss is determined by a difference between the theoretical performance (given by the theoretical parameters of hydrogenerator) and the actual performance at the nominal pressure which can be set up by a throttle valve. In the course of



2. A dismantlement-free check-up of the technical state of the hydrogenerator of the hydraulic circuit of the servocontrol booster in the tractor
1 tank, 2 hydrogenerator, 3 safety and control valve, 4 quick coupler in the inserted component, 5 pressure gauge, 6 throttle valve, 7 thermometer, 8 oil filter, 9 hydraulic engine, 10 switch, 11 revolution counter, 12 push button, 13 switch clock, 14 distributor, 15 booster piston, 16 steering connecting rod, 17 steering wheel

measurements it is supposed that with the open throttle valve the liquid volume Q_t supplied per unit time equals the theoretical volume. The searched-for diagnostic signal can be obtained from two measurements and is defined by the equation

$$\Delta P = p.(Q_t - Q)$$

where: ΔP...performance loss in the hydrogenerator /W/,
p...nominal liquid pressure, specified by the manifacturer and set up by a throttle valve /Pa/,
Q_t...volume discharge of liquid per unit time, the throttle valve is fully open and the back pressure equals zero $/m^3 . s^{-1}/$,
Q...volume discharge of liquid per unit time, with the set up pressure p.

5. CONCLUSION

Proposed method is quick and simple. It saves time as a number of dismantling and assembling operations connected with the check-up of the hydrogenerator or the proper booster body can be excluded. Dismantling-free process avoids fouling of hydraulic circuit. Accuracy of measurement fully comply with respective aim.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

SPECTRAL APPROACHES TO ESTIMATION OF MAIZE GRAIN QUALITY

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It is shown that absorption spectra parameters of zein proteins and carotenoid complex may be used as marker features of maize endosperm mutants with improved seed quality.

maize grain quality; endosperm mutants; absorption spectra; zein; carotenoid complex

The use of endosperm mutations is one of the ways to create perspective selective forms of maize with improved biological value. Besides this, it is necessary to develop methods for selection materials choice using specific peculiarities of improved quality seeds. Both direct methods for definition of a some single biochemical parameter and indirect ways for estimation of marker features characterizing forms with improved nutritive value may be used to solve above mentioned problem. Early we have shown that distinctive peculiarities of maize endosperm mutants are infrared spectrum parameters of albumins /1/ and circular dichroism spectrum parameters of albumins /2/, diffuse reflectance in near infrared region of milled kernel /3/, correlation of seed chemical composition parameters with using NIR method /4/.In this work, when developing spectral approaches to estimation of maize grain quality, characteristic peculiarities of zein proteins and carotenoid complex from maize endosperm mutants were investigated with using absorption spectrofotometry.

Selection forms of maize with opaque-2 mutation or the double gene combination opaque-2, sugary-2, waxy were used in these experiments. Zeins were extracted with 70% ethanol from milled maize seeds after separating albumins and globulins. Carotenoid complex was extracted with aceton/hexan mixture at ratio of aceton to hexan of 1:1 (v/v). Zein absorption spectra were investigated at 200-350 nm and carotenoids were studied at 350-600 nm.

Zein absorption spectrum curve reveals two maxima at about 285-295 and 310-315 nm. In comparison with ordinary analogues, bathochromic shift of short-wave maximum and hyperchromic effect of long-wave maximum were characteristic peculiarity of endosperm mutants, especially opaque-2 forms.

In this connection,optical dencities ratio of above mentioned maxima is measure of spectral difference as this value was desreased for mutant forms in comparison with ordinary analogues.Determined fact is concerned with modification variability of zeins, as genome markers, under influence of endosperm mutations.

Carotenoid complex absorption spectra are distinguished by typical band which consists of some maxima at about 370, 395, 425, 450 and 472 nm. Influence of endosperm mutations on genetic control of carotenoid biosynthesis results in changes of correlation during accumulation of main carotenoid fractions which differ according to their spectral characteristics. In accord with the fact that observed absorption of carotenoid complex is resulted from specific contributions of carotenoid fractions, above mentioned of observed maxima absorption. Therefor the ratio of optical dencities at 450 and 370 nm was used as a comparative parameter for identification of mutant forms. Endosperm mutants is revealed according to decrease of the comparative parameter value in comparison with ordinary forms.

By virtue of determined spectral differences of zein proteins and carotenoid complex, selection methods were proposed to be of use in improved seed quality selection programs.

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TRENDS IN AGRICULTURAL ENGINEERING
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HARVESTING AND PROCESSING SYSTEMS FOR UNCONVENTIONAL UTILIZATION OF STRAW

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Five systems for harvesting barley, wheat and rice straw have been studied employing standard and round balers. Field and stationary wafering were also experimented using straw added with binders and treated with sodium hydroxide solution. The storage and conservation of conventional and round bales in the open and under shelter were compared. The round bales proved to be stored in the open without excessive losses, but they were unsuitable for medium-distance transport. The wafering required binder addition and high energy consumption, but the increased bulk density made long-distance transport interesting.

Straw, harvesting systems, working capacity, energy needs, baling, wafering, conservation.

1. INTRODUCTION AND PURPOSES

The straw of barley, wheat and rice - the more widespread cereals - is being harvested less and less and, due to ecologic restrictions on field burning, in some countries it is becoming a cumbersome crop residue. The straw's bulkiness and low energy density limit its use out of the farm. However this important biomass, yearly reproducible, allows several uses in industry or as a source of energy; having and energy content of 16-18 MJ/kgDM, it can supply 1-1.3 TEP/ha. Soil incorporation of straw, the more common use, is expensive since, in order to achieve good results, the straw should be chopped, that requires additional power from 10 kW up to 35 kW. Chemical treatments considerably increase the digestibility of straw, which can so be employed effectively for livestock feeding /1/.
On the other hand, the increasing availability of mechanical power, often not fully utilized, in even medium-sized farms and the development of hay and forage harvesting machines, make straw removal from the field easier. Several studies on the alternative use of straw indicate that the factors of prime importance are collection, transport and storage methods, preparation of the straw into the best

physical form or package for its end use, and above all the yearly stable supply /2, 3/. This involves transporting at least over 40 km.

The Institute for Agricultural Mechanization has conducted a multi-year research on the more common methods and equipment for straw collection and storage in Italy, also experimenting new techniques; with the purpose of developing operationally efficient and cost-effective systems feasible in different farm realities and to improve possibilities of alternative uses to the conventional ones for the straw.

2. MATERIALS AND METHODS

The more common systems in medium-sized farms, where harvesting machinery is employed both with hay and straw were surveyed. Barley and wheat straw harvesting starts in mid June, while for rice straw begins in mid September and often lasts until the end of October, in unfavourable weather conditions.

For five years the following systems were tested for functional and power measurements:

1 - Standard baler, pick-up bale loader on the trailer and manual stacking, storage in the barn
2 - Standard baler, self-loading trailer and single bale unloading (**2a**) or stack bale unloading (**2b**)
3 - Round baler, tractor with front mounted fork loader and four flat-bed trailers
4 - Round baler, self-loading-unloading trailer stacking four round bales together under shelter
5 - Wafering machine: field wafering with self-propelled cuber (**5a**) or stationary wafering at farm (**5b**).

For baling, a 59 kW tractor and a round baler with fixed section chamber were employed. For wafering, two commercial cubers were used with fixed ring and radial extrusion, one towed (93 kW engine) and one self-propelled (133 kW). Wafering in the field - with barley and wheat straw only - was carried out spraying the swaths with water or with a solution of sodium hydroxide (40 kg/tDM). In the stationary wafering of the three straws also ligninsulphonate as binder (20 kg/tDM) was tested. Wafering was experimented because it makes it possible to obtain packages of uncomminute straw with high bulk density and physical characteristics suitable for mechanical handling and transport. The fibrous structure of the stalks is maintained and it is possible to supplement or chemically treat the straw increasing the value of the wafers. Treatment with sodium hydroxide (NaOH) solution was used since previous tests /4, 5/ had showed that the alkali, by altering the lignicellulose structure of the fibres, improves cubability and increases digestibility of the straw.

Lastly, different storage and conservation methods were examined. This is of prime importance for rice straw which is sometimes collected with high levels of moisture, unevenly distributed along the swath.

A few days (4-9) after combine-harvesting, depending on the weather and operating conditions, 40 conventional bales and 16 round bales were collected and differently stored. During a 40-days period of exposure in the field, samples were taken several times from some straw swaths to determine the dry matter (DM), chemical composition and energy content, using a calorimetric bomb.

The conventional bales were stacked under shelter in five layers or in the open (not those of rice straw) covered with a plastic sheet. The round bales were stored: partly in the open on concrete and the others under shelter, in two overlying tiers, laid with their horizontal axis. After two months, the round bales were reweighed. Samples were taken from two vertical sections and the bales were opened to separate the rotted or moulded straw. From the conventional bales, samples were taken in the peripheral layer and in the centre to determine chemical composition and energy.

The wafers were stored in 200 kg heaps under shelter and representative samples were taken at production and after 60 day storage in order to carry out the previous analyses and to determine some physical characteristics by the standard methods /6, 7/.

3. RESULTS AND DISCUSSION

The straw kept in swath even for 40 days did not worsen much in quality and the losses of gross energy were contained in the order of 4% for wheat and 10% for rice (Fig. 1).

During the baling stage the round baler system showed higher productivity than those with the standard baler, working with wheat and barley straw, while there were no large differences with rice straw (Table 1). When a self-loading trailer (2) was employed, it was possible to increase at baling - by up to 30% with rice straw - the density of conventional bales making this system more competitive, but it was decidedly lacking during loading and moving from the field, especially for rice where an extra worker was needed to align the bales before loading. The working chain with self-loading and unloading bales in stacks (2b) revealed a high working capacity for transport and storage, though productivity in the latter stage was lowered by the labor needed to cover the stack with plastic.

The systems with round baler showed higher working capacity during baling, roadsiding and stacking, but there was no relevant difference for transporting,

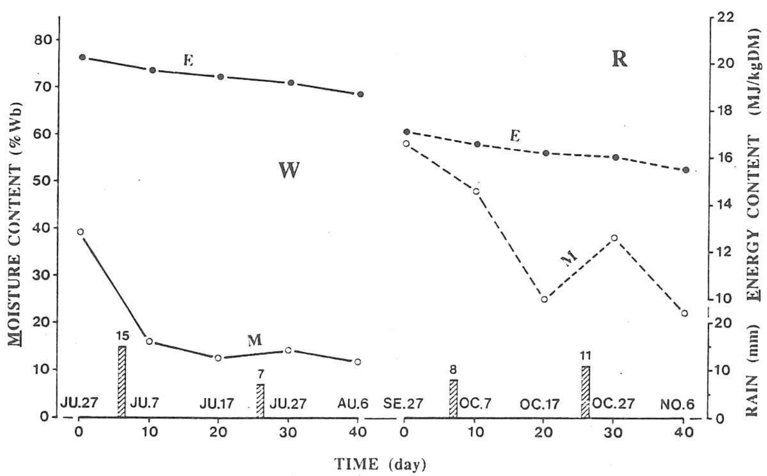

Fig. 1 - Changes in moisture and energy content of wheat (**W**) and rice (**R**) straw left on swath for forty days after grain harvest

Table 1 - Working capacity of different stages and total energy needs of five systems for harvest, transport and storage of barley (**B**), wheat (**W**) and rice (**R**) straw

Stages and energy needs \ Systems	Straw	STANDARD BALER: Trailer + pick-up loader (1)	STANDARD BALER: Self loading trailer, single bale unloading (2a)	STANDARD BALER: Self loading trailer, stack bale unloading (2b)	ROUND BALER: Front mounted fork loader + trailers (3)	ROUND BALER: Self loading-unloading trailer (4)	WAFERING MACHINE (5a)
Baling (tDM/h*)	B	3.92	4.02	3.96	4.68	4.68	2.02
	W	3.88	3.98	3.92	4.56	4.56	1.98
	R	3.83	3.96	--	4.01	4.01	--
Loading-roadsiding (tDM/h*)	B	1.23	3.95	4.02	7.25	7.58	12.80
	W	1.28	4.02	4.08	7.31	7.50	12.28
	R	1.19	3.63	--	7.03	7.20	--
Transport** (tDM/h*)	B	8.88	8.95	8.88	8.62	8.08	15.40
	W	8.93	9.04	8.92	8.58	8.22	14.30
	R	8.72	8.38	--	8.26	8.05	--
Unloading-stacking (tDM/h*)	B	1.54	3.10	7.36	10.30	12.72	14.78
	W	1.58	3.06	7.28	10.45	12.89	14.20
	R	1.48	3.02	--	10.32	12.61	--
Total energy needs (MJ/tDM)	B	82	93	89	113	104	504
	W	83	92	90	112	104	516
	R	86	97	--	115	108	--

* man-hour
** time for 0.5 km transport distance from field to stacking site

especially for rice straw. Total productivity of the system employing the front mounted fork loader (3) was limited by the need for a second operator with a tractor of at least 50-55 kW for loading and roadsiding.

The field cuber (**5a**) gave its higher working capacity (2.0 tDM/h) for the wafering of wheat straw NaOH treated, decidedly lower than the values referred in literature, /8/, and the wafers characteristics were worse than those obtained with stationary wafering. On the other hand, this system had the highest productivity for transport and storage.

Stationary wafering (**5b**) showed a limited working capacity (1.6-2.3 tDM/h), especially with rice straw, and the energy need for packaging (420-480 MJ/tDM) was clearly higher than for the other machines. The addition of binders and above all the treatment with NaOH improved the quality of the wafers and increased the working capacity, particularly with rice straw. Wafers were obtained with a bulk density of 240-360 kgDM/m^3 and having a durability suitable for mechanical handling (Table 2).

Dry matter losses were negligible for wheat and barley straws in conventional bales under shelter and approximately 5% of initial dry matter content in those stored in the open.

Table 2 - Effect of additives and sodium hydroxide treatment on the working capacity of the machine and on the physical characteristics of the wafers in stationary wafering - **5b** - of barley (**B**), wheat (**W**) and rice (**R**) straw

Additives and treatment product	Straw	Working capacity	Whole wafer content	WAFER Density	Bulk density	Durability
		(tDM/h)	%	(kgDM/m^3)	(kgDM/m^3)	%
	B	1.72	45.22	821	248	71.65
Water (60 l/tDM)	W	1.68	43.10	832	243	69.50
	R	1.61	48.70	818	272	72.30
	B	1.92	68.12	902	330	78.50
Ligninsulphonate (20 kg/tDM)	W	1.89	61.20	882	318	74.30
	R	1.78	70.25	864	306	83.55
	B	2.28	75.18	911	361	90.12
Sodium hydroxide (40 kg/tDM)	W	2.15	73.40	903	352	83.48
	R	2.02	78.40	882	358	86.18

The round bales stored outdoors gave losses of 7-8% DM, caused by rotting and mouldings concentrated in the ground contact points and at the twines. Heavier losses were found in rice straw round bales stored in the open, 24% of the initial dry matter, and 15% DM in those under shelter /9/.

For all three wafered straws, the losses of dry matter were negligible, and the quantity of whole wafers after storage markedly increased by treatment with NaOH. Interesting results were obtained with rice straw which showed the best waferability. The wafered straws did not reveal changes in chemical composition or reductions in the energy content, moreover, due to the higher bulk density, at the end of the storage period they revealed the greater energy concentration; the highest values 6542 MJ/m^3 were obtained with barley straw, while the lowest ones were given by round bales of rice straw stored in the open (Table 3).

4. CONCLUSIONS

The systems for harvesting straw are very much linked to the farm structure, work organization and local weather conditions.

Under average weather conditions, the straw left in swath, even for a month (two weeks for rice), does not sensibly worsen its chemical composition and energy content. This and the use of round balers which enable the separation of baling from field moving allow a better use of farm labor and machines, thereby extending the collection period to recover a higher amount of straw, thus reducing unit costs. The productivity of the systems with standard baler is still competitive during baling, especially in the rice field, where a high incidence of down times occurs using the round baler.

Round bale storage in the open does not involve large losses for wheat and barley straw, they are slightly higher for rice straw but appear to be mostly due to

Table 3 - Density, energy volume density and storage volume, after conservation, of barley (**B**), wheat (**W**) and rice (**R**) straw differently packaged and stored in the open (**OP**) or under shelter (**SH**)

Physical characteristics	Straw	BALES Conventional OP	Conventional SH	Round OP	Round SH	WAFERS Added*	Treated**
Density (tDM/m^3)	B	0.094	0.096	0.092	0.095	0.330	0.361
	W	0.096	0.099	0.095	0.098	0.318	0.352
	R	--	0.095	0.086	0.091	0.306	0.358
Energy volume density (MJ/m^3)	B	1710	1776	1660	1743	6138	6542
	W	1732	1810	1711	1783	5883	6388
	R	--	1510	1307	1419	4937	5710
Storage volume (m^3/tDM)	B	11.70	11.45	12.82	12.35	3.65	3.28
	W	11.45	11.27	12.53	12.40	3.78	3.52
	R	--	11.47	13.95	13.10	3.98	3.48

* with ligninsulphonate ** with sodium hydroxide

the uneven moisture content at baling rather than to the weather. The result is that round bales allow to store the product, even for several months,with limited costs.

On the other hand, they are not very suitable for transport even over medium distances (40-50 km), whereas straw wafers, with a bulk density 2.5-3 times higher, allow to get full carrying capacity of trailers. Nevertheless, the low working capacity of wafering machines and the high energy needs restrict at present, their use. Further improvements to the commercial machines tested, together with a wider location over the territory of straw utilization plants, would make it possible to obtain a cost-effective alternative to present use of this by-product.

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TRENDS IN AGRICULTURAL ENGINEERING
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AGRICULTURE INFORMATION SYSTEM

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In this paper some aspects of establishing the information system in agriculture have been considered. The task and structure of information system, with a special stress to the role of simulation methods in planning process and production control, have been analyzed. A term „permanent planning" has been introduced as the prerequisite to the qualitative production control and the role of a computer in this process. The perspective of the information system in agriculture, and the role of personal computers in it, is presented at the end.

Key words: information system, personal computer (PC), permanent planning, agricultural production, simulation planning.

1. INTRODUCTION

The agricultural production represents a complex technological - technical system. A special unfavorableness is its connection to the meteorological conditions, as well as, to the production discontinuity which is connected to the inevitability of work in an open space with plant or animal kinds, which have complex requirements in breeding.

There is a great number of participants in a production process which carry the technological operations applying different technical systems - machines, with the requirement of a strict respect of different weather terms. As there is, without doubt, the functional connection between some influential factors which reflect the final financial effect, it is necessary to follow intensively the technological cycle /4/. In order to meet these requirements there is a great number of information which ought to be classified and evaluated. The moment the number of these information is increased to such an extend, that it is impossible to master them in an adequate way, appears the need for the introduction of automatic data processing, i.e. computer. Having in mind that the agricultural production is a complex technological - technical system, it is quite natural that it represents the unique information system at the same time.

2. TASK OF THE INFORMATION SYSTEM

Since the task of any production is to create the surplus of values or profit, the agricultural production must aim to meet this requirement. Due to its specificity the agricultural production may have some other criteria for the evaluation of its success. However, the need for further intensive following remains, and that is one of an important task of the information system. By processing the relevant number of information the application of simulation methods in planning process is applied, what represents the second important task of the information system. By correct information evaluation, we achieve the possibility of production control with previously set up parameters, both regarding the material and financial effects, what represents the third important element of the information system.

The three mentioned tasks of the information system are not the only ones, but they represent the basis of the successful business.

3. STRUCTURE OF THE AGRICULTURAL INFORMATION SYSTEM

The structure of the information system follows the structure of information flow from the point of appearance to the point of processing. The information distribution must be adapted to the user's requirements.

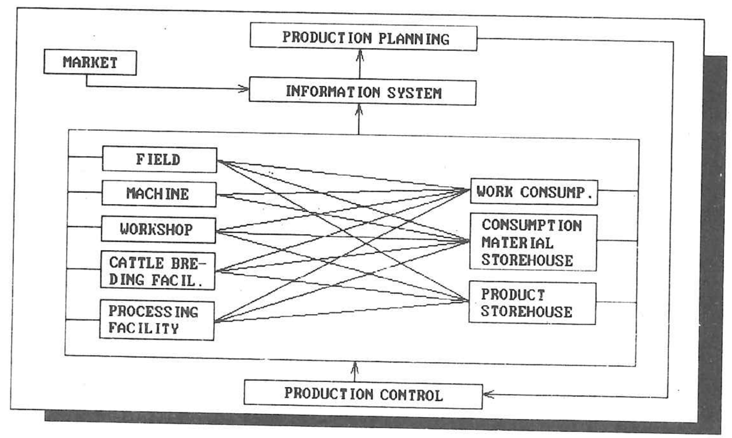

Fig. 1. BASIC STRUCTURE OF AGRICULTURAL INFORMATION SYSTEM

It is necessary to stress separately the importance of providing the qualitative starting information which, in case of agricultural production, greatly depends on the information supplier /2/. In order to provide this, the information supplier has to be motivated to give the correct information and this can be achieved if we provide the starting information to be processed on the spot of input, up to this level which will enable the primary processing and recurrent transfer to the information supplier. Such a system must have modularity so that information input in the information system should be maximally approached to the information source. In this way the time of recurrent influence is shortened and the regulation role of an information system is enabled. The logic of information processing on a spot of event, with the aim of processing results approach to the user himself directly on a spot of processing, is enabled by the use of PC.

4. PLANNING BY SIMULATION METHOD

The production planing in agriculture represents the basis for successful business. Having in mind that the planning procedure in agriculture has a technological biological importance also, we have to pay a special attention to it. In present practice this kind of planning is represented by the application of graphoanalytical methods which require extremely long time and patience of an expert team work from different fields. In such circumstances this planning had an extremely static character requiring, in the best case, two variants to be established. All disturbances during the plan realization are registered without the possibility to evaluate the changes in the continuation of plan realization. There is no possibility of making new variants in such circumstances, taking into account the production dynamic, so that we are mainly satisfied with the estimation of realization continuation.

The complexity of planning process is illustrated in the continuation of this work on the example of farming production where a number of segments of technological cycles appear, the ones that have very defined reciprocal relations.

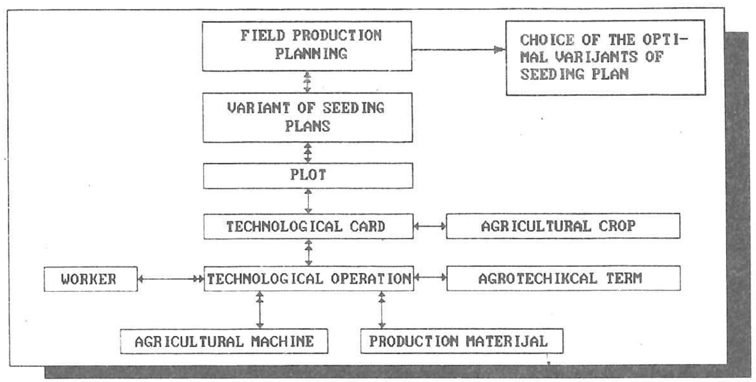

Fig.2. PLANNING STRUCTURE OF FARMING PRODUCTION

The planning of such a complex structure can be best realized by applying the simulation methods. It appeared to be a good experience to accept the analogy with graphoanalytical methods. Computer processing which enables incomparable faster work and obtaining of extremely qualitative results which could be easily used in analysis /1/, gives us a new quality. The packages of computer programs made up to now, use this analogy to a great extent, and in future we can talk about the term „**PERMANENT PLANNING**„ which should be understood as constant plan examining and correction in accordance with the coming changes and disturbances in plan

realization. As the example of such a program package we can take the program package **TTPP** (TTAP), **(TECHNOLOGY - TECHNIQUE - AGRICULTURE - PLANNING)**. This program package enables us to meet these requirements by forming a great number of technological cards which are made in variants describing the work technology. The variants of technology consists of variants of technological operations and all are in a direct dependency on agricultural machines. All these enables the optimization of technologies individually, as well as the optimization of of the total production, taking into consideration the complexity of all mutual influences of individual technologies in a unique seeding plan. The requirements for one kind of machines (Wheel tractor of 20 kN category) during a technological year graphically presented (horizontal histogram) per days is illustrated in a figure.

In a similar way we enable, besides the checking of the machines, the checking of other requirements, as for example, the consumption material, fuel, manpower. The special value is the possibility of expressing the financial production effects, both in absolute and specific indicators, presented in relation to the product or surface unit. The presented analysis points out that, in a shorter time period, there is the disproportion between the requirements and available number of the analyzed kinds of machines. This could be concluded already in the phase of plan forming, so that it can be reacted in due time.

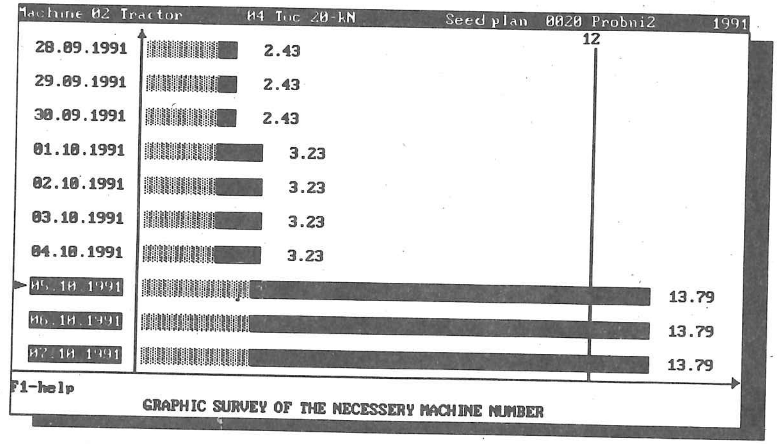

Fig.3. SAMPLE OF SCREEN FROM „TTPP„

5. EXPECTED DEVELOPMENT DIRECTIONS

In future period we ought to expect the further transformation of information requirements. The penetration of personal computers is going to be continued, what will influence the mass computer use in most different areas. The exceptional importance for agriculture is:

- Information role,
- Technologies control,
- Processes control,
- Analytical plan role,
- Financial bookkeeping role.

The software development is directed to the aim of intensive computer use in control and planning /3/.

The separate qualitative change will bring the mass application of automatic activation of information values. The transfer of these information will be by a direct way. Such a development is a logic continuation of the endeavor to approach the place of information input, to the processing place from one side, and place of information origin from the other side.

6. CONCLUSION

Information revolution has stepped into agriculture. In the initial development phase, the central information computer units were formed and they had the task in an exclusive financial scope on the basis of work following. The computer development and their use have placed the new tasks, first of all, in the field of planning and production control. In this development peronal computers have played a special role and their mass appearance had influenced the price decrease and intensive development of the corresponding software. The production planning, by the use of simulation methods, represents the new value in the information and technological sense.

In the further development, the simulation planning method will be transferred to the permanent planning, and finally, to the unique expert system with defined control requirements.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

A NEW TECHNIQUE FOR ULTRA - LOW - VOLUME SPRAYING

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Summary:
The new addition comprises adaptaion of a fabric cover over the atomizers to catch the spray drops and apply them back to plant foliage. Thus the advantage is to avoid serious drifting inherent with ULV. The spray was found to become established over 6000 rpm, regarding spread of distribution and resulting drop-size. Uniform droplets of 40 μ size resulted at this speed. With 10 cm. overlapping, the proper atomizer boom spacing is 110 cm. for uniform distribution. The fabric cover was found to collect about one third of the total spray ready for contact application to plant foliage.

I MATERIALS AND METHODS :

The setup used in the test is composed of the following compnents(Fig.1):(1)interchangeable spinning disk of 6,10, and 14 cm.Dia. with corrugated rims, and 6,and 10 cm.Dia. with straight rims. Disks are mounted on a battery-operated motor (2). Later replaced by a D.C.variable-speed motor with surplus power. Liquid (water)flows from an elevated tank with a sirface head of 68 cm.above the level of the emitter boom(3). The unit is supposed to be protected by the fabric cover,(4). This cover receives the stray spray and applies its to the plant surface by contact,thus solving the "ULV"problems of driifting and difficulty of distribution and coverage on plant foliage. More then one of the above units can be mounted on a boom (6) as desired. Boom inclination is about 45°with the horizontal according to the design of Awady et al 1981.

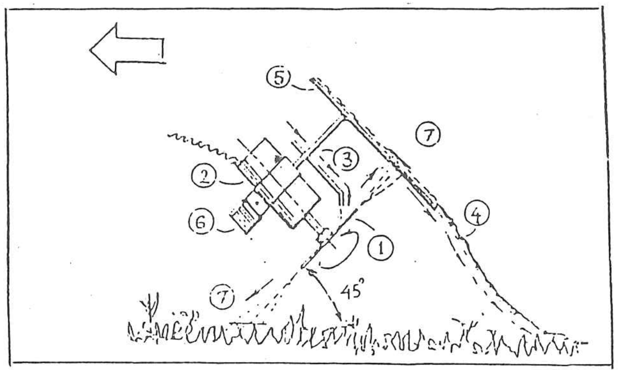

Fig. 1: The ULV spray unit.

1. Spinning disk. *2. Battery-operated motor.*
3. Liquid emitter. *4. Fabric cover.*
5. Frame for cover. *6. Boom section holding spinners.*
7. Sampling cards.

Tests Involved:

(1) Investingating the effect of spin disk diameter and cor rugation on the extent of the sprayed trace on a plane 40 cm. below.

(2) Effect of the position of water emission at the spin disk on the extent of the trace. Four positions were used All positions were 5 mm from the rim.(25,45,and 65 mm from the centers of disks for diameters of 60,100,140,cm resp.)

(3) Effect of speed of rotation of the spin disk on the extent of trace and average droplet size and distribution. Four speeds were :950,2600,7600,and 13100 r.p.m.Speeds were measured by means of a revolution counter and stop watch. The spray was received on paper cards of 2 x 8 cm spaced every 20 cm. in line lateral to movement direction of the application .Cards were placed either on ground or on the fabric cover according to point of sampling. Time of sampling was about 3 sec. cutoff of the sampling time was carried out by moving in of an interceptor sheet over the plane of sampling. In latter experiments sampling cards were attached to lances that were moved over, above and below the atomizing devices by a speed pertinent to the exposure time.

TO measur the resulting drop sizes, samples were collected simultaneously in an oil bath and on the paper collecting surface. Calibration was carried out by comparing the paper stain sizes with the oil-bath drop diameters. Drops and staing were measured by a comparative oculer graticule on a monocular microscope. Counting of drops was under a binocular microscope. Calibration could be expressed by:

$$d = 3.33 \sqrt{dp}$$

Where d:diam.of drop, and dp:diam of stain on paper.

This result conforms with the findings of(jarman,1956)who suggested the form. $d = a(D)^b$

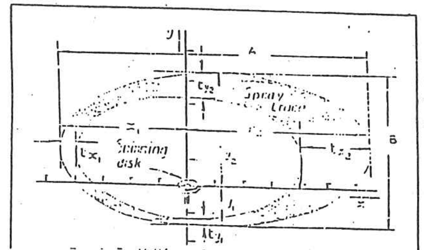

Fig.2: Definitions of spray - trace Dimension.

II RESULTS AND DISCUSSION:

The sketch of **Fig.3** shows the geometrical dimensions describing the trace of spray as received on the ground. Different traces were obtained on paper sheets placed on the ground 40 cm below the axis of the spin disk. They were taken to show the effects of:

1. Condition of the disk edge: whether plain or with corrugation .
2. Diameter of the disk.
3. Position of water emission
4. Spinning speed: on trace width, and on drop sizes.
5. Lateral distribution of spray droplets.
6. Catch of drops by the fabric cover.

1. Effect of disk edge:

Figure 3 show as an example the traces from plain-edge disk of 6 diameters. Each run included the four water emission positions. The figure show that edge corrugations give a little more dispersion of droplets, thus more filling in with the trace core. Yet, the differences are not of much practical value. Thus plain-edge disks are satisfactory.

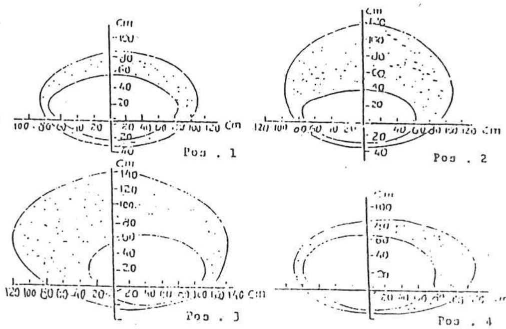

Fig. 3: Traces from plain edge 6 cm spin disk, for different enission position.

2. Effect of the spin-disk speed on trace spread"A":

In the speed tests,6-cm dia. disk was used, with plain edge,and with water emitted near the top(pos.1).

Four speeds were used:950,2600,7600, and 13100 rpm. Table 1 shows the different trace-dimensions for the different speeds.

Fig.4 shows the major-axis spread "A" of the traces, for the 4 stated speeds and the four emission position(major diamter).

The figuer clearly shows that the diameter "A" increases considerably by the increase of the disk speed up to about 6000 r.p.m. The range up to this speed can be expressed as developing speed range. The spread obviously increases with speed in this range due to the increased inertia given to droplets.

Later on (over 6000 rpmm.), the spread curve flattens out,without much variation with speed. This range will be termed "established-speed range". In this range inertia of droplets increases with speed but decreases with greater atomization accompanying the speed buildup. The two contery effects cause the flattening of the spread curve. The "stablished-speed range" is of practical improtance since spread stays without radical changes, in addition to the eminent stability of drop sizes. Thus recommended speed-range is over 6000 rpm.

Table 1: The trace dimensions for 6 cm plate diameter at four water-release positions and plate speeds.

Position	x_1	t_{x_1}	x_2	t_{x_2}	A	y_1	t_{y_1}	y_2	t_{y_2}
				N_1 = 950 r.p.m. Dimensions - cm					
(1)	85	24	75	10	194	22	9	55	30
(2)	85	28	30	90	233	25	5	62	35
(3)	65	45	75	20	205	23	5	40	80
(4)	82	50	80	10	222	23	4	67	20
				N_2 = 2600 r.p.m. Dimensions - cm					
(1)	76	35	70	32	213	28	7	50	10
(2)	36	40	75	34	185	30	6	45	23
(3)	75	28	70	42	215	30	6	42	31
(4)	71	54	73	40	238	27	8	50	20
				N_3 = 7600 r.p.m. Dimensions - cm					
(1)	30	44	0	54	132	21	18	6	24
(2)	87	-	48	-	135	37	-	53	-
(3)	75	-	59	-	134	35	-	65	-
(4)	67	-	75	-	142	35	-	69	-
				N_4 = 13100 r.p.m. Dimensions - cm					
(1)	66	-	193	-	159	35	-	-5	-
(2)	83	-	55	-	138	37	-	26	-
(3)	80	-	73	-	153	39	-	37	-
(4)	65	-	87	-	153	39	-	39	-

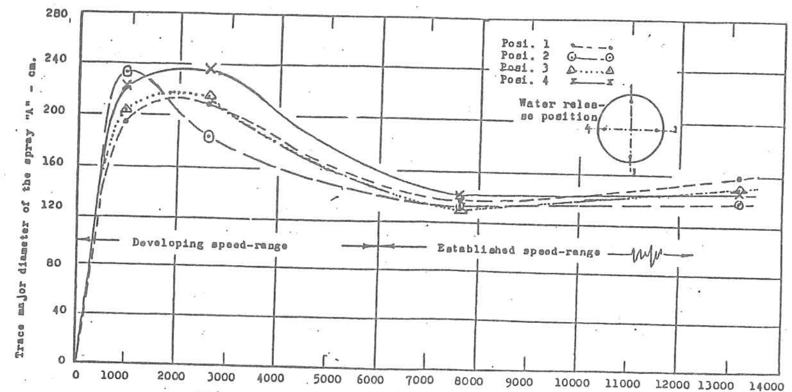

Fig. 4: Trace width vs. r.p.m

3. Catch of drops by the fabric cover:

Fig.5 shows the distribution of drop intensity as collected from the ground, 40-cm below atomizers, and from the fabric cover. Conditions involve 6-cm dia disk of plain edge rotating at 6000 rpm, with water release near the top.

Quantity collected by the cover represents about one third of the total spray, as estimated from the figure. Notice that this is less than 50 % because some of the stray drops fall back by gravity toward the ground.

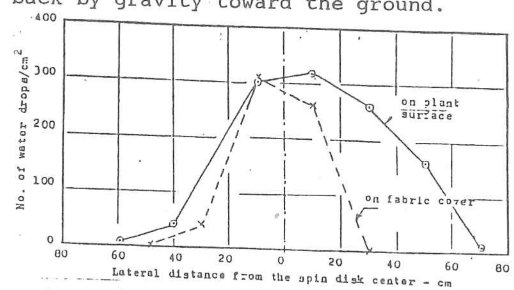

Fig. 5: Distribution of spray intensity on ground and on fabric cover.

SUMMARY AND CONCLUSION

The developed device is "ULV" applicators composed of spinning disk atomizers. The new addition comprises adaptation of a fabric cover over the atomizers to catch the stray drops and apply them back to plant foliage. Thus the advantage is to avoid serious drifting inherent with "ULV".

Corrugated disk edge was tried along with variations in diameter and found of no outstanding advantage over plain disk-edge of small size (6-cm dia).

Liquid was applied to the disk in 4 positions (near top, bootom, right, and left). The first two positions gave symmetrical patterns on right and left direction, in contrast with the last two. The top position is preferable since it gives more even pattern in the two and four directions.

. The spray was found to become established over 6000 rpm, regarding spread of distribution and resulting drop-size. Uniform droplets of 40μ size resulted at this speed.

With 10 cm. overlapping, the appropriate atomizer boom spacing is 110 cm for uniform distribution.

The fabric cover was found to collect about one third of the total spray ready for contact application to plant foliage.

The estimated field capacity "c" of a man carried divice, based on 2 spinner lance with (2.2 m swatch width), the operator's speed "v" of 2 km/hr, and assumed field efficiency " η " of 0.75 is calculated:

$$C = \frac{W \times V}{10000} \times \eta$$

$$= \frac{2.2 \times 2000}{10000} \times 0.75 = 0.33 \text{ ha/hr} = 0.75 \text{ fed/hr.}$$

The workable rate of discharge "q"was measured at 4.3 l/hr. Accordingly, the intensity of spraying"i" is calculated:

$i = q/c$

$= 4.3/0.33 = 13$ l/ha $\doteq$ 55 l/fed.

Intensity is in the desired order of magnitude. If can, moreover, be easily regulated through the rate of discharge.

<u>Recomendation for operation condition:</u>

Disk : 6 - cm dia, plain edge.
Water application : near disk top.
Speed : over 6000 rpm, with 40μ drop size.
Spacing :110 cm with 10 cm spray overlap.
Fabric cover : to collect 1/3 of spray .
Estimated field capacity for 2-spinner lance: 1/3 ha/hr.
Workable spray - intensity approxmately: 13 l/ha. according to the plant condition.

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TRENDS IN AGRICULTURAL ENGINEERING

<u>PRAGUE 15 - 18 SEPTEMBER 1992</u>

DEVELOPMENTS IN MECHANICAL HARVESTING OF OLIVES FROM THE GROUND

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Experimental tests were carried out about olive harvesting from the ground from big trees. By choosing the right machines and by combining them suitably, it's possible to reduce the harvesting costs and to have an oil of better quality because of the smaller time olives remain on the ground.

1. <u>INTRODUCTION</u>

In olive growing regions with big, high yield trees of gradually ripening varieties, harvesting is generally done after olives have already fallen onto the ground. The soil onto which olives fall must be properly prepared, weeded, and levelled.

Since olives ripen gradually, a certain period of time will elapse from the moment the first olives fall to the end of the fruit dropping period. This interim can damage the quality of the fruit, since it remains in contact with the soil. Prolonged contact will give the deriving oil an unpleasant taste. Therefore, this oil will have to be refined in order to make it edible.

Apart from these qualitative considerations, the high cost of traditional harvesting must be also taken into account. For these reasons, in the last few years, partial or total mechanization has been spreading even in the most "difficult" areas.

Mechanical harvesting can be performed by small, low cost machines (sweepers, suction equipment, cleaning equipment, etc.) which replace manual jobs; moreover shakers can enhance fruit detachment. The use of the above said machines helps to reduce the period of time olives remain on the ground thus ensuring a rather clean product (mechanical separation from soil, leaves, impurities) and, as a consequence, an oil of better quality.

A great step forward in oil quality has been achieved by using mechanical systems instead of ground harvesting techniques. Fruit is cleaner, less damaged and can be transported immediately to the processing plants.

In the light of this, tests of mechanical harvesting of olives in these areas were carried out using different harvesting chains aiming at comparing the two different harvesting methods.

2. METHODS

The tests were carried out in an olive-grove at Taurianova, Calabria, from January to February, with trees of the cultivar "Ottobratica" on flat and even plots. The soil had been previously levelled and prepared for mechanical harvesting.

The trees, about 70-80 years old and with a large tree-top, were 14-15 metres high; 3-4 branches spread out from the trunks having a diameter of more than 80 cm. The planting distance, not regular, was approximately 15 m x 15 m.

Three different harvesting chains were compared. By the first harvesting chain olives were harvested after falling onto the ground naturally whereas by the second olives were harvested after falling upon the ground through the action of a shaker. By the third harvesting chain olives were harvested in the same way, but by means of a different picker.

In the first case, olives were collected by a picker equipped with brushes and were then unloaded into a box, suitably placed (there were 12 boxes in total). As soon as a box was full, it was automatically unloaded to the ground and replaced by an empty one. The cycle continued until all boxes were full. After that the boxes were loaded onto a truck and carried to a sorter, where olives were separated from leaves and other impurities.

In the second case olives, fallen to the ground by using a shaker, were harvested by means of the above said picker.

In the third case, finally, olives fallen by mechanical shaking were collected by a brushing-picking machine. This machine equipped with a tank (having a capacity of 0.3 t) unloaded olives onto the conveyor belt of the sorter.

The machines worked along a row, then at its end they turned and continued along the adjoining row, until harvesting in the whole area was performed.

3. RESULTS

In the tests carried out, fruit-removal percentage of the shakers as well as of the other machines utilized and the work capacity of each harvesting chain was also determined in order to get a parameter with which to compare the efficiency of the different harvesting chains.

Due to the large trunk diameter, shakers could not be fastened directly to trunks. Each branch had to be shaken, therefore much more time was required. Actually most time was employed to move and place the machine and to adapt the shaking head to the tree.

As a consequence the percentage of olives detached was rather small (about 60%), due to the size of the trees and the difficulty of transmitting vibrations to the branches far from the point where the shaking head had been attached. (tab. 1)

Table 1 - Results of the tests of olive mechanical harvesting.

Harvesting chain		Yield per tree (kg)	Fruit removal force (N)	Product removed by the shaker (%)	Work capacity of the harvesting chain (t/h)	Harvest productivity (kg/h·man)
A	- Picking of the fruit fallen naturally(1) - Sorting (4 men)	-	-	-	0,640	160
B	- Shaking - Picking (1) - Sorting (6 men)	490	4,7	60	2,192	365
C	- Shaking - Picking (2) - Sorting (4 men)	480	5,2	57	2,210	552

1) Harvesting by a picker unloading olives into boxes (3 men).
2) Harvesting by a picker with tank (1 man).

It is therefore advisable to perform the intervention again, also on account of gradual ripening and the usually high productivity of these plants.

Pickers recorded a high percentage of harvested product (97%). The sorting machines also attained a high harvest productivity (98%).

As far as the work capacity of the different harvesting chains employed is concerned, it amounted to 2.2 t/h with shakers. It was remarkably lower (0.64 t/h) in the chain where olives were collected after falling onto the ground naturally.

The values of harvest productivity were also considerably higher in the chains resorting to mechanical shaking.

The highest work productivity was recorded in the third harvesting chain, mainly on account of the lower number of workers employed due to the presence of the tank. Actually it amounted to 552 kg/h · man as against 365 and 160 kg/h · man recorded in the second and first harvesting chain, respectively.

Fig. 1 refers to the comparison between the experimental points (d, P) and the following equation:

Chain A $P = 296.3\ d^{0.37}$ (1)

Chain B $P = 292.9\ d^{0.50}$ (2)

Chain C $P = 431.3\ d^{0.79}$ (3)

where P is the work productivity and d is the olive density on the ground. The coefficients of equations (1), (2) and (3) are estimated by using the least squares method.

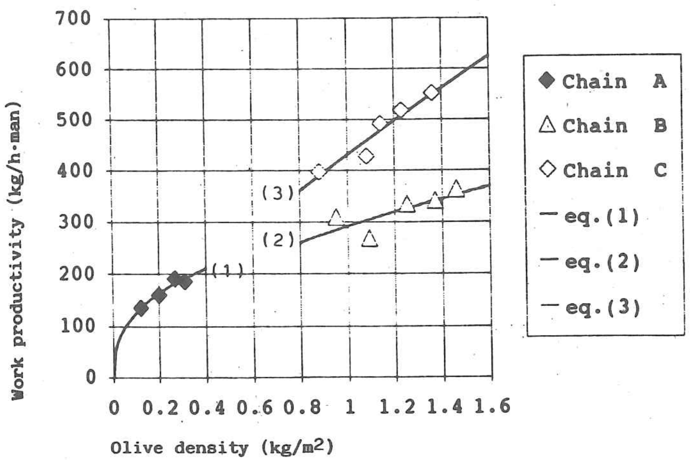

Fig. 1. Work productivity of chains A, B and C as the olive density on the ground varies.

In the harvesting chains using a shaker, a picker and a sorter, olives fell onto the ground through the action of a shaker, were selected and then carried to processing plants. The limited period of time olives remained on the ground and sorting ensured an oil of better quality compared with that deriving from olives fallen naturally.

4. CONCLUSIONS

Harvesting olives from big trees is rather difficult because of the size of the tree-top as well as of gradual ripening. Therefore harvesting directly from the ground is widely performed. However harvesting, be it manual or

partially mechanical, requires a high number of workers which results in a low harvest productivity.

In the tests carried out, the highest harvest percentages were attained by the chain where a shaker, a picker with built-in tank and a sorter were used.

Therefore, by choosing the right machines and by combining them suitably harvesting costs can be remarkably reduced even in "difficult" areas, as the one where tests were carried.

One should, however, point out that olives still come in contact with the ground, (even though for a more limited period with mechanical harvesting) thus damaging the quality of the final product.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

THE PROCESS OF THRESHING BY MEANS OF A MULTIDRUM SET FOR THRESHING AND SEPARATING

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The work elaborates on the research pertaing to grain separation in a multidrum set for threshing and separation. The influence of capacity, revolutions of the separating drums, size of the working slots between the drums and threshing floors for separation as well as moisture of the threshed grain mass on effectivness of separation has been described. Attention has been paid on the process of separation in the function of the number of the separating sections.

a multidrum set for threshing and separation, grain separation, the influence of work parameters

1. INTRODUCTION

Scientists' and constructors' work aiming at the increase of combine-harvesters capacity goes in two directions. The first one is a construction of a combine-harvester with axial flow of grain mass. The other one aims at a construction of combine-harvesters provided with multidrum sets separating grain from straw mass. These sets have replaced hey shakers which used so far as they resrained a general capacity of combine-harvesters and inreased their dimensions.

On the basis of the investigations done so far and survay of literature one can assume that in climatic conditions of Central Europe combine-harvesters with a multidrum set for

separation will be commonly used in practise.

2. THE AIM OF THE WORK

The aim of the work was to do a post research of the process of grain threshing and separation in a multidrum set for threshing and separation and the mathematical description of the process of grain separation with consideration of the influence of the essential work parameters of the set and moisture of grain mass threshed.

3. THE CONDITIONS AND METHODOLOGY OF THE RESEARCH

A set for threshing and separation consisting of threshing drum and eight separating sections (Fig.1) was built in the Institute of Agricultural Mechanization of Agricultural Academy in Lublin.

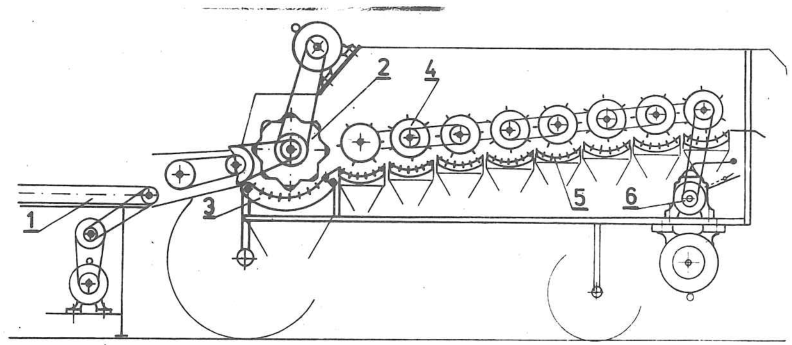

Fig. 1. The technological scheme of the research post.
1 - a belt conveyor, 2 - a threshing drum,
3 - a threshing floor, 4 - separating drums,
5 - grates, 6 - a powering set

The set was examined while threshing winter wheat, Grana brand, with the straw moisture of 12,81; 14,93 and 16,1% and the grain moisture of 13,69; 15,71 and 17,63%. The research was done with the capacity of a threshed mass equal to 2,5; 4,0; 5,5 and 7,5 kg/s. The sizes of the working slots were equal to 25 and 40 mm. The influence of peripheral speeds of the separating drums on the process of separation was observed. The peripheral speeds of the drums amounted to 10,6; 15,6 and 21 m/s and they corresponded to the angular speeds of the drums of 53,78 and 103 rad/s.

The straw mass was passed to the set for threshing and separation with a belt conveyor on which threshed portions of wheat were regularly placed. The speed of the conveyor belt was equal to 1 m/s. The grain separated from particular sections was caught into separate special sacks and then it was weighted and amount of separated grained was defined in percentage for each separating section.

The results obtained in this way were for a construction of a mathematical model describing the process of grain separation in the set for threshing and separation under discussion.

4. THE RESULTS AND THE ANALYSIS OF THE RESEARCH.

The evaluation of the influence of particular factors on the process of grain separation was very important task. The influence of the capacity - Q, the angular speed of the separating drums - ω, the size of the working slot -c, the straw moisture - w and the amount of separating sections - n was examined.

The analysis of multiple regression taking into consideration the factors mentioned above proved that the number of separating sections - n was the most important factor. Other variables turned out to be statistically irrelevant and they increased multiple regression coefficient R^2 only to a limited degree.

The conclusion that the amount of separating sections had the basic influence on efficiency of grain separation allowed to formulate a formula describing interrelations between the amount of separated grain expressed in percentage and the amount of sections. The equation has the form:

$$Y = 64,0497\exp(0,14249\ n - 0,01072\ n^2) \qquad (1)$$

for $1 \le n \le 9$, with $R^2 = 89,38\%$

Figure 2 presents the course of the function according to the equation (1).

Transforming the formula (1) to the form:

$$s = 100 - 64,0497\exp(0,14249\ n - 0,01072\ n^2) \qquad (2)$$

we obtain a dependence which enables to indicate theoretically grain losses that arise where subsequent sections are excluded from work. In this way a necessary number of separating sections with a definite level of grain loss can be defined.

It should be noted that the research was conducted only with wheat having pretty advantageous physical characteristics for the process of threshing and separation. Therefore, there is need of investigation on a wider scale while threshing four kinds of grain with more differentiated morphological features and with a wider range of moisture.

It was observed that a multidrum set for threshing and separation caused considerable overgrinding of straw

interfering with the process of grain refinement. It is an obvious disadvantage of the set.

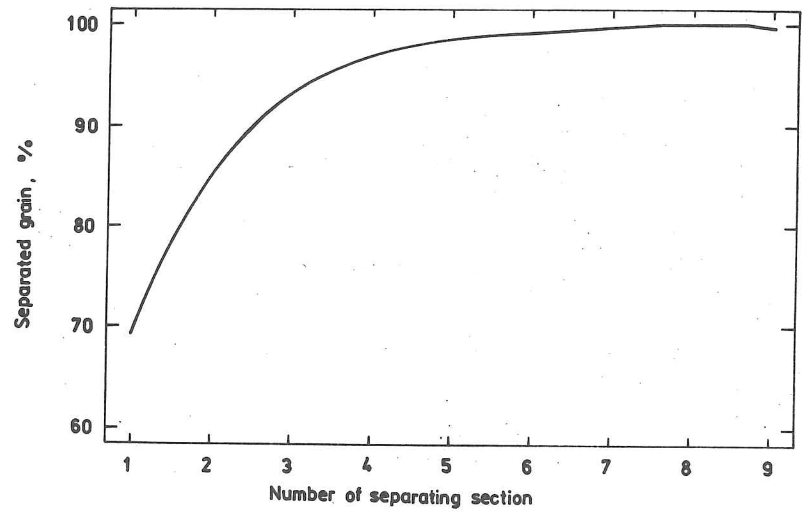

Fig. 2. The course of the function according to the equation(1).

5. CONCLUSIONS

As a result of the conducted investigation it was ascertained that a multidrum set for threshing and separation fulfills the conditions necessary for usage in combine - harvesters. During the examination of the set provided with eight separating sections grain loss resulting from underthreshing was not observed. It was noticed that the amount of separating sections could be smaller without essential worsening of the process of grain separation. The most advantageous working conditions were obtained with the angular speed of 78 rad/s and the size of the working slot of 40 mm. The mathematical analysis conducted allowed to elaborate on a model of the process and on analytical definition of grain loss in particular separating sections.

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TRENDS IN AGRICULTURAL ENGINEERING
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THE ANALYSIS OF THE PROCESS OF GRAIN DAMAGE IN A MULTIDRUM THRESHING SET.

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The examination of a multi-drum set for threshing and separating pertaining to damages of wheat grain separated in the set under discussion has been presented. The examination covered micro- and macro-damages of grain caused by particular separating sections. It has been observed that the following factors had considerable influence on the amount of grain damages: angular speed of the separating drums, size of the working slot, capacity of the threshed mass and grain moisture.

a multidrum set for threshing and separation, wheat threshing, micro- and macro damages of grain.

1. INTRODUCTION

Combine harvesters play the main part in mechanization of grain harvest. The harvest with combine harvesters goes efficiently with a small work and cost impute in comparison to other methods of harvest.

A combine harvester, however, is a machine consisting of many working sets; the most important of them are: a drum set for threshing and key shakers increasing, unfortunately, the harvesters dimensions and delimiting their capacity. That is why, new solutions in the construction of a set for threshing and separation are being searched for in many scientific centers and designers' studies in order to replace key shakers. A research like this has been conducted in the Institute of Agricultural Mechanization in Agricultural

Academy in Lublin. A special post was constructed where the research was conducted with various work parameters of particular working elements of the set.

2. THE GOAL AND SCOPE OF THE WORK

The goal of the research was to evaluate quality of work of a multidrum set for threshing and separation. The criterion accepted was the amount of micro- and macro-damages of grain separated in the process of threshing. The amount of grain damages caused by particular separating section and in the mass of separated grain as a whole were defined.

3. THE GENERAL CHARACTERISTIC OF THE OBJECT AND RESEARCH CONDITIONS

The scheme of a multidrum set for threshing and separating consisting of a flail threshing drum and light separating section was presented in /5/.

The research was conducted with threshing winter wheat, Grand brand, using variable parameters of work of the separating elements. Three angular speed of the drums amounting to 53,78 and 103 rad/s and two size of the working slots equal to 20 and 40 mm were used. The research was conducted with the capacities: 2,5; 4,0; 5,5 and 7,0 kg/s of the grain mass. Moisture of the threshed straw equaled to 12,81; 14,93 and 16,1% and grain moisture to 13,69; 15,71 and 17,63%. The set for threshing and separating was powered with a belt conveyor with speed of threshed mass delivery equal to 1 m/s.

4. METHODOLOGY OF THE RESEARCH AND ELABORATION ON THE RESULT

Methodology of the research covered:
- the way of chosing samples of grain for the analysis,
- the method of defining of physical and mechanical characteristics of grain and straw,
- the method of defining of the amount of micro- and macro-damages
- the method of the analysis of the results obtained

Samples of grain separated in particular sections of the separating set were collected in five repetitions. The amount of damaged grain was defined in grain mass from all section as a whole.

Grains with macro-damages were separated by hand from 100 grams samples and their mass and per-centage were defined. Grains with micro-damages were defined in the grain mass without macro-damages separated before. The samples equal to 100 grains were put into a bath for 120 s in 1% water solution J+KJ, called Lugol liquid. The liquid entering through

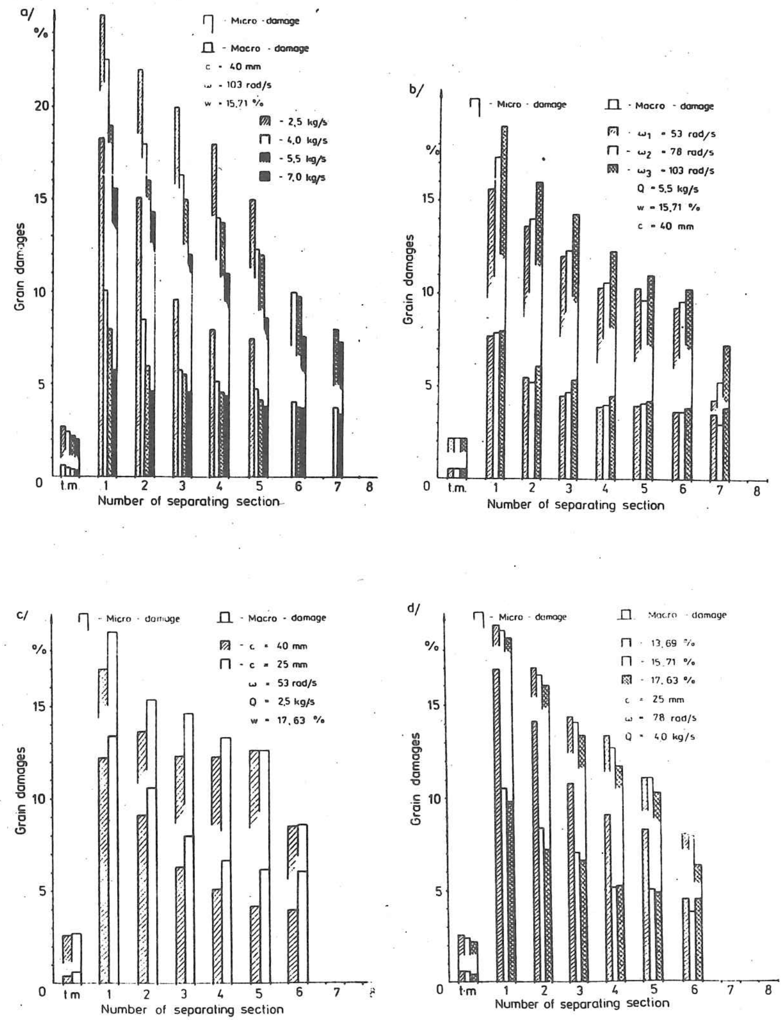

Fig. 1. The diagrams characterize the influence of:
a - capacity
b - angular speed of the separating drums
c - size of the working slot
d - grain moisture
on mechanical grain damages.

invisible damages of fruit and seed cover coloured starch in the places of damages into brown. The coloured grains were separated and their amount was defined in percentage.

5. THE RESULTS OF THE RESEARCH AND THEIR ANALYSIS

Mechanical grain damages (macro- and micro-) diminish its biological value. Quite often the amount of the damages is the accepted criterion of evaluation of the threshing process /1-7/. The experiments conducted proved that all the factors taken into account (capacity, angular speed of the separating drums, size of the working slot and grain moisture) had a considerable influence on the amount of mechanical grain damages.

The factor which has a considerable influence on the extent of mechanical damages of separated grain is capacity-Q, Fig.1a. It results from the picture that increase of capacity results in diminishing of the amount of mechanically damaged grain. With lower capacities the contrary phenomenon was observed.

Next important exploitation factor having influence on the amount of mechanical damages of grain is angular speed of the separating drums - ω. The research proved that increase of angular speed of the drums results in increase of the amount of macro- and micro-damages in the separated grain, Fig.1b. It should be also noted that with peripheral speed of the separated drums higher than 15,6 m/s (78 rad/s) the amount of damages grows considerably, Fig.1b.

Another factor having influence on quality of separated grain is size of the working slot between the drums and the separating grates. The influence of the slot on the amount of grain damages is characterized by diagrams on Fig.1c. The analysis of these diagram lets us conclude that grain separated with the working slot equal to 40 mm has less damages in comparison to the grain separated with the slot equal to 25 mm.

Moisture of the threshed grain - w has also influence on the extent of grain damages. It results from the research that during wheat threshing with law moisture of grain the amount of its mechanical damages increases - Fig.1d.

6. CONCLUSIONS

The research under discussion lets us formulate the following conclusions:

6.1. Percentage share of micro- and macro-damages of wheat grain separated by particular sections is various, Fig.1. Most damages are caused in the first and the second separating sections.

6.2. The amount of mechanical grain damages separated by a multidrum set depends on its work parameters and grain moisture.

6.3. During the research it was observed that the amount of wheat grain do macro-damages amounted to 1,5 - 5,5% while the amount of micro-damages from 5,5 - 10,5%. These amounts are twice as high as those caused by a traditional thresher of a combine harvester provided with a key shaker.

6.4. It seems advisable to conduct research covering the other kinds of grain (except oat) and some other non-corn plants gathered with combine harvesters e.g. rape and leguminous coarse-grained. Research should also cover grains with increased range of moisture and differentiated physical characteristics.

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TRENDS IN AGRICULTURAL ENGINEERING
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OPTIMIZATION OF A TRACTOR HYDRAULIC LIFTSYSTEM ON THE BASIS OF GEOMETRIC PARAMETERS

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The approach to the optimization of essential cinematic and dynamic work indicators of a tractor hydraulic liftsystem on the basis of geometric parameters are given in this paper. For the adopted structure of this device, a mathematical model was formed that comprised difficult and changeable work conditions of the tractor aggregate. A program for computer was made, the one used for the work simulation of the tractor hydraulic liftsystem. The numeric method of direct search was used. More optimization criteria were adopted. The obtained optimal solutions of a tractor hydraulic liftsystem met more or less the set criteria of the solutions on the existing tractors.

Key words: Optimization synthesis, tractor hydraulic liftsystem, implement, mathematical model, computer program, analysis, simulation

1. INTRODUCTION

The tractor hydraulic liftsystem influences to numerous important tractor exploitation possibilities and to the quality of work of the implement. The lack of this system with some types, categories and manufacturers of tractors are: the insufficient concordance of structural parameters of the tractor hydraulic liftsystem and implements, inadequate stability of maintaining the given implement work regime, inadequate dynamic load distribution on tractor's wheels, inadequate lifting power and inadequate reliability of the hydraulic components of the liftsystem.

The requirements that are expected from the tractor hydraulic liftsystem are numerous and mutually contradictory. This is why the aim of this work is that for the adopted structure of the tractor hydraulic liftsystem, the optimization of geometric parameters is carried out. As the basic criteria of the optimization the following kinematic and dynamic work indicators are adopted: transmission ratio of the tractor hydraulic liftsystem, lifting power on the lower connecting wheels, driving piston load and stability of tillage depth. The obtained optimal solutions of the tractor hydraulic liftsystem have been compared with the solutions on the existing tractors.

2. INVESTIGATION METHOD

In forming the mathematical model, the tractor hydraulic liftsystem structure, as on the kinematic scheme (Fig. 1.) has been accepted. The adopted tractor was of 20 and 30 kN category and the implement was suspended plough. The soil resistance could be changed depending on: specific soil resistance, depth of tillage, number of ploughing bodies, working width, working speed, plough mass and position of plough center of gravity. The soil was real, uneven with inclination.

The function of the tractor hydraulic liftsystem has been mathematically described by vector analysis, during one cycle (lifting from a minimum lower working, into the maximal upper, transport position). In this way the mathematical relations were obtained in which the coordinates of the supporting i connecting points of the liftsystem figurated. This was important, since in the optimization, the limits as the values of these coordinates were used, the ones that were defined by the corresponding JUS standard.

The following work indicators of the tractor hydraulic liftsystem were analyzed: position of the instantaneous semi revolution, transmission ratio of the device, transmission ratio of the aggregate, dynamic coefficient of the tractor load distribution, moment of plough penetration into soil, lifting force on the lower connecting points, necessary drive power and angle speed of the connecting triangle (Part 8 Fig. 1). The stated work parameters are analyzed in the function of driving piston stroke.

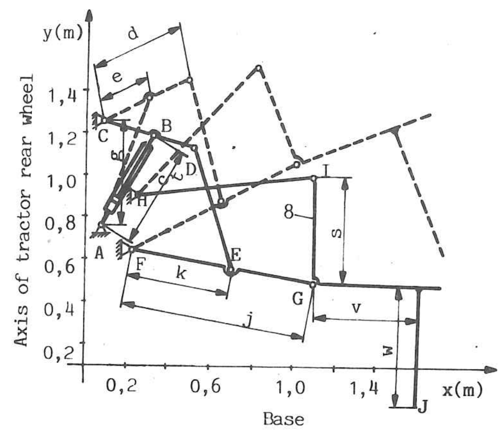

Fig. 1: Kinematic scheme of the adopted tractor hydraulic liftsystem

On the basis of such a mathematical model a computer program package has been made, the one that has three different possibilities: to analyze the work of the existing solution of the tractor hydraulic lift system, to analyze the change influence of the parameters to the work indicators of the tractor hydraulic liftsystem and to optimize this device depending on the chosen aim function.

2.1. Interdependence of the parameters and work indicators

In order to get the precise important direction for the choice of the optimal solution of the tractor hydraulic liftsystem, we have analyzed the interdependence of approximately forty different parameters and the above stated work indicators first of all. The coordinates of the basic points influence to the greatest extend (A, F, C and H, Fig.1.), then the plough length (e, d, k, j, and v) and coordinates of the connecting points (G and I).

As the example we give the length influence „e„ and driving force „F_K „ to the lifting force „F_G „, diagram (Fig. 2. and 3.). Comparing these two diagrams we can conclude that it is more rational to increase the lifting force by the increase of parameters „e„, then by the increase of the value of driving force „F_K„. By the increase of parameter „e„, we differently influence and chain reaction to many of other indicators.

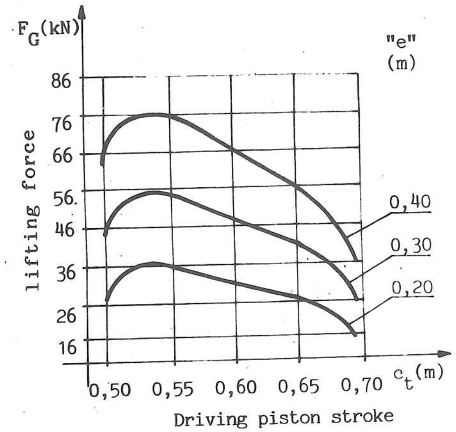

Fig. 2: Influence of parameter change „e„ to the lifting force „F_G „

On the basis of such an analysis we have obtained, the initial, approximate solution of the tractor hydraulic liftsystem that served as the basis for finding the optimal solution.

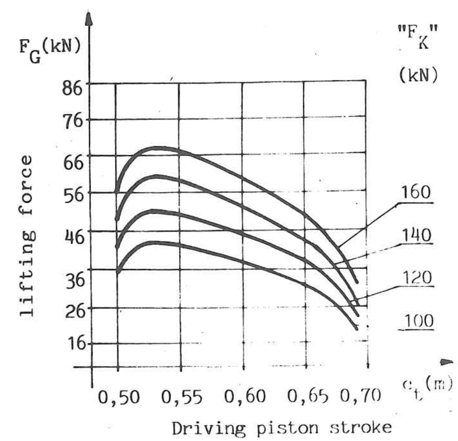

Fig. 3: Influence of the driving force change „F_K „ to the lifting force „F_G „

3. PROCEDURE FOR DETERMINING THE OPTIMAL SOLUTION

3.1. Optimization criteria

As the optimization criteria those indicators that have the direct practical value have been adopted and the ones that mostly depend on the tractor hydraulic liftsystem itself. Four categories of optimization criteria have been adopted: basic, obligatory, desirable and additional.

The basic optimization criteria is the one that the movement of mechanism is which is one-valued defined in the function of driving piston stroke.

The obligatory optimization criteria are: that the transmission ration of the device is $i_m \rightarrow$ const >1 for the whole work cycle, lifting force $F_G \rightarrow$const (max) for the whole work cycle and driving force $F_K \rightarrow$const (min) for the whole work cycle.

Desirable optimization criteria are: that the instantaneous turning pole of rotation is between the front and rear tractor wheels, that the moment of penetration of the implement is M_p >O, until the plough does not reach the given tillage depth, that the dynamic coefficient of tractor load distribution is λ_d =0,6 for tractors (4x4)S and that the angle speed of the connecting triangle $\omega_8 \rightarrow 0$ while the plough is in the soil.

The additional criteria of optimization are the limitations prescribed by the corresponding JUS standard for tractor category 20 and 30 kN.

As the optimization criteria indicators the corresponding statistical parameters have been adopted: arithmetical mean, variation distance, standard deviation and Pirson's coefficients.

3.2 Optimization results

In the purpose of obtaining the optimal solution of the tractor hydraulic liftsystem, different variants of this device have been searched. The different variants were obtained so that one geometric parameter was changed in a certain ratio, and the rest of parameters were constant and so on. In such a way some thousand different solutions were searched, depending on optimization criteria. The solution that will meet the basic and obligatory optimization criteria was searched, and after that the desirable and additional criteria were checked. The search program was made in such a way that a solution which mostly meet the basic optimization criteria is memorized, as well as the values of optimization criteria and values of all geometric parameters of the optimal gained solution of the tractor hydraulic liftsystem.

In this way we have got four optimal solutions, which more or less, differ.

The optimal solution of the tractor hydraulic liftsystem obtained, depending on i_m and F_G, as the optimizacriteria are nearly identical and meet all given criteria to a great extend.

The optimal solution, obtained depending on F_K , as the criteria of optimization, slightly differ from the two previous optimal solutions and also greatly meet all given optimization criteria.

The optimal solution that met ω_8 , as the optimization criteria, has met only this desirable and basic criteria of optimization, while the rest ones did not meet.

As the example we give the change of the necessary driving force on the cylinder during one work circle, for constant outer load for one existing tractor (Fig. 4. curve a) and for the optimal obtained solutions, depending on optimization criteria (Fig. 4. curve b,c,d).

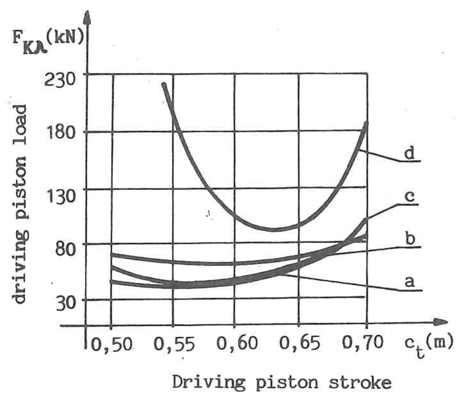

Fig.4: Necessary driving force for different solutions of tractor hydraulic liftsyştem: a) for the existing solution and for optimal solutions when the optimization criteria: b) i_m , c) F_G , d) F_K and d)ω_8

It is obvious that the optimal solution that met i_m , F_G and F_K, as the optimization criteria (Fig. 4 curve b and c) in advantage in ratio to the existing solution and optimal when the optimization criteria ω_8 (Fig. 4. curve a and d).

4. CONCLUSION

On the basis of this investigation, the following can be concluded:

1. From the totally fourteen analyzed geometric parameters, which mostly influence the work indicators of tractor hydraulic liftsystem, only two on the existing tractors could be changed during the work. This is the vertical coordinate of the support point of the upper rod and the height of the connecting triangle (Fig. 1. point H and parameters S).

By the change of Y_H coordinate, we influence to the dynamic distribution of the load on tractor wheels, while we influence to a lesser degree to the necessary drive force F_K and moment of penetration into soil M_p, and to the other indicators it does not influence.

By the change of parameter „s„ we change the dynamic load distribution on the tractor wheels, very little to the necessary driving force, while it does not influence the other indicators.

2. The parameter which is practically and technically most simple to be changeable during the work, and with which, in principle, we can efficiently influence the analyzed work indicators of the tractor hydraulic liftsystem is the length of the lower lever (Fig. 1. parameter k).

By the change of „k„ parameter we influence to the: transmission ratio of the implement, lifting force, necessary driving force on the rod and dynamic distribution on the wheels.

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TRENDS IN AGRICULTURAL ENGINEERING
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COMPUTING MAXIMUM STRESS UNDER VEHICLE RUNNING GEAR

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The paper deals with a practical way of computing the maximum vertical stress under a vehicle running gear contact area of rectangular shape representing tyres or tracks. The proposed method makes use of the formulae derived by W.Söhne and of the newly introduced form factor.

soil stress; running gear; contact area; computation

1. INTRODUCTION

Fröhlich when developing the classical Boussinesq's theory [1] of stress state in the isotropic and elastic semispace under an external load, introduced the concentration factors ν = 3 - 6 and applied them among others to the formula for vertical stress σ_z at a depth, z, under the centre of a circular plate with the radius r [2] :

$$\sigma_z = q_s \,.\, (1 - \cos^{\nu} \alpha) \quad [kPa] \qquad (1)$$

where $tg\alpha = r/z$ and q_s [kPa] means mean contact pressure. Moreover, he also suggested a solution to this problem for a parabolic loading of second degree

$$q = q_m \,.\, [1 - (\rho/r)^2] \quad [kPa] \qquad (2)$$

where q_m [kPa] means maximum pressure, valid for the whole range of his concentration factors.

Söhne [3] has intoroduced these ideas to the field of terramechanics in a classified way according to his research experience (table 1). He also provided for the detailed solution of this problem.

Grečenko [4] has combined the work by Söhne with his formula for contact patch area of agricultural tyres to demonstrate the existence of tyre loading limits with respect to soil compaction {agro-loading}.

Table 1 Conditions for stress computation by Söhne [3]

case	condition of soil	c-factor	q - distribution
1	dry, hard	4	$q_m = q_s$ = const
2	normal	5	parabola 4th degree $q_m = 1.5\ q_s$
3	loose, wet	6	parabola 2nd degree $q_m = 2\ q_s$

In his detailed analysis Söhne decided to respect the actual form of the tyre-soil interface which resulted in an exacting numerical procedure, enabling however to compute the presure bulbs.

2. VERTICAL STRESS UNDER THE CENTRE OF A RECTANGULAR AREA

A reasonable practice in terramechanics is to substitute the oval-shaped tyre contact area S_o [m^2] by a rectangle $b.l = S_o$ of proper b/l ratio. Such a form of contact patch is readily applicable to a track running gear, indeed.

Civil engineers have developed well known formulae for stress under rectangular footings in case ν = 3 , corresponding the original Boussinesq's assumptions [5], and with q_s = const. The maximum stress under the centre of such an area $S_o = b.l$ equals

$$\sigma_z = \frac{2.q_s}{\pi} . [\arctan \frac{\vartheta}{z} + 4.z.\vartheta (\frac{1}{b^2 + 4z^2} + \frac{1}{l^2 + 4z^2})] \qquad (3)$$

where

$$\vartheta = \frac{b.l}{2.(b^2 + l^2 + 4.z^2)^{1/2}} \qquad (4)$$

The author found out that this formula in case b = l (i.e. square footing) yields essentially identical results as the formula (1) with ν = 3 and equal area $S_o = b^2 = \pi r^2$ (difference less than 0.2%).

The ratio of σ_z from equation (3) for a rectangular area b.l to the stress σ_z for a square area $b.b = b^2$ of the same size S_o will be denoted <u>form factor f_c</u> :

$$f_c = \frac{\arctan \frac{\vartheta}{z} + 4.z.\vartheta\left(\frac{1}{b^2+4z^2} + \frac{1}{l^2+4z^2}\right)}{\arctan \frac{\vartheta_s}{z} + \frac{8\,z.\vartheta_s}{S_o + 4z^2}} \leq 1 \quad (5)$$

with

$$\vartheta = \frac{S_o}{2.(b^2 + l^2 + 4.z^2)^{1/2}} \quad (6)$$

$$\vartheta_s = \frac{S_o}{2.(2S_o + 4.z^2)^{1/2}} \quad (7)$$

The values of f_c become smaller as the ratio l/b increases according to the table 2 .

Table 2 <u>Values of the form factor f_c for z = 0.5 m</u>

S_o , m^2	l / b					
	1	1,5	2	4	8	16
0.05	1	0.99	0.98	0.93	0.83	0.69
0.10	1	0.99	0.98	0.88	0.74	0.58
0.20	1	0.98	0.95	0.82	0.65	0.48

Thus a longer supporting area will cause less compaction.

<u>The objective of this article</u> is to point out that there is no particular reason why the form factor as defined by the formulae (5-7) could not be applied with a reasonable accuracy to a rectangular contact area with various kinds of pressure distribution. This means in particular that in order to compute the maximum vertical stress under a rectangular contact area S_o = b.l in cases 1 - 3 (ν = 4 - 6) , the respective formulae by Söhne for the circular area of the same size S_o , equivalent to the square area by effect, are to be simply multiplied by the form factor f_c .
The possibly parabolic form of the surcharge over the rectangular area resembles that of an air-inflated structure over a rectangular basement.

<u>Example of the procedure :</u>

there is to be found the maximum σ_z [kPa] at the depth z [m] under a running gear contact area S_o with the ratio l/b and given q_s [kPa] in the case 2 :

step 1
$$l = (S_o.\frac{l}{b})^{1/2} \quad ; \quad b = (S_o.\frac{b}{l})^{1/2} \quad (8)$$

step 2 compute f_c from (5)

step 3 after Söhne - circular contact area (ν = 5)

$$\sigma_{zc} = 1.5\, q_s.[1-\cos^5\alpha - \cot an^4\alpha.(\frac{8}{3} - 5\cos\alpha + \frac{10}{3}\cos^3\alpha - \cos^5\alpha)] \quad (9)$$

where
$$\tan\alpha = r/z = (S_o / \pi)^{1/2} / z \quad (10)$$

step 4 using the form factor f_c :

$$\sigma_z = f_c . \sigma_{zc} \quad (< \sigma_{zc}) \quad (11)$$

3. CONCLUSIONS

The proposed method of computing maximum vertical stress under a rectangular contact area loaded by a parabolic surcharge seems to be prospective due to its simplicity.
The only other known procedure and means to validate the proposed method would be the exacting scheme deployed by Söhne [3] to generate the pressure bulbs.

The formula (11), combining the equations by Söhne (σ_{zc}) with the form factor f_c, can thus become an useful time-saving tool in assessing the compaction behaviour of various running gear arrangements.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

EINFLUß DER GESCHWINDIGKEIT DES STABFÖRDERERS DER KARTOFFELERNTEMASCHINE AUF KNOLLENBESCHÄDIGUNGEN

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Die Trennung von groben pflanzlichen Beimengungen, vor allem des Krautes, erfolgt bei Kartoffelerntemaschinen in der Regel auf dünnem Stabförderer, auf dessen oberen Strang die separierte Mischung vom Ende der Siebkettenvorrichtung fällt. Dabei kommt es zu Knollenbeschädigung.
Wir werden weiter unsere Aufmerksamkeit diesen Einrichtungen aus der Sicht der Knollenbeschädigung widmen.

Material und Methode

Der Sinn der weiter beschriebenen Meßmethode war festzustellen, ob die durch den behackten Stabförderer verursachten Knollenbeschädigungen größer oder im Verhältnis zu den für den Stabförderer mit glatten Stäben in der Literatur angegebenen Werten sind (Dorošev - Plešakov, 1963). Weiter wurde die Abhängigkeit von Knollenbeschädigungen von der Geschwindigkeit des Stabförderers untersucht.

Für die Messung der Abhängigkeit von Knollenbeschädigungen von der Geschwindigkeit des Stabförderers wurde die auf Fig. 1 beschriebene Apparatur angewandt.

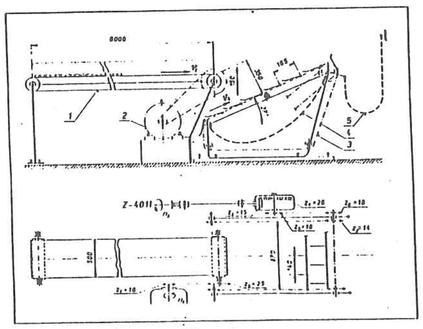

Fig.1

Schema der Meßapparatur: 1-Förderband, 2-einstellbarer Elektromotor, 3-Stabförderer, 4 und 5-Fallzelt, v_1-Geschwindigkeit des Förderbandes, v_2-Geschwindigkeit des Stabförderers

Um Knollenbeschädigungen zu vermeiden, haben die Ketten des Stabförderers Schutzdeckel. Der Stabförderer wird durch die Zapfwelle des Traktors angetrieben - siehe Schema auf Fig. 1.

Für die Messung wurden Knollen der Art Sperber benutzt, die durch ihre Kugelförmigkeit geeignet sind. Temperaturen standen bei einzelnen Serien bei 10,5°C bis 11,5°C.

Beschädigungen wurden bei drei verschiedenen Geschwindigkeiten des Förderbandes gemessen. v_1=const=1,25 ms^{-1}, 1,5 ms^{-1}, 2,0 ms^{-1} (I., II., III. Meßserie) und bei 5 Geschwindigkeiten des Stabförderers bei jeder Meßserie v_2=0,5 ms^{-1}, 1 ms^{-1}, 2 ms^{-1}, 3 ms^{-1}, 4 ms^{-1}. Jeder Versuch mit einem Kollektiv von 200 Knollen wurde viermal wiederholt, so daß der Beschädigungsmittelwert bei jedem Versuch durch Auswertung von 800 Knollen ermittelt wurde.

Herleitung der Abhängigkeit von Knollenbeschädigungen auf der Geschwindigkeit des Stabförderers und Auswertung der Meßdaten

Diese Abhängigkeit haben für den Fall eines Stabförderers mit glatten Stäben Dorošev und Plešakov (1963) gemessen. Durch die Meßdaten des Prozentualanteiles von beschädigten Knollen in Abhängigkeit auf der Stabförderergeschwindigkeit wird eine Kurve gelegt, deren analytische Formel noch nicht gefunden wurde.

Gleichmässige Knollenverteilung in der auf den Stabförderer fallenden Schicht angenommen, haben alle Knollen dieselbe Wahrscheinlichkeit von den Stäben getroffen zu werden, und so kann bei gewisser Verweinfachung die Gleichung hergeleitet werden, welche die Prozentualbeschädigung der Knollen in Abhängigkeit auf der Geschwindigkeit des Förderers angibt (Fig.2). Der Einfachheit halber setzen wir voraus, daß die Knollen kugelförmig und gleich groß sind und in einer Zeiteinheit t=1 auf den Stabförderer in senkrechter Schicht mit konstanter Geschwindigkeit v_h fallen. Beim Zusammenstoß mit dem Stab entsteht in der Schicht ein Volumen V_1 von getroffenen Knollen. Für die Herleitung setzen wir voraus, daß sich der Stab durch eine nichtbewegende Knollenschicht ($-v_h=0$) mit der Geschwindigkeit v bewegt. Es gilt:

$$v = \sqrt{v_h^2 + v_2^2} \quad (ms^{-1}) \quad \ldots (1)$$

In einer Zeiteinheit $t = 1$ durchschreitet der Stab mit Geschwindigkeit v eine Bahn $L_1 = v \cdot t = v$ und es entsteht ein Volumen:

$$V = (d + 2D) \cdot l \cdot L_1 = (d + 2D) \cdot l \cdot v \quad (m^3) \quad \ldots (2)$$

Die Knollen können durch den Stab im Volumen V_1 getroffen werden:

$$V_1 = (d + 2D) \cdot l \cdot š_1 = (d + 2D) \cdot l \cdot š \cdot (\cos\alpha)^{-1} \quad (m^3) \quad \ldots (3)$$

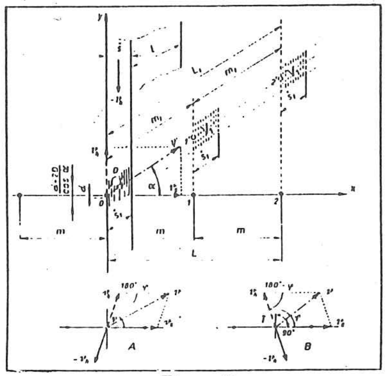

Fig. 2

Die Einwirkung des Stabes auf die Knollenschicht:
d - Stabdurchmesser, D - Knollendurchmesser,
m - Stababstand, m_1 - Bahn des Stabes mit Geschwindigkeit v zwischen zwei Zusammenstößen mit der Knollenschicht,
L - Bahn des Stabes mit Geschwindigkeit v_2 in einer Zeiteinheit,
š - Tiefe der Knollenschicht,
$š_1$ - Bahn des Stabes mit Geschwindigkeit v in der Knollenschicht,
l - Breite der Knollenschicht, V_1 - Zusammenstoßvolumen.
A - Vektorenwinkel v_h, v_2 ist kleiner als 90°,
B - Vektorenwinkel v_h, v_2 ist größer als 90°.

In einer Zeiteinheit t geht durch die Schicht gewisse Anzahl von Stäben:

$$n = L_1/ m_1 = v/ m_1 = v \cdot \cos\alpha \cdot m^{-1} \quad \ldots (4)$$

Jeder Stab hat ein Zusammenstoßvolumen V_1, in der Summa werden pro Zeiteinheit Knollen im Volumen V_2 getroffen, $V_2 = n \cdot V_1$ (m^3)

Nach Einsetzen in (3) und (4):

$$V_2 = V \cdot m^{-1} \cdot \cos\alpha \cdot (d + 2D) \cdot l \cdot š \cdot (\cos\alpha)^{-1} = V \cdot š \cdot m^{-1} \quad \ldots (5)$$

In derselben Zeiteinheit haben die in einer Schicht vom Durchschnitt $š\ l$ (m^2) mit Geschwindigkeit v_h (ms^{-1}) fallenden Knollen ein Volumen:

$$V_h = š \cdot l \cdot v_h \quad (m^3) \quad \ldots (6)$$

Der Volumenquotient : $p_1 = V_2/ V_h = (V_2 \cdot N) \cdot (V_h \cdot N)^{-1}$ ... (7)
gibt die Wahrscheinlichkeit des Zusammmestoßes mit dem Stab an (N - Knollenanzahl).
Die Wahrscheinlichkeit einer Beschädigung nach dem Zusammenstoß kann als Volumenquotient der beschädigten und getroffenen Knollen ausgedrückt werden:

$$p_2 = V_3/ V_2 \quad \ldots (8)$$

Die Wahrscheinlichkeit von Präsenz beschädigter Knollen im Volumen V_h ist bedingte Wahrscheinlichkeit. Also aus (7) und (8) folgt:

$$p = V_3/V_h = p_1 \cdot p_2 \quad \ldots (9)$$

Nach Einsetzen von p_1 aus (7), (5), (6) folgt endlich:

$$p = p_2 \cdot \sqrt{(d + 2D)^2 \cdot v_h^2 / m^2 \cdot v_h + (d + 2D)^2 \cdot v_2^2 / v_h^2 \cdot m^2} \quad \ldots (10)$$

d, m, D und v_h können als konstant angesehen werden, p_1 ist von der Geschwindigkeit v_2 abhängig und auch p_2 ist von dieser Geschwindigkeit abhängig. Der Einfachheit halber nehmen wir an, daß p_2 proportional zu p_1 sein wird : $p_2 = k\ p_1$, k ist Proportionalkonstante.

Also:

$$p = k \cdot p_1^2 = k \cdot ((d + 2D)^2/m^2 + (d + 2D)^2 \cdot v_2^2 / m^2\ v_h^2) \quad \ldots (11)$$

setzen wir : $a_1 = (d + 2D)^2/m^2$; $b_1 = (d+2D)^2/m^2 \cdot v_h^2$

Dann : $p = k (a_1 + b_1 \cdot v_2^2)$ ... (12)

Im Prozentsatz wird für beschädigte Knollen gelten:

$P = 100 \cdot p$, also: $P = k \cdot (a + b \cdot v_2^2)$ (%) ... (13)

Die Gleichung (13) kann nur dann gelten, wenn der Geschwindigkeitsvektor v_h auf den Geschwindigkeitsvektor v_2 im Moment des Zusammenstoßes senkrecht steht. Falls der von beiden Vektoren zusammengeschlossene Winkel nicht recht ist, wird folgendes gelten:

a) $\varphi < 90°$, $v = \sqrt{v_h^2 + 2 v_h v_2 \cos\varphi + v_2^2}$,

$$P = k \cdot (a_2 + b_2 v_2 + c_2 v_2^2) \quad (\%) \quad \ldots (14)$$

b) $\varphi > 90°$, $v = \sqrt{v_h^2 - 2 v_h v_2 \sin\varphi + v_2^2}$,

$$P = k \cdot (a_3 - b_3 v_2 + c_3 v_2^2) \quad (\%) \quad \ldots (15)$$

Die Konstanten a_i, b_i, c_i der hergeleiteten Parabeln können durch Konstruktionsparameter des Stabförderers beeinflut werden. Die Herleitung wäre ähnlich wie im senkrechten Fall.

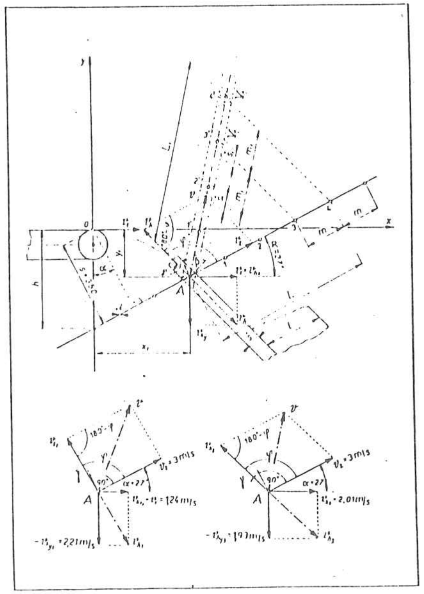

Fig. 3
Wirkung des Stabes des Stabförderers auf die Knollenschicht bei der Messung des Einflusses seiner Geschwindigkeit v_2 auf die Knollenbeschädigung.

Damit es möglich wäre zu beurteilen, welche aus den angegebenen Gleichungen (13) bis (15) den Meßdaten entsprechen könnte, wurden für alle Versuchsserien die Geschwindigkeiten des Förderbandes berechnet (Tab. 1).

$v_1 = \pi \cdot d_1 \cdot n_1/60$ (ms^{-1}),
d_1 - Trommeldurchmesser, n_1 - Drehzahl.

Weiter wurden Geschwindigkeiten der Knollenschicht im Augenblick des Zusammenstoßes mit dem Stabförderer ermittelt. Aus Fig. 3 geht für die Koordinaten der Knolle hervor:

$$x = v_1 \cdot t \ ; \ y = -g \cdot t^2/2 \ ; \ y = f(x) = (-g \cdot x^2):(2 \cdot v_1^2) \quad \ldots (16)$$

Für die Koordinaten des Stabes gilt (17):

$$x = v_2 \cdot t \cdot \cos\alpha \ ; \ y = (v_2 \cdot t \cdot \sin\alpha - h); \ y = f(x) = (x\,tg\alpha - h)$$

Nach Auflösung von (16) und (17) gilt für den Punkt $A(x_1, y_1)$ des Zusammenstoßes :

$$y_1 = \left(\left(-tg\alpha \pm \sqrt{tg^2\alpha + 2gh/v_1^2}\right) \cdot v_1^2 \cdot tg\alpha \right)/g - h \quad \ldots (18)$$

Für die Geschwindigkeit der Knolle im Punkte A gilt :

$v_h = \sqrt{v_{hx}^2 + v_{hy}^2}$, wo $v_{hx} = v_1$ = const., und $v_{hy} = -gt$.

Nach Auflösung: $v_h = \sqrt{v_1^2 - 2gy_1}$

Die Geschwindigkeiten v_h sind in der Tab. 1 angegeben, graphische Darstellung auf Fig. 3.

Tab. 1: Knollengeschwindigkeiten im Augenblick des Zusammenstoßes mit den Stäben des Stabförderers (Fig. 3)

Serie	y_1 (m)	$v_1 = v_{hx}$ (ms^{-1})	v_{hy} (ms^{-1})	v_h (ms^{-1})
I	-0,250	1,24	2,215	2,538
II	-0,228	1,50	2,155	2,593
III	-0,190	2,01	1,934	2,789

Die ermittelte Knollenbeschädigung wurde im Prozentsatz P_c (%) der Gesamtbeschädigung und im Prozentsatz P_m der maximalen Beschädigung (Brečka - Mareš, 1965) ausgewertet.

Resultate

Die Trennungsfunktion des Stabförderers ist durch den Stand von Kraut, durch technische Konstruktion des Förderers und seine Arbeitsgeschwindigkeit bedingt. Der wichtigste Faktor ist die Geschwindigkeit, welche die Beschädigungen stark beeinflußt.

Tab. 2: Durchschnittliche Werte der Förderbandgeschwindigkeit v_1 (ms^{-1}), der Satbförderergeschwindigkeit v_2 (ms^{-1}) und der Knollenbeschädigung. P_1 - Knollenbeschädigung, P_c - Gesamtbeschädigung , P_m - Maximalbeschädigung.

Serie	Versuch	v_1	v_2	P_1	P_c	P_m
I	I/1	1,24	0,50	10,12	4,25	3,71
	I/2	1,24	0,99	8,25	3,57	3,12
	I/3	1,24	1,98	8,62	5,19	4,89
	I/4	1,24	3,00	25,00	23,56	20,62
	I/5	1,24	4,01	49,37	53,08	40,87
II	II/1	1,50	0,50	7,25	2,72	2,41
	II/2	1,50	0,99	12,87	4,87	4,19
	II/3	1,50	1,98	12,37	8,31	7,67
	II/4	1,50	3,00	23,25	17,05	15,82
	II/5	1,50	4,01	40,87	48,81	36,07
III	III/1	2,01	0,50	13,50	5,66	5,08
	III/2	2,01	0,99	13,87	4,01	3,69
	III/3	2,01	1,98	12,50	9,63	7,69
	III/4	2,01	3,00	21,12	18,14	14,29
	III/5	2,01	4,01	42,50	40,16	30,48

Tab.3: Regressionsgleichungen, welche die Abhängigkeit der Veränderung des Prozentsatzes von Beschädigten Knollen P_i (%) von der Geschwindigkeit des Stabförderers v_2 (ms^{-1}) angeben.

Serie	v_1	Regressionsgleichung	Korl. Index
I	1,24	$P_i = 16,1947 - 14,4679v_2 + 5,6889v_2$	0,999
II	1,50	$P_i = 10,987 - 4,6181v_2 + 2,9795v_2$	0.996
III	2,01	$P_i = 20,6428 - 3,5359v_2 + 4,7016v_2$	0,998

Aus der Tabelle geht hervor, daß die Korellationsindexe sehr hoch sind, also wird die hergeleitete Parabelgleichung (15) sehr gut den Meßdaten entsprechen. Die Voraussetzung der Proporzionalität zwischen der Wahrscheinlichkeit des Zusammmenstoßes der Knolle mit dem Stab und der Wahrscheinlichkeit der Beschädigung ist also nicht im Widerspruch mit den Meßdaten.

Tab. 4: Regressionsgleichungen der Gesamtbeschädigung P_c (%) und der Maximalbeschädigung in Abhängigkeit von der Geschwindigkeit des Stabförderers v_2 (ms^{-1}).

Serie	v_1	Regressionsgleichung	Kor. Index
I	1,24	$P_{c1} = 10,8251 - 14,9568v_2 + 6,36018v_2$	0,999
II	1,50	$P_{c2} = 9,4515 - 12,2213v_2 + 5,40790v_2$	0,995
III	2,01	$P_{c3} = 8,8583 - 8,3314v_2 + 3,99007v_2$	0,999
I	1,24	$P_{m1} = 7,3658 - 9,3172v_2 + 4,43345v_2$	0,998
II	1,50	$P_{m2} = 5,6937 - 6,0929v_2 + 3,36200v_2$	0,997
III	2,01	$P_{m3} = 7,4926 - 6,3918v_2 + 3,00202v_2$	0,998

Aus den Korellationsindexen geht hervor, daß auch hier die Parabelgleichung sehr gut den Medaten entspricht.

Aus den Meßresultaten geht hervor, daß alle Beschädigungsarten die kleinsten Werte bei gewissen optimalen Geschwindigkeiten des Stabförderers erreichen.

Tab.5: Minimale Werte der Beschädigungsarten P_i, P_c, P_m (%) und entsprechende Geschwindigkeiten des Stabförderers v_2 (ms^{-1}). v_1 (ms^{-1}) ist die Förderbandgeschwindigkeit.

Serie	v_1	Beschädigung	P_i	P_c	P_m
I	1,24	%	6,99	2,03	2,47
		v_2 optimal	1,27	1,17	1,05
II	1,50	%	9,19	2,54	2,93
		v_2 optimal	0,77	1,13	0,90
III	2,01	%	10,90	4,50	4,09
		v_2 optimal	1,43	1,04	1,06

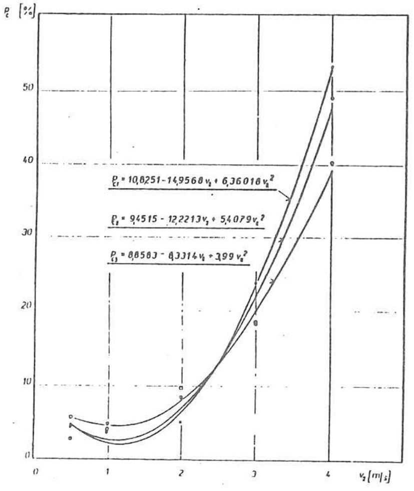

Fig. 7

Gesamtbeschädigung der Knollen P_c durch den Stabförderer bei den Geschwindigkeiten P_{c1} - v_1 = 1,24 m/s, P_{c2} - v_1 = 1,50 m/s, P_{c3} - v_1 = 2,01 m/s des Förderbandes.

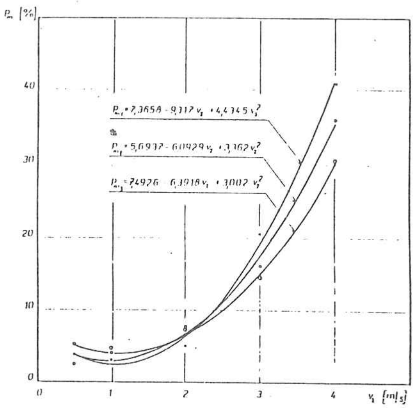

Fig. 8:
Maximalbeschädigung der Knollen P_m durch den Stabförderer bei den Geschwindigkeiten P_{m1} - v_1 = 1,24 m/s , P_{m2} - v_1 = 1,50 m/s, P_{m3} - v_1 = 2,01 m/s des Förderbandes.

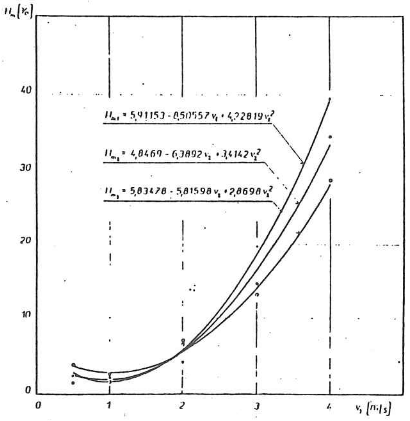

Fig. 9
Grobe Maximalbeschädigung der Knollen H_m durch den Stabförderer bei den Geschwindigkeiten H_{m1} - v_1 = 1,24 m/s, H_{m2} - v_1 = 1,50 m/s , H_{m3} - v_1 = 2,01 m/s des Förderbandes.

Abschlußresultate

Durch die Versuche wurde gezeigt, daß die Gleichung (15) unter gewissen Voraussetzungen den Meßdaten entspricht. Weiter wurde gezeigt, daß der behackte Stabförderer mehrere Knollen beschädigt, als der normale Stabförderer. In unserem Versuch wurden bei Geschwindigkeit des Förderbandes v_1 = 1,24 m/s und bei Geschwindigkeit des behackten Stabförderers v_2 = 2,01 m/s 9,85% beschädigte Knollen ermittelt, bei v_2 = 4 m/s schon 49,65% beschädigte Knollen. Die kleinsten Werte der Maximalbeschädigung P_{min} = 2,47 bis 4,09 % wurden bei optimaler Geschwindigkeit des Stabförderers $v_{2optimal}$ = 0,9 bis 1,06 m/s ermittelt.

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TRENDS IN AGRICULTURAL ENGINEERING
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NEUE MÖGLICHKEITEN ZUR MOBILEN MESSDATENERFASSUNG UND -AUSWERTUNG VON DREHMOMENTEN UND LEISTUNGEN AN LANDWIRTSCHAFTLICHEN MASCHINEN

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A new PC-system method is able to measure technical datas directly on a moving machine on the field. The torque measured by a new designed device is able to be registered in a high frequency range. The PC-system is able to store all measured figures on a digital basis. So the datas can be calculated and a classification is possible. A new transputer system stores 16 M byte that are about 8 x 10^6 measured datas.

1. EINLEITUNG

Wohl in allen Entwicklungsabteilungen gibt es immer wieder das Problem, daß der Konstrukteur für die Auslegung von Maschinenteilen keine ausreichende Datenbasis zur Verfügung hat. So ist der Konstrukteur vielfach gezwungen, Werte aus seiner allgemeinen Erfahrung heranzuziehen.

Hier setzt nun ein am Institut für Landmaschinen der TU Braunschweig entwickeltes mobiles Meß- und Auswertesystem an. Dieses System beruht auf einer PC-Datenerfassung. Das Programm selbst ist so vereinfacht, daß eine Festplatte nicht mehr benötigt wird. Bei gleichzeitiger Aufnahme von z.B. Drehmoment und Drehzahl läßt sich dann auch die momentan benötigte Leistung direkt errechnen.

Ein Einsatzbereich für eine solche Meß- und Auswertetechnik bezieht sich auf die Messung der vom Traktor abgegebenen Zapfwellenleistung. Deshalb galt unser Hauptaugenmerk zunächst der Messung des Ausgangsdrehmomentes am Zapfwellenstummel und der dazugehörenden Drehzahl.

2. ENTWICKLUNG EINER DREHMOMENTMEẞWELLE

Herkömmliche Drehmomentmeßwellen sind aufgrund ihrer Biegemomentenempfindlichkeit, ohne den zusätzlichen Einbau einer Bogenzahnkupplung, nur bedingt geeignet, wie schon in früheren Versuchen gesichert festgestellt wurde /1/. Deshalb wurde am Institut für Landmaschinen die im Bild 1 dargestellte Meßwelle entwickelt, dessen Torsionskörper weitgehend biegemomentunempfindlich ist. Außerdem wurde der Torsionswinkel von ca. 1 Grad (bei herkömmlichen Meßwellen) auf 0,04 Grad durch Verwendung einer Vollwelle aus einer Speziallegierung reduziert.

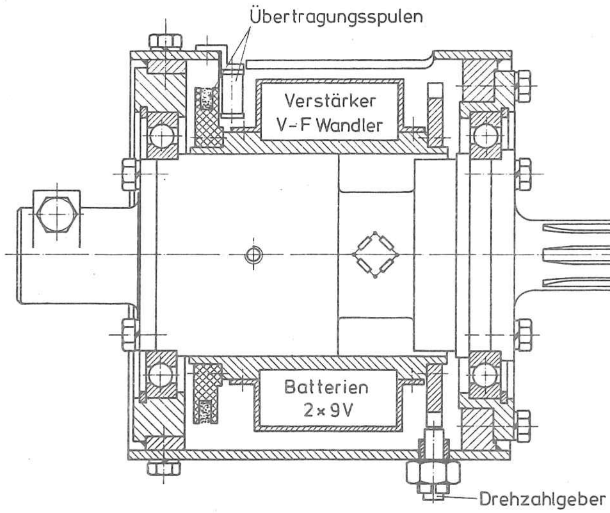

Bild 1: Drehmomentmeßwelle

Ein speziell entwickelter Meßverstärker mit anschließender Spannungs-Frequenz-Wandlung wurde in die Meßwelle integriert. Zur Übertragung des Meßsignales wurde wegen der Störanfälligkeit eines Schleifringkörpers ein induktives Verfahren gewählt. Damit konnte die Schmutz- und Vibrationsunempfindlichkeit erheblich verbessert werden. Allerdings war es dazu notwendig, daß die Spannungsversorgung ebenfalls mit umläuft. Durch die außerordentlich hohe Drehsteifigkeit sind Drehmomente bis 1000 Nm bei einer Drehzahl bis 1500 min^{-1} wegen der hohen Resonanzfrequenz möglich. Möglich ist auch eine Anhebung der oberen Drehmomentgrenze ohne nennenswerte Einschränkung der Meßgenauigkeit im unteren Bereich. Die Welle selbst ist mit 3-facher Sicherheit ausgelegt. Dadurch ist eine Zerstörung praktisch ausgeschlossen.

3. MEẞDATENERFASSUNG UND -AUSWERTUNG

Die Signale von der Drehmomentenmeßwelle (Drehmoment und Drehzahl) werden dann über einen Meßverstärker und einen Meßwandler, der z.B. das in Form einer Frequenz anliegende Drehmoment-Signal wieder in eine analoge Spannung umwandelt, auf einen A/D-Wandler geleitet. Meßverstärkerkarte und Meßwandler sind an die ankommenden Signale

angepaßt und sind ebenso wie der A/D-Wandler im PC mit untergebracht. Alle Einheiten können vom Bordnetz des Traktors versorgt werden. Der A/D-Wandler hat eine Auflösung von 12 bit und kann bis zu 16 Kanäle gleichzeitig abfragen. Es ist eine Summenabtastrate bis 10 kHz möglich.

Als Rechner wurde ein eigener IBM-kompatibler PC aus verschiedenen Baugruppen speziell aufgebaut, der im Bild 2 gezeigt ist. Charakteristisch daran ist, daß er keine eigene Festplatte enthält. Alle Daten werden über eine schnelle Links-Schnittstelle (20 Mbit/s) in einem Transputersystem zwischengespeichert; dadurch wird die Problematik der Schwingungsempfindlichkeit der Festplatte beim mobilen Einsatz vermieden.

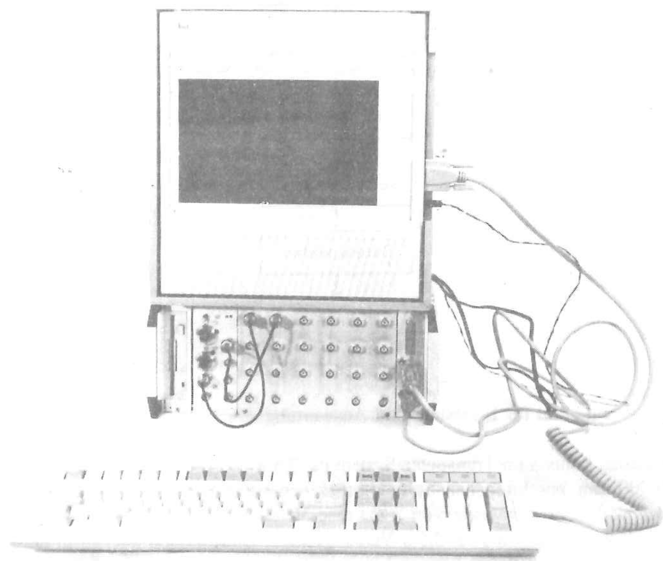

Bild 2: Meßdatenerfassungs- und -auswerteeinheit

Das Programm, das den Meßvorgang steuert, ist eine Eigenentwicklung, in der Hochsprache C geschrieben. Dabei wurde besonderer Wert auf eine einfache Bedienbarkeit gelegt. Das Ablaufschema ist im Bild 3 dargestellt. Nach dem Abgleichen der einzelnen Meßkanäle erfolgt die Eingabe der Abtastrate und der Versuchszeit.

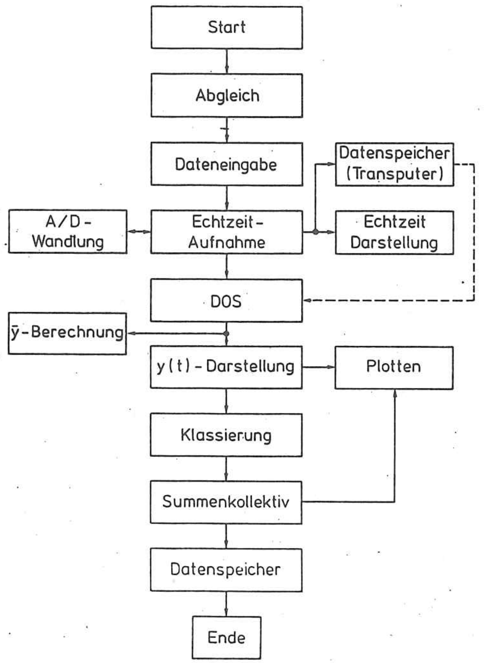

Bild 3: Flußbild für Erfassung und Auswertung

Maximal können im Transputer-System ca. 7,5 x 10^6 Meßwerte abgelegt werden, was etwa 16000 eng beschriebenen Schreibmaschinenseiten entpricht. Das bedeutet z.B. bei 3 Kanälen und einer Abtastrate von 2 ms eine Versuchszeit von 1,5 h oder entsprechend bei einer Abtastrate von 5 ms ca. 3,5 s Versuchsdauer. Diese Zeiten reichen in der Regel völlig aus. Die gemessenen Werte können bereits während des Versuches auf dem Display in y = f (t)-Darstellung angezeigt und verfolgt werden. Damit ist die erste Kontrolle der gemessenen Werte schon während der Versuche möglich. Sollte hier ein Fehler festgestellt werden, kann der Versuch sofort ohne Zeitverlust wiederholt werden. Nach dem Versuch wird auf das DOS-Betriebssystem umgeschaltet und der gesamte Versuch kann mit allen gemessenen und errechneten Werten in einem Diagramm in y = f (t)-Darstellung erneut eventuell auch gespreizt dargestellt werden. Das Programm ist so aufgebaut, daß neben den gemessenen Größen (hier Drehmoment und Drehzahl) auch unmittelbar die dazugehörige Leistung mit berechnet und auf dem Display als Kurven angezeigt werden. Alle drei Parameter geben nun eine erste Aussage für den Konstrukteur.

Diese Daten alleine sind aber noch nicht aussagekräftig genug. Für die Auslegung ist neben der Auskunft über die Spitzenmomente und -leistungen auch die Aussage über deren Einwirkdauer und über die entsprechenden Mittelwerte nötig. Hier bietet es sich an, alle Daten nach dem Verweildauerverfahren in Klassenstufen (hier 128 Stufen) zu klassieren und sie für den gesamten Meßzeitraum oder für bestimmte - frei wählbare Bereiche - zu berechnen und anzuzeigen. Die Wahl dieser Bereiche erfolgt direkt am Bildschirm, so daß man sich hier auch bestimmte interessierende Vorgänge z.B. beim Anfahren heraussuchen kann.

Bisher wurde das Programm beschrieben, mit dem eine Analyse des Vorganges selbst möglich ist. Wenn man nun Daten über einen noch längeren Zeitraum sammeln will, dann hat man die Möglichkeit auf die Echtzeit-Aufzeichnung zu verzichten. Alle Meßgrößen werden ebenfalls nach dem Verweildauerverfahren sofort in bis zu 2048 Klassen eingeteilt und die Verweilzeit des Signals in jeder Klasse gezählt. Die Leistung wird gleichzeitig mit berechnet und klassiert. Mit dieser Methode kann praktisch unbegrenzt das Lastkollektiv berechnet und auf dem Bildschirm sichtbar gemacht werden.

Der in Bild 4 gezeigte Aufbau diente zur Überprüfung der Meßdatenerfassungs- und auswertungseinheit. Eine Antriebseinheit - hier ein Elektromotor mit einem hydraulisch verstellbaren Variatorantrieb vom Mähdrescher - treibt über die Drehmomentmeßwelle einen Verbraucher - hier ein großes Gebläse, dessen Leistungsbedarf durch Drosselung der Zuluft ein-

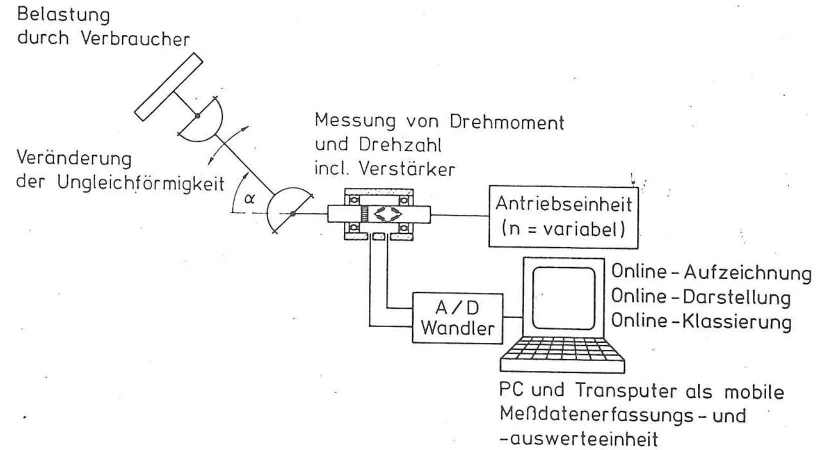

Bild 4: Meßaufbau (schematisch)

stellbar ist - an. Zwischen dem Gebläse und der Drehmomentenmeßwelle wird das Drehmoment mit einer Gelenkwelle übertragen. Dadurch ist es leicht möglich, den Übertragungswinkel zu verändern und somit verschiedene Ungleichförmigkeiten im Gelenkwellenstrang zu erzeugen. Dieser Versuchsaufbau wurde gewählt, weil es bekanntlich beim Antrieb einer großen Masse, bedingt durch die Federsteifigkeit der Antriebswellen und der Meßwelle, bei entsprechender Anregung zu Resonanzschwingungen im System kommen kann. Diese Reso anzfrequenz wurde bei dem vorgestellten System wegen der hohen Steifigkeit nicht erreicht.

4. DARSTELLUNG DER MEßERGEBNISSE

Der Verlauf der Drehzahl, des Drehmomentes und der daraus berechneten Leistung ist für den eben beschriebenen Versuchsaufbau im Bild 5 dargestellt. Dabei zeigen die beiden oberen Diagramme die jeweiligen Meßwerte aufgetragen über der Echtzeit.

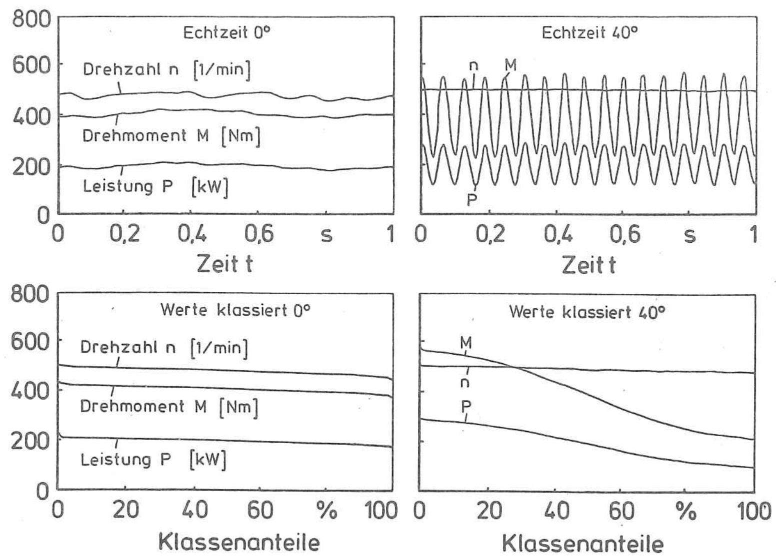

Bild 5: On-line-Darstellung und Klassierung

Die bei nahezu konstanter Drehzahl auftretenden Drehmomentschwankungen sind natürlich auch beim Verlauf der Leistungen wiederzufinden. Die Ungleichförmigkeit ist bei einem Übertragungswinkel von 40° zwischen Abtriebsstummel und Antriebstummel deutlich sichtbar. Das entsprechende Ergebnis ist auch in den unteren Bildern erkennbar. Deutlich wird hier auch der wesentlich gleichmäßigere Verlauf der klassierten Werte für 0°.

5. MESSUNG DES DREHMOMENTENVERLAUFS BEI EINER RUNDBALLENPRESSE

Nach den guten Ergebnissen auf dem stationären Versuchsstand wurden die Messungen auf dem Feld fortgesetzt. Dazu wurde mit freundlicher Unterstützung durch die Firma Welger der Drehmomentverlauf an zwei gleich großen Rundballenpressen unterschiedlicher Bauart auf dem gleichen Feld, am gleichen Tag, mit dem gleichen Fahrer und der gleichen Fahrgeschwindigkeit gemessen. Die Versuchsdauer für je 3 Ballen betrug etwa 3,5 min. Der Verlauf der Kurven (im Bild 6) sowohl bei der Presse A als auch bei der Presse B zeigt noch nicht auf den ersten Blick einen direkt erkennbaren Unterschied.

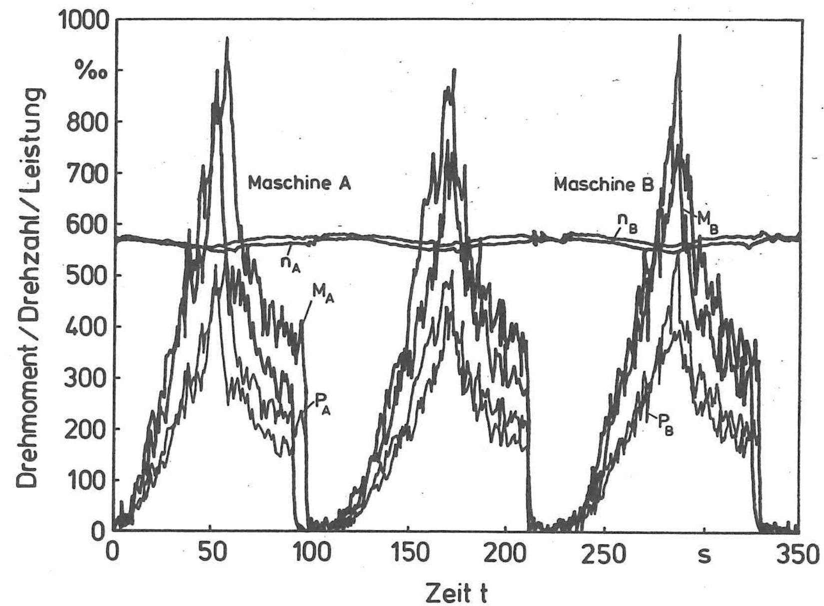

Bild 6: Drehmoment, Drehzahl und Leistung in Echtzeit bei zwei verschiedenen Rundballenpressen

Auch wenn man die Kurven übereinanderlegt, wird nicht unmittelbar ein Unterschied sichtbar. Klassiert man aber die gerade aufgezeichneten Werte über den gesamten Zeitraum, dann werden doch erhebliche Unterschiede deutlich (siehe Bild 7). So ist die Presse A

gegenüber der Presse B bei nahezu gleicher Drehzahl im mittleren Drehmoment und damit auch im Leistungsbedarf um ca. 20 % schlechter. Noch stärker wird der Unterschied, wenn man die Ballendichte mit einbezieht, die bei der Presse B im Mittel sogar noch um ca. 8 % höher lag als bei Presse A.

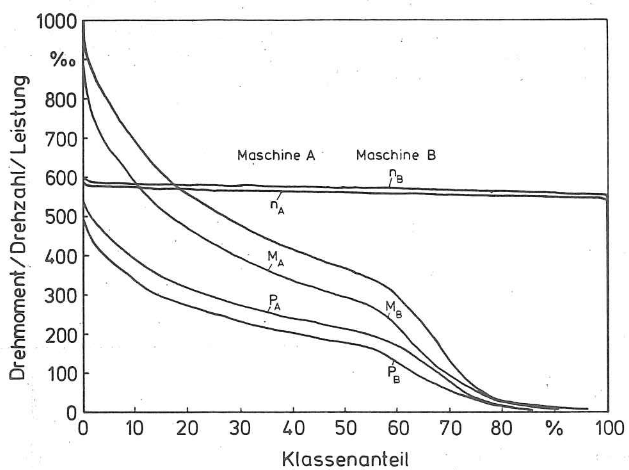

Bild 7: Drehmoment, Drehzahl und Leistung (klassierte Werte) bei zwei verschiedenen Rundballenpressen

6. ZUSAMMENFASSUNG UND AUSBLICK

Mit dem hier vorgestellten Meßdatenerfassungs- und auswertungssystem wird eine gute Basis für die Erfassung von verschiedenen Meßwerten auf mobilen Arbeitsmaschinen am Beispiel von Drehmoment, Drehzahl und Leistung einer Rundballenpresse vorgestellt. Die gleiche Ausrüstung läßt sich gleichzeitig auch als Regelungseinheit einsetzen, was insbesondere durch den Einsatz des Transputers noch gute Weiterentwicklungsmöglichkeiten für die Zukunft bietet.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

TRENDS IN AGRICULTURAL MECHANIZATION IN COUNTRIES OF THE THIRD WORLD

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Summary: At present the agricultural machines and equipment for plant cultivation can be divided in four main groups.

1) HAND-TOOL IMPLEMENTS

2) DRAUGHT ANIMAL-TOOL IMPLEMENTS

3) AGRICULTURAL MACHINES WITH ENERGETIC UNITS

4) FULL AUTOMATIC UP-TO-DATE MACHINES

It is generally presumed that at present agricultural machines from the third and fourth of the above mentioned items are used in the world. The truth is somewhat different. For the time being more then 90% of the Third world, mainly the countries with tropical and subtropical conditions, carry out the tillage work by the hand-tool implements and draught-animal tools.

Key words: suitable technology, appropriate technology, full-scope mechanization, draught animal technology, hand-tool implements,

Introduction.

The main problems of the THIRD WORLD include the very low technological standard of agricultural production. Measures taken in the past for increasing the energy saturation of agricultural production often failed to succeed, because the principals of "appropriate technology" were not respected.

As to the "appropriate" or "intermediate technology", e.g. farming systems corresponding to technico-social conditions and (above all) economic (financial) possibilities of producers (farmers), at least four types of technologies or three types of technological levels theoreticaly differentiated by energy inputs in production can be found.

These can be:
- SPECIAL MACHINERY SYSTEMS (FULL-SCOPE MECHANIZATION),
- PARTLY MECHANIZED
- DRAUGHT ANIMAL and HAND-TOOL GROWING TECHNOLOGIES

The trends observed in the agricultural mechanization in the countries in question subject to the above mentioned farming levels and, because of the objective need to respect actual production conditions, aim at gradual changes toward higher and more effective production stages.

Characteristics of technical levels.

The farm "appropriate technology" is used for a certain stage of development of the method and technology of the plant growing (developing from subsistance farming up to large-scale production of commercial crops). At any rate, it means machinery corresponding to the economic, organizational and physical possibilities of producers and, at the same time, acceptable from the sociological point of view.

The practical implementation of the "appropriate technology" is a prerequisite for removing the food crisis of the Third World which includes the following partial tasks:
- increase of the areas of cultivated land
- increase of the soil fertility (irrigation, drainage, de-salting)
- control of diseases and insects
- rational fertilization
- introduction of new crops and cultures
- removal of illiteracy, adult-education activities

Taking the above shown criteria as well as the fact that a technological level is mainly characterized by the degree of energy inputs more or less corresponding to mechanical , animal and human power spent on growing processes, the following classification of technological levels can be offered.

1. SPECIAL MACHINERY SYSTEM TECHNOLOGY (FULL-SCOPE MECHANIZATION).

This is based upon heavy-duty machine lines the machines and equipment of which link one to another technically and agrotechnically having a corresponding capacity output. This technology suits a large-scale form of production either for intensive or extensive farming, noted for lower yields, however, huge production areas. There are also fully mechanized lines of lower capacity (Japanese model) working on small-tractor types.

2. PARTLY MECHANIZED TECHNOLOGY.

The main working processes like soil tillage, fertilizing, sowing and harvest are executed by tractor operated or self-propelled machines. All the operations of inter-cultivation and, very often, grain harvest, are done by hand tools or by simple machines drawn by animals.

3. DRAUGHT ANIMAL TECHNOLOGY.

The main operations such as soil preparation and, on occasion, some of inter-cultivation are executed by animal drawn implement. The sowing and land clearing (removing old vegetation) are carried out either by animal drawn machines (implement) or by hand tools, the rest of the working processes, including harvest, are hand-tool. This technology is of lower energy output character having its number of working operations considerably limited. Manuring, basic fertilizing as well as chemical weeding is rarely practiced.

4. HAND-TOOL TECHNOLOGY.

The number of working processes of enormes reduced on some basic hand-tools ones that can be: old vegetation removing and land clearance, seed-planting (combined, eventually, with compost manuring), hoeing /weeding, harvest, drying and corn cleaning. The technology finds on the lowest energy input stage that does not enable the peasant to cultivate large areas. Its simplicity and lowest energy requirements makes it possible to be fully used in huge backward regions by economicaly weak rural inhabitants.

DEVELOPING TRENDS WITHIN SEPARATE FARMING SYSTEMS.

It is possible divide this study acording to continents. First of all it is necessary to consider all conditions, which means economics, social and political conditions which influence culture and standard of life in all the countries of the world. In this article we turn our aim to the specific subject, namely how and which agricultural machines are used takening into account the factor of technology which is used on the particular continent.

AFRICA: Is the largest continent in the world. Regarding to agriculture, Africa is influenced by its position from the equator and the climat is mainly influenced by the sea. Typical for North and South Africa is the Partly Mechanized Technology and Draught Animal Technology (45%). The Hand-Tool Technology is used in 42% and the Special Machinery System Technology is used as well, mainly harvesting machines and some technologies for post-harvest technology and storage.

Trends until 1999 are that the present situation will not change much, only rich countries will up-date farm equipment, machines and technologies.

For "Equator Africa" and countries without the sea is typical the Draught-Animal Technology and the Hand-Tool Technology. Occasionally simple energetical units as simple small tractors or some stationary I.C. Engine are used. It seems that the situation will not change much.

Agriculture in Africa needs subsidies so that the food crisis of this continent will be solved.

AMERICA: North America is known as a continent where in agriculture and food production up-to-date machines and technologies are used which are present in the group of the Special Machinery System Technology. The named machines and technologies are not only with high efficiency and economical, but their design corresponds to environmental requirements as well.

Central and South America correspond as to agricultural conditions with Africans conditions. The Draught-Animal and the Hand-Tool Technologies are typical for this continent (70%). Only in Mexico and Brazil are tillage and harvest works carried out by the Partly Mechanized Technology (25%), and occasionally some machines from the Special Machinery System Technology are used mainly in the post-harvest technology, storage and food production technology.

Good perspectives to improve the agriculture have mainly Mexico, Argentine, Brazil, Venezuela and Panama.

ASIA: Asia is again an area where ninety percent of all agricultural production is performed in tropical and subtropical conditions. From 70% to 80% of all agricultural work is carried out by the Draught-Animal and Hand-Tool Technology. About 20% is used the Partly Mechanized Technology. Exceptionally is used the Special Machinery System Technology. This exception are countries such as Israel, Saudia Arabia, South Korea and Pakistan, where mainly the water system, water storage and food technologies are on a very good level. Trends in agriculture in Asia will be created by the above mentioned countries which will govern the development in this part of the world. A new, but not important role will play countries from the former USSR.

AUSTRALIA: Australia with a special climat which is near the European conditions in the south, through subtropical conditions to tropical conditions near the equator. In Australia is generally applied the Partly Mechanized Technology and the Special Machinery System Technology where mainly harvest of crops is provided by the up-to-date harvest machines which are made mainly in the US or West Europe. Post-harvest technology and green-house technology are on a good level as well.

Trends in Australia are similar as in North America, it means to reduce the production expences and minimize loses in post-harvest and storage technology.

EUROPE: Europe is a continent where the Western and Central European countries has agriculture on a very good level and where in 85% the Special Machinery System Technology is used. Some countries in Europe, mainly post-communist countries, together with Greece and Turkey are not on the same level as Western Europe.

A typical representantative where the Partly Mechanized Technology is used is Romania, Poland and European countries from the former USSR. It seams that Czechoslovakia and Hungary will be in the course of two or three years competitors as to agricultural production and food production with possibilities to go to the Western European market. The rest of the Eropean countries will slowly increase the level of agriculture. The presumtion of the above mentioned forecasting is that situation in the East-South Europe will be stabilized.

From the above mentioned information it is posible to notice that the up-to-date machines and technologies are applied only in the devoloped countries of the world.

In seventy percent countries of world are used the Partly Mechanized, Draught-Animal and Hand-tool technologies. Mainly economic situation in the Third world doesn't allow the application of up-to-date technologies. It would be nice if the producers of agricultural machines would consider the above mentioned situation and would adapt their production program to the real needs.

TRENDS IN AGRICULTURAL ENGINEERING
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Perspektiven in der Technik der pflanzlichen Produktion

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Kurzfassung

Die derzeitige Überschußsituation für Agrarprodukte hat oft zur Folge, daß weitere Fortschritte in der Produktionstechnik als nicht erforderlich oder sogar unerwünscht angesehen werden. Diese Betrachtungsweise läßt außer acht, daß nicht weltweit ein Stopp im Fortschritt der Produktionstechnik verordnet werden kann. Die arbeitssparende, ertragssteigernde und damit je Produkteinheit kostensparende Landtechnik ist gerade bei sinkenden Agrarpreisen als ein wichtiges Mittel für die konkurrenzfähige, kostendeckende Produktion anzusehen.

Perspectives in the mechanization of plant production

Summary

The present surplus situation in farm products often gives rise to consider further progress in production techniques as unnessary or even undesirable. This consideration disregards, that on a worldwide base a progress-stop in the production techniques cannot be decreed. Agricultural techniques which save labor and increase the yield - on the contrary - must be regarded as important means for a competitive, costefficient production.

Key words: production techniques; sensors and actors; land use in the future

Bodenbearbeitungs- und Bestelltechnik

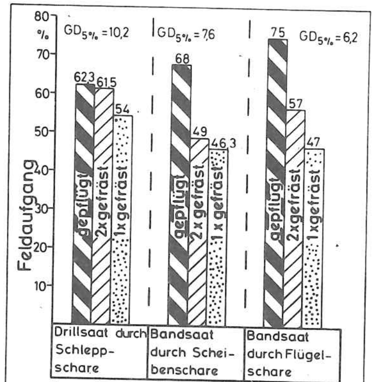
Hier steht die Frage an, ob die Pflugkultur, die Grubberkultur oder die Fräskultur für die Zukunft in Betracht kommen. Wir können zunächst einmal davon ausgehen, daß in der Reihenfolge Pflug-Grubber-Fräse sich der Kapitalbedarf, der Arbeitsbedarf, der Energiebedarf und die Kosten der Bestellung (Tab. 1) verringern. Der Pflug ist weiterhin sowohl dem

Tab.1:

	Überbetriebliche Verrechnungssätze absolut (Mittelwerte)	relativ
Bestellung nach Pflugeinsatz		
Pflügen	155 DM	
Kombination von Kreiseleggen und Säen	180 DM	
Summe	335 DM	100 %
Bestellung nach Tiefgrubbereinsatz		
Tiefgrubber	78 DM	
Kombination von Kreiseleggen und Säen	180 DM	
Summe	258 DM	77 %
Bestellung nach Fräseinsatz		
Kombination von Fräsen und Säen	180 DM	54 %

Kosten der Bestellung nach überbetrieblichen Verrechnungssätzen einschl. Schlepper und Arbeitskosten

Bild 1:



Versuchsbedingungen:
sandiger Lehm, Vorfrucht Winterroggen mit 50 dt Stroh je ha, das bei der Ernte (13.9.85) gehäckselt und in allen Fällen bei der Bestellung des Winterweizens (15/16.10.85) in den Boden eingebracht wurde
Arbeitstiefe des Pfluges 30cm, der Fräse 10cm
Sekundarbearbeitung nach Pflug durch Kreiselegge

Feldaufgang von Winterweizen

Tiefgrubber als auch der Fräse in der Mischwirkung deutlich unterlegen. Er kommt deshalb für das Stroheinarbeiten bei der Stoppelbearbeitung kaum in Betracht. Die nackte Bodenoberfläche fördert die Bodenerosion. Man kann sich durchaus fragen, weshalb trotzdem auf nahezu allen Betrieben heute noch gepflügt wird.

Nun, der Pflug übertrifft auch heute noch alle anderen Bodenbearbeitungsgeräte in der Wendewirkung. Das fördert die Vernichtung von Unkrautpflanzen. Man muß deshalb für pfluglose Verfahren mehr Herbizide einsetzen oder in einer Bracheperiode durch mehrfache Bearbeitung das Unkraut vernichten. Gegen Durchwuchsgetreide hilft meistens nur die letztgenannte Methode. Der Pflugersatz durch Tiefgrubbern oder Fräsen hat auch oft zur Folge, daß Vorfruchtreste - wie z. B. das Stroh - im Saatbett verbleiben. Dadurch kann sich der Feldaufgang verringern (Bild 1). Denn erstens hat das Stroh bei allen Säverfahren mit höhenbeweglichen Scharen zur Folge, daß die Tiefenablage der Samen ungleichmäßiger wird. Zweitens kann Stroh die Wasserabgabe vom Boden an die Samen behindern. Drittens und nicht zuletzt werden bei der Zersetzung des Getreidestrohes chemische Verbindungen wie Phenole oder Essigsäure frei, die den Keimvorgang, die Wurzelentwicklung und die Entwicklung der jungen Pflanzen behindern können (1). Diese negativen Auswirkungen des Getreidestrohes im Saatbett treten insbesondere dann auf, wenn sehr kurzfristig nach der Vorfruchternte bestellt werden muß und danach reichliche Niederschläge eine schnelle Zersetzung des Strohes einleiten. Bei spät gesätem Wintergetreide und insbesondere bei Sommergetreide treten Schäden durch Strohabbauprodukte wesentlich weniger auf, da diese dann bereits größtenteils ausgewaschen sind.

Auch wenn das Stroh nicht abgeräumt wurde, kann eine gleichmäßige Saattiefe mittlerweile aber bei Frässaat erreicht werden. Auf höhenbewegliche Säschare muß dann aber verzichtet werden und stattdessen die Samenablage durch eine über die Frässohle schleifende, pneumatisch beschickte Breitsäschiene erfolgen (Bild 2). Die Samenablage direkt auf der Frässohle begünstigt bei diesem Verfahren den Feldaufgang.

Chemischer Pflanzenschutz

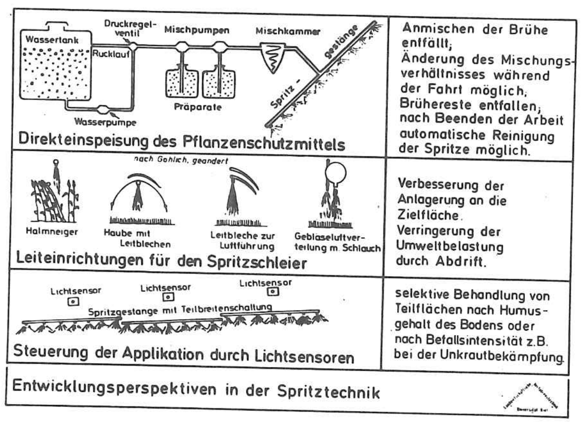
Dieser Bereich hat in der Vergangenheit im erheblichen Umfang zu Ertragssteigerungen und gleichzeitig zur Verringerung des Arbeitsaufwandes beigetragen. Ihm ist aber auch zuzuschreiben, daß heute die Landwirte von einem Teil der Gesellschaft als Giftmischer und Giftspritzer angesehen werden. Für die Zukunft gilt es, mögliche negative Auswirkungen zu verringern. Ansätze dazu bieten Techniken für die Direkteinspeisung von Präparaten in Pflanzenschutzspritzen nach dem Durchlaufverfahren, Leiteinrichtungen für den Spritzschleier (2) und für die fernere Zukunft auch die Steuerung der Applikation durch Lichtsensoren (Bild 3).

Mineraldüngung

Auch hier wird es für die Zukunft darauf ankommen, gezielter als bisher entsprechend dem variierenden Bedarf zu applizieren. Das gilt insbesonder für Regionen mit wechselnden

Bild 2: Samenablage unter dem Bodenwurf einer Fräse durch eine über die Frässohle schleifende Breitsäschiene

Bild 3:



Bodenverhältnissen und großen Schlägen. Im einzelnen gibt es natürlich viele Kriterien, an denen die Nährstoffapplikation sich orientieren sollte, wie z.B. Fruchtart, Bodenart, Ergebnis der Bodenuntersuchung und nicht zuletzt der Entzug an Nährstoffen durch die Vorfrucht. Zumindest für die entzugsorientierte Düngung der Zukunft zeichnet sich ein Verfahren ab, das den wechselnden Bedarf innerhalb eines Feldes automatisch berücksichtigen kann.

Grundlage diese Verfahrens könnte zunächst eine automatische Positionsbestimmung von Landmaschinen innerhalb eines Feldes durch Funkortung mittels Satelliten sein. Diese Funkortung basiert auf Trilateration über Laufzeitmessung der Funksignale. Die Empfangsgeräte für diese Funkortung werden bereits auf dem Markt angeboten. Spätestens ab 1993 sollen genügend Satelliten die Erde umkreisen, so daß ab dann zu jeder Tageszeit und an jedem Punkt der Erdoberfläche die Ortung möglich ist (3, 4, 5).
Wenn nun die Erntemaschine mit einem Empfänger für die Funkortung und darüberhinaus mit einem Gerät für eine ständige Durchsatzmessung ausgerüstet ist, könnte man diese Daten einander zuordnen. Ein Rechner könnte eine Feldkarte mit dem positionsbezogenen Ertrag erstellen und die dazugehörigen Daten speichern. Mit Hilfe dieser Daten könnte dann eine Feldkarte für eine positionsbezogene, entzugsorientierte Düngung der Folgefrucht erstellt werden. Wenn dann auch die jeweilige Position des Düngegerätes im Feld erfaßt wird, wäre eine rechnergesteuerte Düngung nach Entzug der Vorfrucht möglich (Bild 4).

Ernte von Körnerfrüchten

Hier steht für die Zukunft die Frage an, ob Mähdrescher mit Tangentialfluß-Dreschwerken wie bisher das Feld beherrschen werden oder ob Geräte mit Axialfluß-Dreschwerken sich durchsetzen können. Bekanntlich ist bei den Axialflußgeräten die Kornabscheidung duch das Dreschwerk wesentlich höher und deswegen kein Schüttler vorhanden.
Für die Wirtschaftlichkeit des Mähdrescher-Einsatzes ist von großer Bedeutung, ob ein hoher Durchsatz mit vergleichsweise geringen Kornverlusten erreicht werden kann. Die Durchsatz-Verlustkurven sollten also flach verlaufen. Nur dann ist es möglich, geringe Verluste und hohe Flächenleistungen zu kombinieren. Interessant ist dabei der Vergleich des Tangential- und Axialflußdrusches für verschiedene Früchte (Bild 5). Bei der vergleichsweise trockenen Wintergerste führt der Axialflußdrusch - außer im arbeitswirtschaftlich uninteressanten unteren Kurvenbereich - zu günstigeren Ergebnissen (6). Beim Raps ist die Situation umgekehrt. Der Tangentialflußdrusch ermöglicht bei gleicher Verlustquote annähernd einen doppelt so hohen Durchsatz. Der Grund für das schlechte Ergebnis des Axialflußdrusches ist im wesentlichen darin zu suchen, daß das Rapsstroh durch das Dreschwerk zu stark zerschlagen wird. Die Stroh-Kleinteile gelangen teilweise mit auf die Reinigungsanlage und erhöhen die Reinigungsverluste. Dieses Problem der Reinigungsverluste entsteht im übrigen bei allen Mähdreschern, die das Rapsstroh stark zerschlagen.
Für die Rapsernte sollte man also beim Tangentialfluß-Mähdrescher mit Hordenschüttler bleiben.

Bild 4: Entwicklungsperspektiven für eine entzugsorientierte, rechnergestützte Düngung

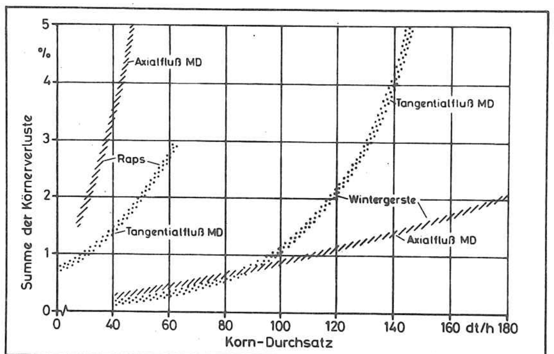


Bild 5: Summe der Dreschwerks-, Schüttler- und Reinigungsverluste (nach Spiess, geändert)

Ähnliches gilt auch dort, wo nicht trockenes, sondern oft auch feuchteres Getreide mit Grüngutanteilen zu dreschen ist (7). Völlig anders ist die Situation dort, wo die Ernte von Körnermais oder Maiskolbenschrot im Vordergrund stehen. Speziell für diese Früchte haben die Axialfluß-Mähdrescher sich als überlegen erwiesen. Es ist sicherlich kein Zufall, wenn die Axialfluß-Mähdrescher sich bislang vor allem im Maisgürtel der Vereinigten Staaten einführen konnten.

Ernte von Speisekartoffeln

Zwecks Minderung von Kartoffelbeschädigungen ist der Wechsel von der einphasigen zur zweiphasigen Ernte durch die Gerätefolge Schwadleger-Schwadsammler von Interesse. Üblicherweise wird dabei der Schwadleger am Vormittag und der Schwadsammler am Nachmittag eingesetzt.

Betrachtet man die Kartoffelbeschädigungen (Bild 6), so zeigt sich, daß diese sehr deutlich von den Kartoffeltemperaturen abhängig sind (8). Die einphasige Ernte am frühen Vormittag führt zu Beschädigungen von knapp 40 %. Mit steigender Tageszeit und gleichläufig steigender Kartoffeltemperatur im Damm sinken die Beschädigungen bis zum späten Nachmittag auf rund 6 %. Bei der zweiphasigen Ernte werden die Knollen zwangsläufig sowohl durch den Schwadleger als auch im Schwadsammler beschädigt. Die Knollentemperatur im Schwad ist aber - bei gleicher Tageszeit - immer etwas höher als im Damm. Die Folge ist, daß die Gesamtbeschädigungen bei der zweiphasigen Ernte auf ähnlich niedrigem Niveau liegen wie bei der einphasigen Ernte am Nachmittag. Wir haben also zwei Möglichkeiten für die Ernte mit geringen Beschädigungen, nämlich entweder die zweiphasige Ernte in der üblichen Zeitfolge oder die einphasige Ernte lediglich bei höheren Knollentemperaturen. Das Problem ist, daß die einphasige Ernte lediglich bei höheren Knollentemperaturen als Folge der zeitlichen Einschränkung in der Regel zu teuer wird. Das Sammeln und Laden der Kartoffeln bei höheren Knollentemperaturen kann zweiphasig billiger erledigt werden als einphasig. Hinzu kommt, daß die zweiphasige Ernte bei dunklen Böden als Folge des Antrocknens der Knollen im Schwad zu einer besseren Erdabscheidung und damit zu helleren Schalen führt.

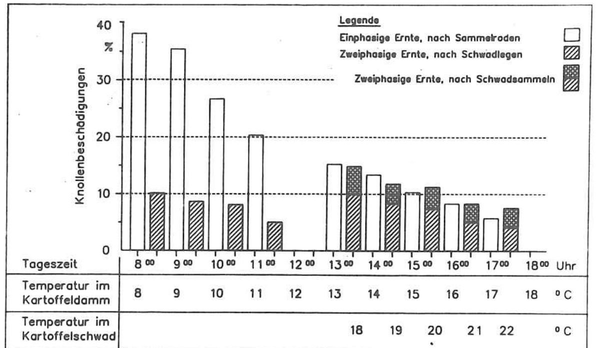
Ernte von Grünlandfutter

Die Feldtrocknung des Futters für die Bearbeitung von Konserven wie Welksilage oder Heu muß beschleunigt werden, damit weniger Verluste auftreten.

Es ist seit langem bekannt, daß man durch Quetschen, Knicken oder Anschlagen des Futters die Trocknung bei gutem Wetter beschleunigen kann. Technisch ist diese Aufbereitung kein Problem. Ein Problem sind aber bislang die bei sehr intensiver Aufbereitung entstehenden kleinen Futterteilchen. Diese kleinen Futterteilchen werden durch die Zinken der Rechgeräte und der Pick-up Trommeln an den Erntegeräten nicht erfaßt.

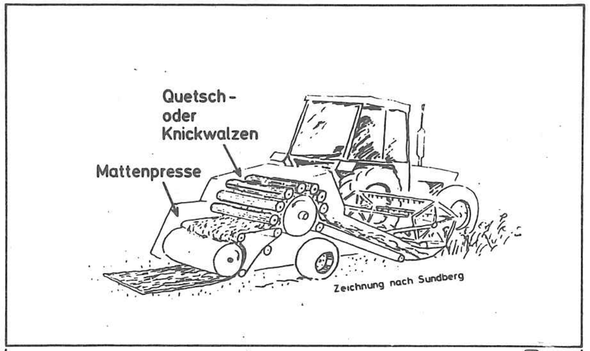
Vornehmlich aus diesem Grunde ist die sehr intensive Aufbereitung in der Praxis nie eingeführt worden. Stattdessen wird bislang in der Praxis mit geringer Intensität

Bild 6:



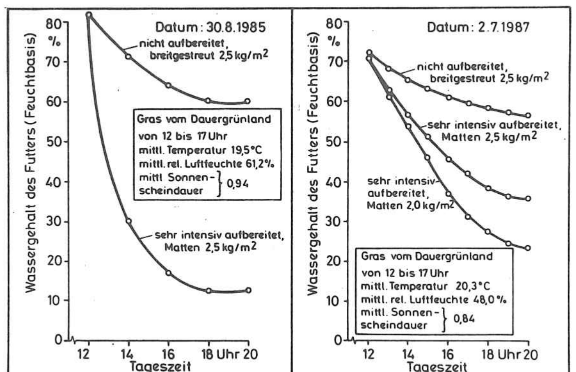
Kartoffelbeschädigungen bei der ein- oder zweiphasigen Ernte (nach Specht, Dethlingen, geändert)

Bild 7:



Mattentrocknung von Grünlandfutter
nach Verfahren Koegel und Shinners

Bild 8:



Feldtrocknung von Grasmatten in Schleswig-Holstein

aufbereitet, wodurch einerseits zwar Verluste an Kleinteilen weitgehend vermieden werden, andererseits aber auch die trocknungsbeschleunigende Wirkung der Aufbereitung sich verringert.

Der Wunsch, die trocknungsbeschleunigende Wirkung einer sehr intensiven Aufbereitung ohne höhere Verluste an Kleinteilen zu erreichen, ist vielleicht durch die sogenannte Mattentrocknung zu verwirklichen. In diesem Fall wird das Futter nach dem Mähen zunächst sehr intensiv aufbereitet und danach in eine dünne Matte gepreßt, in der die Kleinteile vor allem durch die klebende Wirkung des Zellsaftes festgehalten werden. Die 3 bis 5 mm dicke Futtermatte wird dann auf den Stoppeln für die Feldtrocknung abgelegt (Bild 7).

Es gibt bislang lediglich Versuchsgeräte für dieses neue Verfahren der Futtertrocknung (9,10,11). Die Trocknungsgeschwindigkeit derartiger Grasmatten unter norddeutschen Verhältnissen zeigt Bild 8. Bei voller Ausnutzung des täglichen Trocknungspotentials inclusive der späten Vormittagsstunden - die in Bild 8 nicht berücksichtigt sind - ist die Bodenheutrocknung innerhalb eines Schönwettertages möglich (11). Das wäre im Vergleich zur bisherigen Situation ein erheblicher Fortschritt, der weitere Bemühungen um ein praxisreifes Verfahren sicher rechtfertigt.

Sensoren und Aktoren

In allen Produktionsrichtungen wird künftig der rechnergestützten Überwachung, Steuerung oder Regelung von Gerätefunktionen große Bedeutung zukommen. Es geht dabei um die intelligente Verknüpfung von Sensor- und Aktortechnik (Tab.2) mit dem Ziel, die Qualität der Maschinenarbeit durch ständiges Optimieren der Geräteeinstellung während der Fahrt zu verbessern. Denn die bisher vorherrschende gleichbleibende Maschinenarbeit innerhalb eines Schlages berücksichtigt nicht die große Variabilität der Bodenverhältnisse und des Pflanzenbestandes.

Extensivierung oder Intensivierung der Produktion

Die Gesellschaft erwartet bekanntlich von den Landwirten einerseits eine preisgünstige Versorgung mit Lebensmitteln, andererseits aber auch mit steigender Vehemenz mehr Einsatz für den Erhalt der Artenvielfalt in der Flora und Fauna. Viele Menschen gehen davon aus, daß im Zeitalter von Agrarüberschüssen die allgemeine Extensivierung der Flächennutzung nötig sei. Sie übersehen dabei, daß diese allgemeine Extensivierung die Kosten je Produktionseinheit erhöht. Eine stärkere Differenzierung in der künftigen Landnutzung wird vermutlich eher auch die vielseitigen Wünsche der Gesellschaft erfüllen können. Auf intensiv genutzten Flächen - die mit moderner sensorgesteuerter und damit auch umweltschonender Agrartechnik bewirtschaftet werden - können preiswertere Nahrungsmittel erzeugt werden. Diese Flächen bilden gleichzeitig die Voraussetzung dafür, daß im erheblichen Umfang zusätzliche Flächen als Naturschutzgebiete verfügbar werden und dadurch für die Erhaltung der Artenvielfalt in Flora und Fauna günstige Vorbedingungen entstehen.

Eingangsgröße	Sensortechnik basiert auf...	Aktortechnik wirkt auf ...
Tiefgang des Pfluges	Ultraschall–Abstandsmessung	Schlepper–Dreipunkthydraulik
Bodenrelief nach der Sekundärbodenbearbeitung	Digitale Bildanalyse	Zinkengeschwindigkeit des Bodenbearbeitungsgerätes
Tiefgang der Säschare	Ultraschall–Abstandsmessung o. Bodenwiderstandsmessung o. Bodenfeuchtemessung	Schardruck
Humusgehalt des Bodens	Reflektion von Rotstrahlung	Applikationsrate von Bodenherbiziden
Unkrautbesatz des Bodens	Digitale Bildformenanalyse	Applikationsrate von Blattherbiziden
Positionsbezogener Ertrag der Vorfrucht	Positions–und Durchsatz–messung während der Ernte	Positionsbezogene Applikation von Düngern
Schüttler-und Reinigungs-verluste des Mähdreschers	Piezoelektrische Erfassung der Verlustkörner	Fahrgeschwindigkeit oder Luftdurchsatz des Gebläses
Kartoffelbeschädigungen durch die Roder-Siebkette	Piezoelektrische Erfassung der Druckbelastung einer künstlichen Kartoffel	Schwingbewegungen der Siebkette

Tab.2: Ansätze für den zukünftigen Einsatz von rechnergestützter Sensor– und Aktortechnik in der Pflanzenproduktion

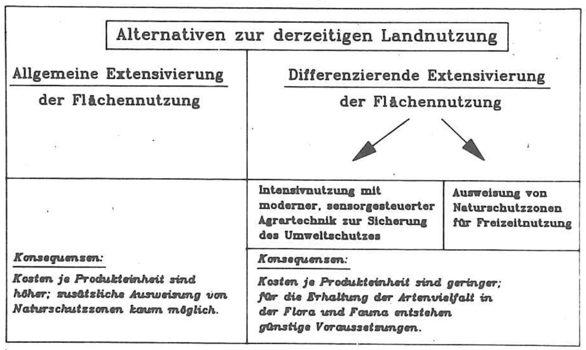


Bild 9: Entwicklungsmöglichkeiten für die Landbewirtschaftung im Zeitalter von Agrarüberschüssen

Die moderne Agrartechnik kann insofern auch sehr wesentlich dazu beitragen, daß die Versöhnung von Mensch und Natur gelingt.

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TRENDS IN AGRICULTURAL ENGINEERING
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MODIFICATION OF THE SENSOR FOR CONTINUOUS OBSERVATION OF MILK CONDUCTIVITY OF QUARTERS

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Four-electrode probes connected as a two-electrode measuring method were used on the basis of experiments. Considerable affection of the electrode surface and quality occurs with biological materials independently of used electrode material. Therefore the electrodes were connected as a four-electrode method, and different influence of electrode surface damage with the two-electrode and four-electrode methods of liquid conductivity measuring was observed.

liquid conductivity; two and four-electrode method; electrode surface damage influence on measured values

1. INTRODUCTION

During observing physical properties of agricultural materials and products it is possible to observe electric and magnetic properties in connection with various chemical and biological processes, i.e. during mutual affection of both the probe material and the measured sample. From here the condition of minimal influence of measuring method and probe on explored agriculture material, and on the contrary, zero influence of agriculture material on the probe. The probe in itself connected with a device can evoke high imaginary component, polarizing effects, undesirable double layers, thin films at the electrodes and others.

We observed Czechoslovak, Hungarian probes and probes of own production as well, classical and miniature probes as well with various materials, forms, dimensions and orientations as well, two and four-electrode probes as well, etc. The influence of frequency, voltage and measuring current as well was observed. Theory, study of search facts, own experiments and conclusions for further measuring in practise are brought in the author's work /1/.

For mentioned reasons carbon electrodes were chosen and used in usual practice, which are advantageous for reasons of handling, cleaning, price, easy and unperturbed replacement, etc. On the basis of experiments the probes with four carbon electrodes connected as two and four-electrode liquid conductivity measuring method were chosen.

The two-electrode method is used above all with measuring of electric conductivity of ionic liquids (for example agriculture products juices, milk and others) the conductivity of which is tenth to hundredth part of $S.m^{-1}$ in order. The big disadvantage of this method is the fact that during measuring we must take account of the contribution of complex impedance arising at the boundary between the electrode and the electrolyte. Unfavourable influence of this complex impedance, mainly capacity of electrical double layer, is also made in a higher extent during measuring of physiologic liquids (milk as well).

Another disadvantage of this relative two-electrode method is necessity of measuring system calibration which is mostly made through the salt ($NaCl$, KCl) solutions with known conductivity and if it is necessary in dependence on temperature as well. However, the measuring element resistance constant obtained in this way can be changed substantially with the influence of electrode deformation, with the changes of their surfaces and with fact that temperature courses for physiologic solution does not correspond to temperature courses of calibrated solution as a rule. The method of conductivity measuring through four electrodes with double immersion would eliminate most of these inefficiencies in relatively wide scope of measuring.

2. FOUR-ELECTRODE METHOD

In the first place the method was developed for surface conductivity measuring of semiconducting materials at the research laboratory of the Philips firm. Then it was modificated for electric conductivity measuring of ionic liquids with the fact that it is measured with two various immersions of the electrodes. It is the absolute method which does not require the calibration. With this method the influence of phase boundary impedance and the influence of capillary and skin effects as well are excluded fully.

The principle of this method consists in the fact that while alternate electric current with suitable frequency is led through one couple of electrodes, the potencial of the electric field produced by this current is measured by the uther couple of electrodes. Considering that no current flows through the electrodes sensing electric potencial (provided high input resistance of measuring device), nor the influences of interphase boundary are made.

The measuring with this method consists in the fact that during one immersion of the electrodes the voltage U_1 of the electrode couple with the current I_1 flowing through the opposite electrode couple is measured (Fig. 1). In next step the electric orientation of the electrodes is turned by 90° and the voltage U_2 with the current I_2 is measured. First from thus measured values the partial resistances $R_1 = U_1/I_1$ and $R_2 = U_2/I_2$ will be calculated, from which the average value of the resistance R with the immersion A will be calculated.

The change of the electrode orientation was brought because in this way it was possible to a considerable extent compensate the irregularity in geometrical arrangement of the electrodes. In next step the electrodes are immersed into the liquid more deep by the value ΔW and the measuring is repeated in the same way as above. The result with the deeper immersion B is the average value of the resistance R_B calculated in the same way.

The conductivity of the measured liquid is then calculated according to the equation which was derived /2/ in the form

$$\gamma = \frac{\ln 2.(R_A - R_B)}{2\pi\ R_A.R_B.\Delta W}$$

It is interesting that only the measured resistances R_A,R_B and the immersion ΔW are found in the equation.Thus no dimensional parameters of sensing element presented for example with the all-determinating constant C.

3. VERIFICATION OF THE METHOD AND EVALUATION

Certain reductions arise with application of the mentioned method for milk conductivity measuring.Most of all it is unthinkable to solve technically double immersion of electrodes with building the sensing element in milk-milk collector.The electrodes are firmly built in one place to be as far as possible continuously immersed into milk during milking.Thus we obtain only one average value of the resistance R by the contemplated application.We pay for this simplification of the method the worth of the fact that the method looses its character of absolute measuring method and it becomes relative method.Thus the necessity of the calibration is not dropped and the equation is reduced to the form $\gamma = C.R^{-1}$.

Nevertheless all other advantages of this method stay valid: i.e.exclusion of the influence of phase boundary,the influence of capillary and skin effects and others.

To verify this method we carried out measuring with 2-4-electrode sensing elements during various measuring frequencies and with regard to surface damage of their electrodes.For economical reasons the electrodes were produced from carbon rods with the diameter of 3 mm and they were placed in axial distance of 5 mm each to other.While the significant frequency dependence is evident and the surface damage influence on the constant C (Fig.2)is considerable with the two-electrode sensing elements,the frequency dependence is substantially more acceptable and the surface damage influence on the constant C is negligible (Fig.3) with the four-electrode sensing element.

4. CONCLUSION

The practice demonstrated that the sensibility to blocking of milk fat and miscellaneous impurities decreased with a ground electrode surface of the four-electrode carbon probes connected as the two-electrode sensor,but the constant C started changing in some cases:therefore it was necessary to check the value of the constant C every two months with permanently built-in electrodes and their dipping in milk and cleaning solutions.

To prove the decresion of this influence the surface of the four-electrode sensor was demonstratively "modificated"in such a way that the carbon end was cut by a metal saw and this unfiled sensor was measured.The change in the whole scope of the frequency dependence was less than +3% from original value.

Thus the measuring proved high suitability of the used method and especially in operation when the electrode surface damage cannot be often prevented.Simultaneously the surface influences

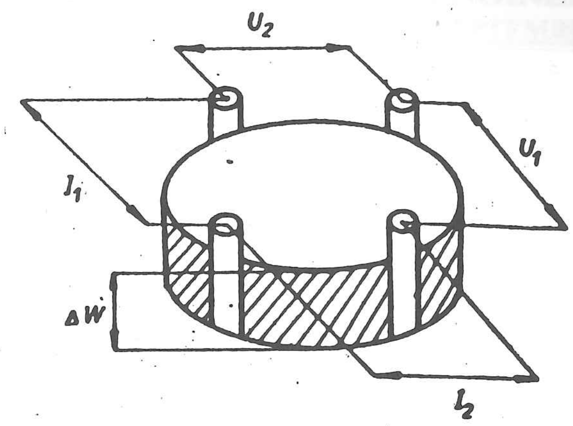

Fig.1. Principle of the method

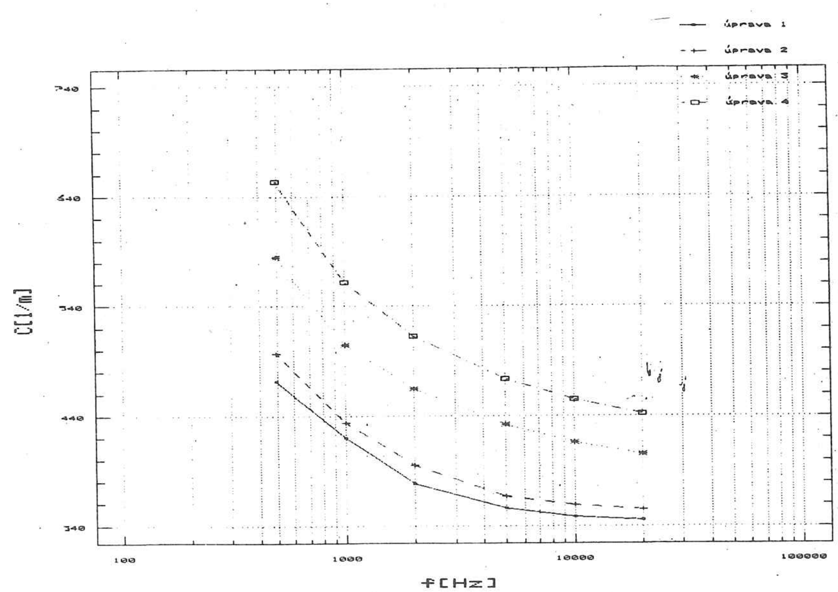

Fig.2. Two-electrode sensing element

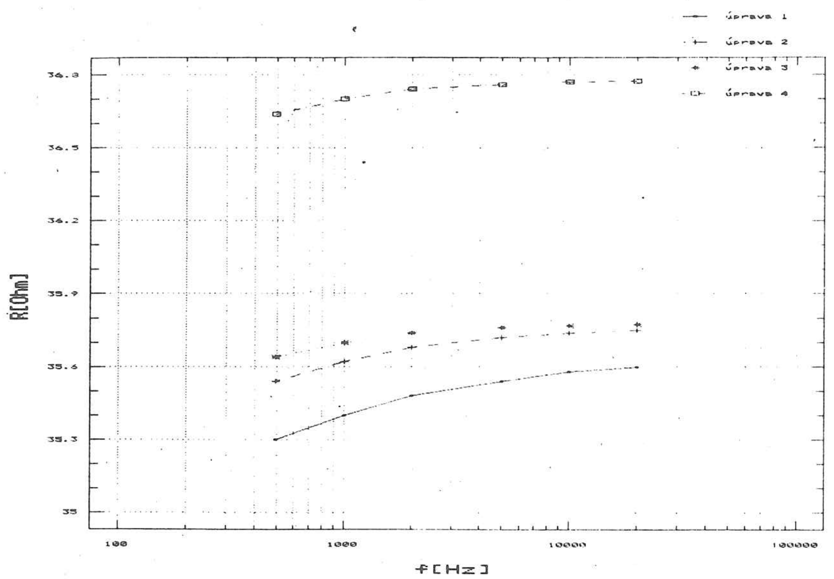

Fig.3. Four-electrode sensing element

the influence of film formation at the electrode surface, the influence of undesirable sediments and impurities, the necessity of check calibrations of the probe and device constants and others are eliminated.

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TRENDS IN AGRICULTURAL ENGINEERING
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DENSITY DISTRIBUTION, VITREOSITY AND RHEOLOGICAL PROPERTIES OF WHEAT ENDOSPERM

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The density distributions were obtained for endosperms of three varieties of Triticum aestivum of two protein contents. The measurements were performed on samples of rectangular parallelepiped form by direct method. The rheological properties were measured on this samples, too, by deformation tests. Pycnometric density was measured on whole grains. The characteristics studied reflect phenomena accompanying the vitreosity changes and protein storage.

wheat endosperm; density distribution; vitreosity; rheology; protein storage

1. INTRODUCTION

Material structure and chemical composition are responsible for material density. The density of cereal endosperm depends on variety, climate, plant nutrition and weather at the time of seed development and ripening [3,5]. The density is influenced by grain vitreosity. Grain hardness and other physical properties are influenced by both of them even if the cause of this dependence is not quite clear. The technological properties can be changed, too. Our research notices some phenomena connected with the mechanism of vitreosity changes and protein storage in grains.

2. MATERIALS AND METHODS

The measurements were performed on three Polish varieties of wheat, Liwilla, Grana and Panda (all T. estivum). The wheats were grown in a field near Lublin. Two levels of NPK fertilizing (N:P:K=1:10.8:1.2) were always applied to evoke two different protein contents in the seeds. 250 or 750 kg/ha was dosed. The grains were harvested manually and stored in an unheated room in the Institute. Grain water content was 1.1 - 1.6 % at the time of experiments. The pycnometric density of the whole grains were measured in toluene.

About 20 g samples composed of about 460 seeds were used. The endosperm density of individual grains was calculated from the weight and dimensions of rectangular parallelepiped samples cut from the seeds with the help of an adapted slide microtome. The dimensions of the samples were 2.689±0.234 x 2.37±30.108 x 2.023±0.109 mm. They contained about 60% of the seed original volume. The distribution functions of the endosperm density were calculated (the order statistics was used) in the following way:

In a sample group of the size n were m≤n samples of the density $\rho \leq \rho_m$ and n-m+1 samples of the density $\rho \geq \rho_m$, where ρ_m is the m-th density from the bottom if they are arranged in increasing magnitude. The cumulative probability of occurrence the density $\rho \leq \rho_m$ was statistically estimated by the relation

$$P_h(\rho \leq \rho m) = [F(\rho \leq \rho m) + 1 - R(\rho \geq \rho_m)]/2 = (m-0.5)/n \qquad (1)$$

where

$$F(\rho \leq \rho m) = m/n; \quad R(\rho \geq \rho_m) = (n-m+1)/n$$

The appearance of each endosperm rectangular sample was visually estimated as mealy, vitreous or intermediate. Then mean vitreosities v were calculated for all materials tested from the formula

$$v = (0.5n_i + n_v)/(n_m + n_i + n_v) \qquad (2)$$

where n_m, n_i, n_v are the numbers of mealy, intermediate and vitreous samples, respectively, in the sample group. Protein content was taken by Kjeldahl method (using a factor of N x 5.83) for the whole grains only, not for the samples. The characteristics of rheological properties were taken from the pressure deformation curves of the rectangular samples deformed between parallel plates. Instron testing machine was used at the cross head rate of 5 mm/min.

3. RESULTS AND DISCUSSION

The experimental distribution functions of the wheat endosperm densities of Liwilla and Panda of both protein contents are shown in Figs. 1 and 2. There were less differences in the grain protein content in the wheat Grana and the appropriate distribution functions are also less different.

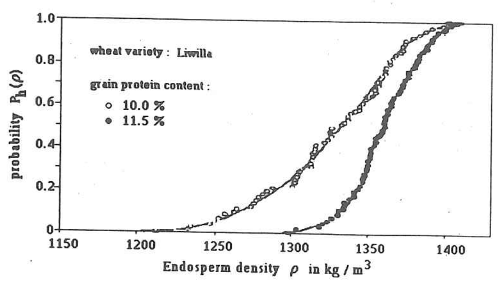

Fig. 1. Endosperm density distribution of winter wheat

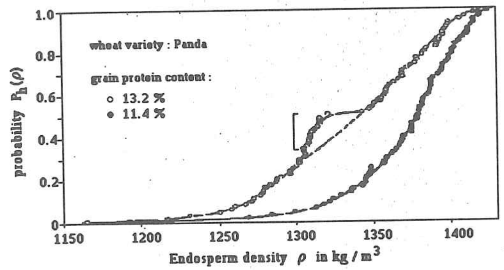

Fig. 2. Endosperm density distribution of winter wheat

The pycnometric densities are given in Tab. 1. The portions of endosperm samples of diverse appearance and their mean densities are in Tab. 1. The mean densities of the wheat endosperm itself from the grains of various protein content differ statistically significantly on the 5%level.

The standard deviations of three repetitions of the pycnometric density measurements of whole grains are small. The means obtained can be taken as population values.

Tab. 1. Protein content and pycnometric density of wheat grains. Means and standard deviations are given.

Variety	Proteins content %	Pycnometric density $kg.m^{-3}$
Liwilla	10.0	1348±4
	11.5	1367±3
Grana	11.4	1365±1
	13.1	1353±0
Panda	11.4	1326±6
	13.2	1350±0

The influence of density and protein content on rheological properties, that are showen in Tab. 3., is the best evident in the wheat Panda. The differences in the characteristics shown are statistically significant at 5 % confidence level, with the exception of Young's modulus. The other two varieties manifested less and nonsignificant differences.

It was possible to describe well the cumulative distributions of endosperm density by three-parametric regession function

$$P_h(\rho) = \begin{cases} 1 - \kappa\,\Phi(u) & \text{for } \rho \geq \rho_{min} \\ 0 & \text{for } \rho \leq \rho_{min} \end{cases} \qquad (3)$$

Tab. 2. Wheat endosperm density and vitreosity.
Means and standard deviations are given.

Variety	Liwilla					
Grain proteins	10.0 %			11.5 %		
Vitreos.,Dens.	26 %	mean	1335±39 kg.m^{-3}	44 %	mean	1364±22 kg.m^{-3}
Appearance	mealy	inter-mediate	vitreous	mealy	inter-mediate	vitreous
Proportion %	47	53	0	13	85	2
Density kg.m^{-3}	1306±33	1360±23	-	1338±20	1368±19	1367
Variety	Grana					
Grain proteins	11.4 %			13.1 %		
Vitreos.,Dens.	50 %	mean	1356±34 kg.m^{-3}	48 %	mean	1369±31 kg.m^{-3}
Appearance	mealy	inter-mediate	vitreous	mealy	inter-mediate	vitreous
Proportion %	5	90	5	8	87	5
Density kg.m^{-3}	1263±9	1360±28	1371±10	1322±34	1372±27	1383±25
Variety	Panda					
Grain proteins	11.4 %			13.2 %		
Vitreos.,Dens.	42 %	mean	1332±52 kg.m^{-3}	64 %	mean	1363 kg.m^{-3}
Appearance	mealy	inter-mediate	vitreous	mealy	inter-mediate	vitreous
Proportion %	49	18	33	19	35	46
Density kg.m^{-3}	1297±38	1331±49	1385±18	1322±55	1358±28	1383±22

if it was $\kappa \geq 1$ and by two-parametric one

$$P_h(\rho) = 1 - \Phi(u) \qquad \text{for } \rho \geq 0 \tag{4}$$

if in the previous regression analysis step $\kappa < 1$ was obtained. $\Phi(u)$ is the normal distribution function.
The variable u has the following significance

$$u = \frac{1}{\delta_h} \ln \frac{1/\rho - 1/\rho_0}{1/\bar{\rho} - 1/\rho_0}$$

where: $\bar{\rho}$ - mean endosperm density
ρ_0 - extrapolated density of nonporous endosperm
δ_h - standard deviation of logarithmic expression which it follows
ρ_{min} - minimum density at which $\kappa\,\Phi(u) = 1$.

Coefficients of correlation where always higher then 0.99.

Tab. 3. Rheological properties of wheat endosperm.
Means and standard deviations are given.
E - Young's modulus, σ_p - pressure strength limit, σ_l - pressure stress at linearity limit,
ε_p - relative deformation at pressure strength limit, ε_l - relative deformation at linearity limit.

Variety	Liwilla	
Protein content	10.0 %	11.5 %
E [MPa]	488 ± 102	514 ± 102
σ_p [MPa]	21.5 ± 6.9	22.9 ± 7.3
σ_l [MPa]	0.0566 ± 0.0229	0.0579 ± 0.0180
ε_p [1]	15.0 ± 5.0	16.2 ± 6.2
ε_l [1]	0.0336 ± 0.009	0.0345 ± 0.0108
Variety	Grana	
Protein content	11.4 %	13.1 %
E [MPa]	557 ± 112	527 ± 111
σ_p [MPa]	27.4 ± 8.4	28.7 ± 9.5
σ_l [MPa]	0.0623 ± 0.0156	0.0616 ± 0.019
ε_p [1]	20.1 ± 7.1	20.8 ± 6.8
ε_l [1]	0.0421 ± 0.0144	0.0410 ± 0.0145
Variety	Panda	
Protein content	11.4 %	13.2 %
E [MPa]	584 ± 127	605 ± 109
σ_p [MPa]	41.2 ± 15.4	49.8 ± 11.6
σ_l [MPa]	0.0877 ± 0.0302	0.0992 ± 0.0269
ε_p [1]	29.3 ± 11.2	35.6 ± 10.9
ε_l [1]	0.0556 ± 0.024	0.0649 ± 0.0228

The distributions are skewed right. Left and right skewed distributions were also obtained by other authors (e.g. [6]).

It was possible to analyse the endosperm densities of 11.4 % protein Panda with the use of Egs. (3) and (4) after leaving out the apparently anomal points. In fact, the distribution is bimodal. The phenomena which form the cause of uneven vitreosity (there were often islet mealy regions in this endosperm) are probably responsible for the bimodal distribution function. This variety formed very few grains of intermediate appearance. Protein content plays without doubt an important role in the mechanism of appearance changes as the distribution anomaly does not appear in more protein grains.

The samples originating in more protein grains of the same variety are more dense even if the protein density is lower than that of starch (about 1320 and 1500 kg/m^3, respectively, by flotation measurements [4]). This denser endosperm must contain fewer air pores which scatter light and cause mealy appearance. The endosperm appearance of wheat Grana was mostly intermediate and practically was not influenced by grain protein content. The trends in density changes with protein content in the whole grains are opposite to those in the rectangular samples for this variety. Explanation should be probably searched for in variety distinctions in the form of protein storage in grains. At the higher level of nitrogen fertilizing there were less pores formed in wheats Liwilla and Panda. Judging from the appearance Grana endosperm contained more protein at the lower fertilizer level. At the higher level of fertilizing protein was probably preferentially stored in outer endosperm layers, aleurone and subaleurone, not present in the rectangular samples.

The rheological properties are influenced by protein content in a complicated way. Both rheological properties of protein itself and its interaction with starch in endosperm structure and the influence of protein content on pore size and number in unit volume play an important role. Rather different results obtained here for various materials and also our earlier results [1,2] support this statement. Some increase of all rheological characteristics given here was always obtained with density if the individual sample data were treated.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

EVALUATION OF THE PROPERTIES OF POLYMER COMPOSITE MATERIALS

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This study contains results of acceleration tests of composite Taboren PH 41C40 (without blowing agent and with blowing agent) simulating the microclimate of stables, mainly the influence of gas environment, during cyclic regime of moisture and temperature. The influence of the environment on the composites was evaluated by the change of tensile strength, elongation, impact strength and modulus of elasticity. The tested composites exhibited a good resistance in the environment, mainly composite with blowing agent $NaHCO_3$.

composites in the livestock sheds; degradation of the composites; laboratory testing of composites; climatotechnology.

1. INTRODUCTION

The development of synthetic materials, mainly plastics and composites considerably outdistance the development of classical materials. In the coming years its application as replacement of structural material is to be extended as replacement of structural materials and that mainly in engineering, building, electronics, farming and packing technologies. As the development of the basic types of plastics has been practically completed and it is not expected that new types of plastics will be applied in industry. Studies are directed mainly to the improvement of new types of plastics, the improvement of the properties of the plastics and their combination with classical materials. For these reasons for the design of suitable materials in the aggressive environment of livestock farming are of great importance corrosion tests of plastics and composites evaluating the changes of their properties /1,2/.

2. PROBLEM ANALYSIS

Above all in the field the filling of plastics has become, in the recent years, the aim of research and it can be stated that it has been found that in many respects significant results have been reached. Additives dispersed in the polymer matrix essentially influence the molecular or chemical structure of the polymers and thus the resulting properties of the products, mainly strength properties, but also shape constancy with higher temperatures, thermal expansion, permeability of steam and gases etc.

The effect or effectiveness of the respective additives is decided, besides by its properties, also by the degree of their representation in the polymer matrix. In many cases this does not mean that the highest degree of dispersion of the additives in the matrix should be reached, but only a certain degree of mixing, which is the most suitable for the maximum utilization of the additive function.

Interaction of the filler or the reinforcement with polymers influence these physical properties /3/:

modulus of elasticity - fillers and reinforcement increase, the modulus i.e. reinforcements more than fillers;
tensile strength - reiforcements increase it, fillers decrease it;
impact strength - reinforcements can increase and decrease it, fillers decrease it;
temperature properties - fillers as well as reinforcements improve it;
shrinkage - fillers as well as reinforcements decrease it.

Additives are used above all for thermosetting resins of the phenoplasts and aminoplasts for synthetic rubber and in some cases also for polyolefines (polyethylene and polyprophylene) for which, however, additives were used only to a limited extent. Among the important additives rank (e.g. kaolin, slate powder, $CaCO_3$), when using 10 % of the weight they improve many physical properties of the polyolefines, the damp resistance and atmospheric ageing.

As compared to other materials the plastics and composites have a greater resistance against corrosion. Therefore they have become not only a significant structural material, but also protection material against corrosion of metals, wood, building materials etc. Information about the conditions when the depreciation of the polymers occurs and the evaluation of corrosion by the change of mechanical properties,is very important. The study of the corrosion of plastics has already led to many findings, which enable the choice of plastics for generally valid environments.

B.Doležel /4/ reached the conclusion that each polymer requires special conditions and a combination of environments which most suitably model the acceleration tests.

Problem in the selection of structural polymer materials occur mainly during their application in the aggressive environment of sheds. Here a higher degradation effect must be taken into consideration, due to the gaseous components in the microclimate, the most important of which are amonium, carbon dioxide and hydrogen sulphide. In the tests, the thermal-humidity regime must also be taken into consideration /5/. The influence of the degradation factors on the corrosion and ageing of these polymer materials has not yet been sufficiently investigated yet and only a few studies deal with this problem /6/. And therefore accelerated laboratory model tests have their justification, which enable a quick determination of the suitability of the various materials. The degree of degradation is evaluated by the changed mechanical properties of the polymers, exposed in time intervals in the model environment.

3. MATERIAL AND METHODS

The aim of the research was to determine corrosion resistance of the composite Taboren for the application in aggressive environment of sheds. For these reasons it was decided to observe the degradation of composites by the change of mechanical properties of the test specimens placed in a climatizing chamber.

Two types of composites were chosen for the tests:

Type I. - Taboren PH 41C40 (polyprophylene + 10 % weight microground calcite $CaCO_3$);

Type II.- Taboren PH 41C40 + 1 % weigth $NaHCO_3$ (blowing agent).

Standard test specimens were produced by an injection moulding press CS 195/100-1 in the chemical plant Silon Planá nad Lužnicí a total of 210 test specimens, out of which 40 comparative specimens.

A simulated microclimate was created in a climatizing chamber by continual dosing of gases in increased concentration as compared to reality and with a cyclic temperature-humidity regime (temperature 20 to 40 ^oC, relative humidity 75 to 98 %).

Hydrogen sulphide H_2S . . . . 40 $mg.m^{-3}$

Ammonia NH_3 . . . . 110 $mg.m^{-3}$

Carbon dioxide CO_2 . . . . . 45 $g.m^{-3}$

Before the tests were started the mechanical properties of the composites were measured. The exposition of the test specimes in the above mentioned microclimate were set for 98 days with 5 samplings: 1. - after 28 days; 2. - after 56 days; 3. - after 70 days; 4. - after 84 days; 5. - after 98 days.

At every sampling the following mechanical properties were determined: tensile strength σ_t and elongation ε_r (to the accor. ČSN 64 0605), impact strength a_n (to the according ČSN 64 0612), modulus of elasticity E (to the according ČSN 64 0614).

4. TEST RESULTS

Because of the great range of values only the changes of mechanical properties of the 5th sampling are given in relation to the comparison volues (Tab.1). Graph (Fig.1) shows these changes in %.

5. EVALUATION OF RESULTS AND CONCLUSION

In the evaluation of the results of changes of mechanical properties of composites Taboren PH 41C40 (without blowing agent and with blowing agent) exposed for 98 days in an increased concentration of the microclimate of a shed, partial changes can be observed. Essential changes were mainly observed in the elongation and impact strength. In composite without blowing agent a decrease of elongation by 13.1 % and a decrease impact strength by 5.4 %. In the composite with blowing agent elongation increased by 13.7 % and a negligeble decrease of

Table 1. Values of mechanical properties of Taboren

Taboren		σ_t [MPa]	ε_r [%]	E [GPa]	a_n [kJ.m^{-2}]
type I.	A	22.34	22.24	1.95	22.96
	B	22.56	18.44	2.08	21.71
type II.	A	22.88	16.40	2.26	18.18
	B	22.28	18.64	2.29	18.11

A - values before the test
B - values after the 5th sampling

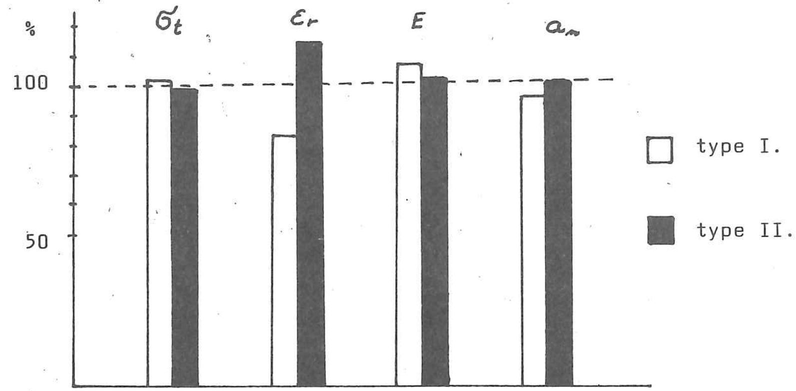

Fig.1. Changes of mechanical properties of Taboren in %

impact strength by 0.4 %. This shows the effect of the blowing agent on the above properties. The other values of mechanical properties do not essentially differ from the original values. Both materials can by recommended for a shed environment, Taboren without blowing agent for less stressed products. A repetition of the tests and verification in real condition are necessary for accurate decisions. The results of the tests are very significant for the production of the above composites and extended knowledge about these materials.

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TRENDS IN AGRICULTURAL ENGINEERING
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THRESHING CONCAVE WITH DRIVEN ROTATING CYLINDRES

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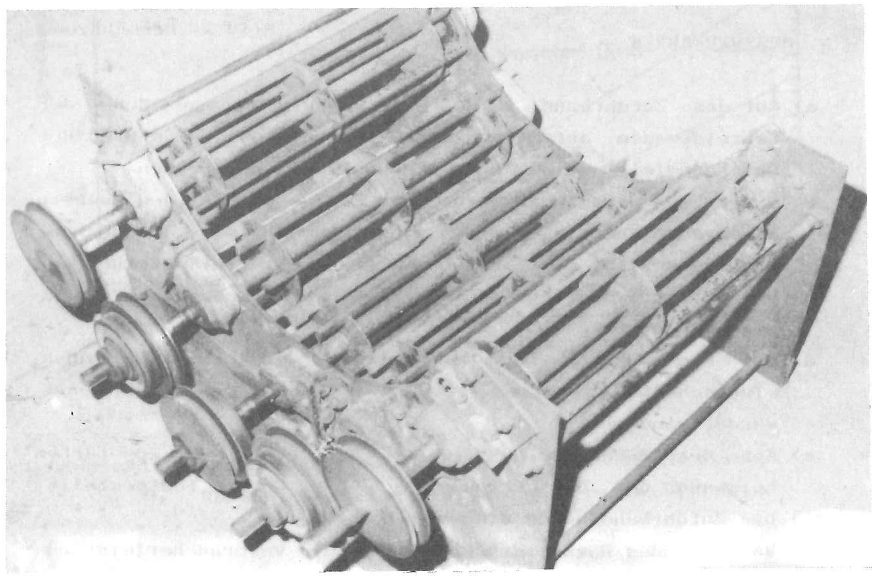
A threshing concave with driven rotating cylinders enables the increase of the threshing cylinder circumferential velocity without large deteriorations of the separation properties of the threshing mechanism. The increased relative velocity of the threshing-material's layer creates the assumption for the treble passage of threshing- materials per unit length in the threshing mechanism. At the same time, the power input of the technological process of threshing is reduced to a third per time unit.

threshing mechanism; driven rotating cylinders; circumferential velocity; threshing of grains; power input; technological process

1. EINLEITUNG

Die Laboratorvorrichtung für das Experiment wurde am Lehrstuhl für Landmaschinen der Fakultät für Landtechnik der Hochschule für Lanwirtschaft in Prag im Jahre 1990 erzeugt. Diese Vorrichtung besteht sich aus dem Dreschmechanismus und

aus dem Zuführband für die Einlegung der Dreschmasse. Die Dreschtrommel wurde in der Zentralforschungswerkstatt der Hochschule aus einem Druckrohr mit dem Durchmesser 500 mm und der Länge 530 mm hergestellt. Die Leisten rund um den Umlauf des Dreschkorbes wurden aus Zugstaben mit dem Durchmesser 10 mm verfertigt und angeschweißt. Die Trommel wurde dynamisch ausgeglichen und der Antrieb der Dreschtrommel ist mit Riemenscheiben vom Elektromotor konstruiert. Die Umfangsgeschwindigkeit der Dreschtrommel erreicht bis 48,9 $m.s^{-1}$. Der Dreschkorb wurde im Jahre 1986 hergestellt und er ist mit dem ČSFR Patent No. 22 0054 geschützt [1]. Der zweite Teil des Dreschmechanismus besteht aus fünf angetriebenen Rotationswalzen mit dem Durchmesser 140 mm, die im Dreschkorb eingebaut sind. Der Antrieb der Rotationswalzen ist mit zwei Keilriemenscheiben vom Kommutatorelektromotor mit dem Drehzahlregler gelöst. Diese Antriebskomposition ermöglicht die Umlaufgeschwindigkeit von 2,3 $m.s^{-1}$ bis 25 $m.s^{-1}$ zu regulieren. Für die Lieferung der Getreidemasse wurde ein glattes Zuführband (mit der Breite des Bandes 450 mm; Arbeitsgeschwindigkeit 1,5 $m.s^{-1}$) benutzt.



[illegible] mit eingebauten Rotationswalzen

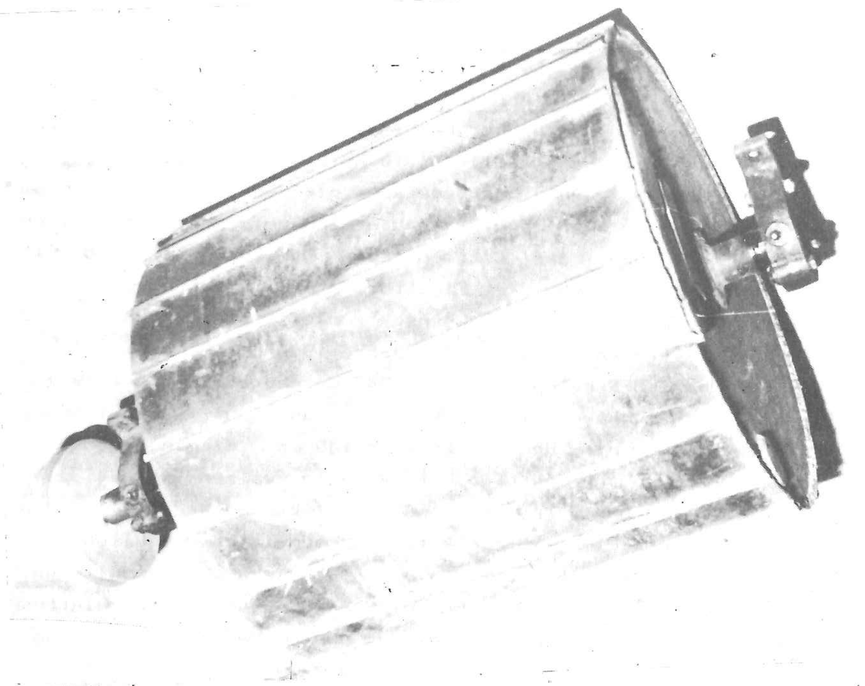


Bild 2: Dreschtrommel

2. MESSVERFAHREN

a) Auf das Zuführband wurde eine vorhergemessene Menge der Getreidemasse aufgeladen; die Getreidemasse mußte der Durchgangleistung des Dreschmechanismus entsprechen.

b) Unter dem Dreschkorb wurde das Zahlgefäß mit den Kammern angebracht und hinter dem Dreschmechanismus wurde das Fängersegel für den Einfang von Dreschmaterial untergebracht.

c) Der Elektromotor für den Antrieb der Dreschtrommel wurde eingeschaltet.

d) Der Elektromotor für den Antrieb der Korbwalzen wurde eingeschaltet und die Geschwindigkeit der Drehfrequenz wurde eingestellt.

e) Auf der Meßanlage wurde der Ablesewert der zugefürten Leistung der Dreschtrommel und des Korbes festgestellt.

f) Das Zuführband wurde eingeschaltet.

g) Während des Häckseldruschs wurde die Verbraucherleistung festgestellt.

h) Das Korn wurde gewogen und die Kornproben wurden nach dem Gesichtspunkt der Beschädigung ausgewertet.

2.1. Durchgangleistung

Die mehrmeisten Mähdrescher haben eine Dreschtrommel, die mit einer Umfangsgeschwindigkeit von 28 $m.s^{-1}$ bis 32 $m.s^{-1}$ arbeitet und der Dreschkorb ist statisch befestigt. Die Schicht des Dreschmaterials hat die relative Geschwindigkeit von 11 $m.s^{-1}$ bis 12 $m.s^{-1}$ [2].

Wenn wir die Differenz der Geschwindigkeiten errechnen (Dreschkorbwalzen 20 $m.s^{-1}$ und Dreschtrommel 50 $m.s^{-1}$), bekommen wir die Relativgeschwindigkeit der Schichte des Materials von (20 + 11) $m.s^{-1}$, also ungefähr 30 $m.s^{-1}$.

Diese Geschwindigkeit ist ungefähr dreimal größer als bei der Mehrheit der weltweit gebauten Mähdrescher. Das heißt, daß die Durchgangleistung auch dreimal größer ist und alle diese experimental erworbenen Ergebnise auf die Längeneinheit des Dreschmechanismus bezogen sind.

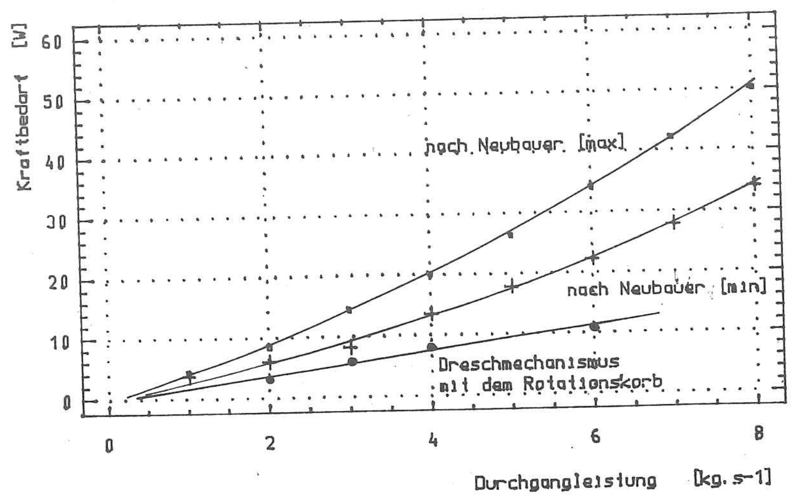


Diagramm 1: Energetische Anspruchigkeit des Drusches in Abhängigkeit von der Durchgangleistung des Dreschmechanismus

Im Diagramm 1 ist der Kraftbedarf des Schlagleistendreschmechanismus nach Neubauer [2] für die niedrigste und höchste Umfangsgeschwindigkeiten gezeigt (Linie 1 und Linie 2).

$P = (a.q + b.q^2).\ v_b$; $v_b = 28{,}2 - 31{,}4\ m.s^{-1}$

$a = 90 - 120\ N.kg^{-1}.s$

$b = 7 - 10\ N.kg^{-2}.s^{-2}$

wo ist

- P - Kraftbedarf (W),
- a, b - Konstanten,
- q - Durchgangleistung ($kg.s^{-1}$),
- v_b - Umfangsgeschwindigkeit der Dreschtrommel ($m.s^{-1}$).

Die dritte Linie im Diagramm bildet der Verlauf des Kraftbedarfes des Dreschmechanismusmodells in Abhängigkeit von der Durchganqleistung. Dieser gesamte Kraftbedarf besteht aus dem Kraftbedarfen von Dreschtrommel und Rotationswalzen des Dreschkorbes. Im Kraftbedarf der Dreschtrommel ist auch der Bansertrommelkraftbedarf mitberechnet.

2.2. Separation und Beschädigung

Experimentale Ergebnisse beweissen, daß die vergrößerte Durchgangleistung die Separationseigenschaften des Dreschmechanismus verschlechtert. Zum Beispiel bei einer Durchgangleistung von 3 $kg.s^{-1}$ bleibt durchschnittlich 28,8 % der Masse des lockernen Korn im Stroh hinter dem Dreschmechanismus. Mit vergrößerter Durchgangleistung ist dieser Wert noch größer. Es ist also notwendig mit einer größeren Belastung des Reinigungsmechanismus zu rechnen.

3. DISKUSSION

Aus den Ergebnissen geht hervor, daß der Dreschmechanismus mit dem Rotationskorb die größere Beschädigung verursacht. Die Beschädigung ist größer als bei den jetzigen benutzten Dreschmechanismen. Dieser Wert mit vergrößerter Durchgangleistung sinkt. Die Umfangsgeschwindigkeit der Korbwalzen hat keinen Einfluß auf die Größe der Beschädigung.

4. SCHLUSSVOLGERUNGEN

Dieser Dreschmechanismus zeigt die Vorteilhaftigheit vom Gesichtspunkt des niedrigen Energiebedarfs bei den großen Durchgängen aus. Die schlechteren Separationeigenschaften bei höheren Durchgängen sind bloß eine Konstruktionsfrage der Sauberkeitsorganen des Mähdreschers.

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TRENDS IN AGRICULTURAL ENGINEERING
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IMPROVEMENT IN DURABILITY OF MACHINE ELEMENTS WITH THE AID OF COMPOSITE COATINGS

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The article deals with general methodological problems of designing composite coatings (CC) for operation under specific conditions. The results of the research of flame spraying of metallized composite powders and the application of this method for restoring and hardening agricultural machine elements are presented below.

composite coatings; flame spraying; matrix; filler; ceramics; interphasic interaction; wear rasistance.

1. INTRODUCTION

One of the main trends of quality improvement of agricultural machine elements is the application of new promising materials, specifically composite ones, in restoration practice. Composite material is a volumetric artificial composition of 2 or more materials differing in form and properties with a clearcut boundary surface between them, advantages of each material being derived. Recently composite materials have come into use as coatings (composite coatings), which is very important for restoration and hardening machine elements. The constituents of composite coatings are the compositions of materials referring to basic material classes: metals, ceramics, plastics. The procedure of giving terms to composite coatings is based in the first place on filler name and then on matrix name [1]. For example: metal ceramics coating-ceramics (base) impregnated with metal; cermet coating-ceramic particles harden metallic matrix etc.

We have developed a number of methods to apply composite coatings to machine elements [2]: different kinds of facing (arc deposition,high frequency facing, oxyacetylene surfacing and others); plasma and explosion spraying; foundry technology methods etc. The most advanced methods producing coatings for the machine part restoration are solid phase and solid-liquid phase technologies which do not bring the materials being treated to the melting point. We speak about the methods of powder metallurgy, pressure welding, galvanotechniques and others.

2. DESIGNING COMPOSITE COATINGS

The technology of designing components with CC specifies the following main stages: the analysis of initial design data (requirements to coating and a component as a whole); working out the constitution and the structure of composite coatings (the kind of matrix and filler, their quantitative relation, the geometry and the order of arrangement, component compatibility); the development of the structure of "coating-component base" system; working out the technology of CC application; the property evaluation of CC and a component.

Taking into account abrasion wear, the structure of wear-resistant CC is to meet the following requirements: elasto-plastic matrix; the particle hardness of the hardening phase must be greater than the abrasive hardness; the distances among the filler particles must be smaller as compared to abrasive particle size; great cohesion bond among the components of composite coatings. Iron, nickel cobalt and their alloys are mostly used as matrix materials. Different ceramic materials serve as wear-resistant fillers: carbides, borides, oxides, nitrides and others. In our experiments we used chromium carbide and alumina as fillers.

To solve the problem of the component compatibility of CC means to cope with two conflicting tasks: on the one hand the provision of great adhesion among the components which implies their definite interaction and on the other hand inadmissibility of intensive development of their interaction on phase boundaries which may result in mutual dissolving of components, in the emergence of brittle intermediate phases and finally in the loss of CC hardness. Both principles, in spite of their being contradictory, are practically feasible. It is only necessary for the interaction to take place at the moment of CC formation and later on under the operation conditions when temperature is usually lower, this interaction will have to stop or at least to slow down.

Experiment is the main source of receiving data about material compatibility under specific conditions. At the same time the necessary initial information about the interaction capability of components in CC may be obtained from the constitution diagrams of material systems, thermodynamic calculations, the analysis of interaction kinetics and the calculation of thermomechanical compatibility. The following techniques of compatibility control have also been worked out: the change of the chemical composition of the filler surface by means of applying coatings; the directional matrix alloying; the application of special atmospheres; mechanical and temperature activation of CC applying processes.

3. FLAME SPRAYING OF COMPOSITE POWDERS

Flame spraying (FS) of high heat ceramic particles is greatly problematic because of the insufficient gas flame temperature and the low velocity of particle flight. In a case like this composite metallized powders [2-3] with more fusable metal sheath as compared to ceramic core are promising materials for flame spraying.

The increase of flight velocity of powder particles is possible due to the use of special accelerators (activators) in a sprayer design. They "push on" particles with additional air flow supplied to the jet under the pressure of 0.6 - 0.7 MPa (Fig. 1).

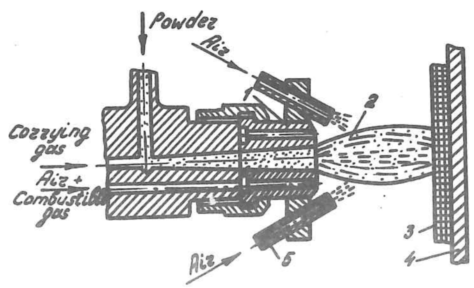

Fig. 1. Diagram of flame spraying with an activator: 1 - nozzle; 2 - torch; 3 - coating; 4 - base; 5 - activator.

When analysing FS with an activator of composite particles in such systems as Cr_3C_2-Ni and Al_2O_3-Ni it was established

that the velocity of particle flight was about doubled (from 30-40 m/sec to 65-80 m/sec). The surface of fine particles (< 63 mu) is heated to the melting temperature of the sheath (nickel) already at the distance of 80-100 mm from the nozzle exit section and then the melting process of the total nickel volume with established heat dissipation is probably going on into a ceramic phase. At the distance of about 150 mm one can ascertain nickel sheath overheating to the peak value and then gradual surface cooling of particles.

On the basis of the data obtained we can define the most significant technological parameter of the process - the optimum spraying distance. For the particles < 63 mu the surface being sprayed should be spaced just after the point of convergence of the activator air jet i.e. at the distance of 110-140 mm. This distance is coincident with the maximum velocity of particle flight and with sufficiently great temperature value of the surfaces of the particles. If spraying is carried out at the distance of 180-220 mm where the maximum heating of particles takes place the overheated nickel sheath is separated from the ceramic core as a result of particles colliding with component surface, and immediate deterioration of coating arises.

While studying microstructure of CC it was found that the filler is rather evenly distributed in the matrix. The matrix of CC, being produced by the spraying of powders of the composition of Cr_3C_2-Ni, is solid solution C-Cr-Ni. The number of unbonded carbides is determined by particle size and the content of nickel in a composite particle. If ceramic particle size increases and cladding metal quantity decreases, the number of unbonded carbides becomes larger. If the content of nickel is considerable, carbides are activly dissolved - they "are disintegrated" and are not detected metallographically, the matrix being saturated with chromium. Alumina is present in coating in a free state. In addition to alumina CC contains NiO, pure nickel and spinel $NiAl_2O_4$. In our experiments spinel was detected when an activator was used, i.e. when an additional air supply to the jet was provided. The presence of spinel in CC makes interphasic interaction more active as well as must have a favourable effect on the porosity decrease, the increase of wear resistance and adhesiveness of coating and a base.

Thus, with flame spraying of CC it is possible to control the degree of interaction of its components and coating structure as well. By controlling size grading, the content of nickel in a composite particle and other spraying conditions, it is possible to produce CC with varying content of unbonded carbides, to carry out directional alloying of matrix, to form new intermediate phases among the components of CC.

It is the degree of interphasic interaction that affects the standard of the microhardness of CC (Fig. 2). When spraying of composite powders of the composition of Cr_3C_2-Ni (20% mass.) is carried out a fairly great number of unbonded carbides with microhardness of (17-31) 10^3MPa is detected in such coating, the matrix microhardeness mainly being within the limits of (7-11) 10^3MPa (Fig. 2a). If the content of nickel in composite particles increases up to 30% mass. the intensity of its interaction with Cr_3C_2 rises and as a result coating heterogeneity smooths down, i.e. more uniform microstructure of (3-13) 10^3MPa is formed. (Fig. 2b).

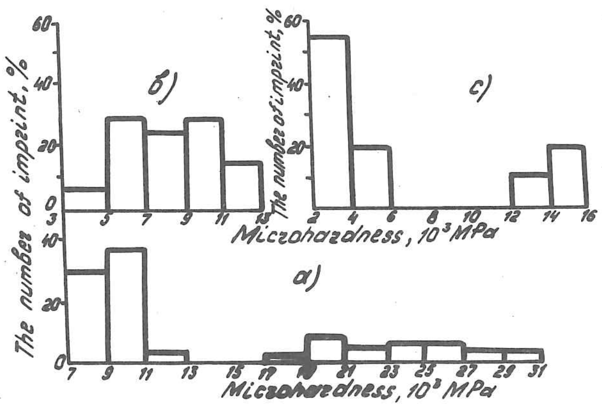

Fig. 2. Microhardness of composite coatings sprayed with powders of the following composition : a) Cr_3C_2-Ni - 20% mass; b) Cr_3C_2-Ni - 30% mass; c) Al_2O_3-Ni - 30% mass.

The results of microhardness measurements of CC of the composition Al_2O_3-Ni (30% mass.) indicate the presence of two apparent constituents - the matrix with microhardeness of (2-6) 10^3MPa and the filler with microhardeness of (12-26) 10^3 MPa (Fig. 2c). The intermediate phases resultant from the component interaction of CC are detected to a lesser degree as compared to the system Cr_3C_2-Ni. It is advisable to use cermet CC for restoring and hardening agricultural machine tools, operating in abrasive environment [4]. One of the mass rapidly worn parts of agricultural machines is a seed disk of a grain

drill. If a disk wear is more than permissible one, the agrotechnical requirements are not met, particularly the uniformity of drilling depth, the latter resulting in harvest losses.

CC were sprayed on a disk periphery from the side opposite to the side of grinding. The regimes of spraying: distance - 110 mm; the speed of disk rotation - 100-120 min ; acetylene pressure 0.1 MPa; oxygen pressure - 0.2 MPa; powder consumption - 12-25 g. per disk. Coating width - 10 mm, thickness - 0.15-0.20 mm. Exothermal reaction powder PT-NA-01 was used as a precoat.

We have carried out comparison reliability bench tests of the disks (steel 65 G) not treated thermally but hardened with the aid of CC and disks of series production. The motion speed of shares was 12km/hr; the ploughing depth of shares - 80 mm; the spring pressing effort of push rods - 80 kg; soil moisture - 20%; soil composition - one part of clay and five parts of sand. Share running was 1000 hours (2700 ha.) which corresponds to 9-year drill running.

The tests showed that the wear resistance of sprayed disks is by 1.6-1.8 greater than that of series ones. The wear rate of the disks coated with Al_2O_3-Ni - 0.8mm/100ha; of the disks coated with Cr_3C_2-Ni - 0.7mm/100ha; of the series disks - 1.3mm/100ha. This level of disk wear resistance increase is sufficient to provide for the equal strength, i.e. to make disk life approximately as long as drill life. Along with wear resistance increase the application of CC provide for the self-sharpening of blades.

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Table 1. Relationship between N-fixing activity and optical characteristics of Bradyrhizobium arachis strains

Treatments	Total uptake of N by plants, mg	Symbiotically fixed N, mg	I. R,%	I. A %	II. R,%	II. A %
Check(untreated)	166	-	16,70	70,38	23,46	53,13
Strain 11	259	93	16,51	68,25	10,59	80,46
Strain 13	382	216	9,12	82,34	12,40	78,40
Strain 21	322	156	8,62	82,36	8,60	82,66
Strain 30	304	138	10,54	80,71	9,61	78,16
Strain 302	141	25	16,50	67,64	18,47	57,70
Strain 303	522	356	7,40	86,63	8,63	84,63
Strain 3188	175	9	11,72	79,84	15,36	67,76
Strain 3G4b20	606	440	7,08	88,46	8,98	86,20
Strain 17GA22	571	405	5,48	89,97	8,11	86,10

TRENDS IN AGRICULTURAL ENGINEERING
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OPTICAL CHARACTERISTICS OF LEAVES OF CULTIVATED PLANTS

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Plant leaves represent specific optical filters which determine the capacity of the photosynthetizing apparatus (3,4). The latter is best described by two coefficients: absorptance A% and reflectance R%.

The objective of this paper has been to define the relationship between the N-fixing activity in various microbial (Bradyrhizobium arachis strains) fertilizers, the mineral fertilizer rate and the optical characteristics of plants cultivated for agricultural purposes.

Pot experiments with different cultivated plants have been carried out:

(1) Two experiments in which peanut plants were grown on an alluvial meadow soil and the N-fixing activity of 9 strains of Bradyrhizobium arachis was assessed;

(2) An experiment in which maize plants were grown on two different soils and received different fertilizer amounts. The leaf absorptance A% was measured at blossoming;

(3) An experiment in which the effect of 4 N-fertilizer rates on garden bean plants was evaluated. Averaging to 3 leaves was adopted;

(4) An experiment with the Poly E-1 sugar beet hybrid treated with preparations differing in their biological effect: DMS-4, N-40, HP-44/$_{20}$ and HP-44/10^2ml ha $^{-1}$. Reflectance R% was measured in all treatments.

The optical characteristics of plant leaves absorptance A% and reflectance R% were measured using an automated laser system operating on the basis of a Pravetz-8 PC. The sensor of the system is a modified Ulbricht sphere with a 2 mW He/Ne laser light source and a hemisphere with 20 photoreceiving elements. The system measures the amount of passing and reflected monochromatic light energy with a wavelength λ = 632.8 nm and calculates leaf absorptance A% (1,2).

These pot experiments have yielded the following results:

1. Table 1 shows the data on the N-fixing activity of the strains studied and the optical characteristics of leaves reflectance R% and absorptance A% at two stages of plant growth. These data indicate a wide range of variation among the N-fixing activities of the tested strains. The measurements show no activity of strain 302, a very weak activity of strain 3188 and a weak activity of strain 11. The highest activity has been displayed by strains 3G4b20 and 303. The activity of the rest of the strains is in the middle of the scale. Reflection data show a negative relationship between the strains' N-fixing activity and leaf reflectance . The highest values have been detected for the check plants and the low-active strains. The lowest reflectance has been observed in plant leaves treated with highly active strains. The relationship between the strains' N-fixing activity and absorptance A% follows exactly the opposite pattern with a highly positive correlation. The highest absorptance values have been found in the leaves of the plants treated with the most active N-fixing strains.This stands to reason because these plants grow under the most favourable conditions regarding N nutrition and the photosynthetizing apparatus in them operates at fuller capacity.

The above relationships hold good for the second pot experiment

(table 2). Here again, the lowest reflectance R% values and the highest absorptance A% values have been found the leaves of the plants treated with the active peat-like preparation obtained from the highly active strian 303. No particular effect of the Vafotox preparation has been discovered because the latter is effective in a different area: it is used mainly to protect seeds from pest-caused damage.

2. The measurements of absorptance A% in young maize plants (table 3) have shown a strong relationship between the N-fertilizer rate and leaf light absorption for both soils used.

3. Fig.1. shows a high correlation between the N-fertilizer rate and the absorptance A% in garden bean plants.

4. The measurements of abrorptance A% in sugar beet treated with preparations differing in their biological effect have shown a better correlation with chlorophyll B absorption than with chlorophyll A absorption. This is accounted for by the closeness of wavelengths: for the He/Ne laser λ = 632.8 nm and for the chlorophyll B absorption λ = 644 nm while for the chlorophyll A absorption λ = 665 nm. That is why plants containing more chlorophyll B have a higher absorptance A% value (Fig.2).

Finally, the following conclusions can be made:

(1) The optical characteristics A% and R% of peanut plants can be used for express evaluation of the N-fixing activity of microbial fertilizers based on various strains (e.g. Bradyrhizobium arachis strains) and their effectiveness.

(2) Absorptance and reflectance by the leaves of young plants can be used in the evaluation of the N-fertilizer rate adequacy.

(3) The absorptance A% values can be used in assessing the effectiveness of preparations differing in their biological effect when applied to sugar beet.

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Table 2. Relationship between N-fixing activity and optical characteristics of two peanut cultivars

Treatment	Total uptake of N by plants, mg	Symbiotically fixed N, mg	I		II	
			R,%	A %	R,%	A %
			I. Cultivar 2609			
Untreated	166	-	16,70	70,31	23,46	53,13
Untreated+Vofatox	161	-	14,47	71,52	20,36	59,93
Treated with a peat-like preparation containing strain 303	529	363	7,05	87,81	9,77	84,40
Treated with a peat-like preparation containing strain 303 + Vofatox	516	350	7,64	86,30	6,79	87,50
			II. Cultivar "Kalina"			
Untreated	162	-	9,42	80,13	13,70	68,36
Untreated + Vofatox	124	-	10,33	79,81	14,73	68,83
Treated with a peat-like preparation containing strain 303	554	392	9,02	96,64	6,74	87,56
Treated with a peat-like preparation containing strain 303 + Vofatox	533	371	8,75	87,61	6,39	87,23

Table 3. Absorptance A% for young maize plants receiving different fertilizer amounts

Chernozem-smolnitza		Grey forest soil	
Fertilizer rate	A %	Fertilizer rate	A %
0	44,95	0	51,12
200	61,52	200	58,98
400	79,35	400	82,95
600	81,63	600	83,94

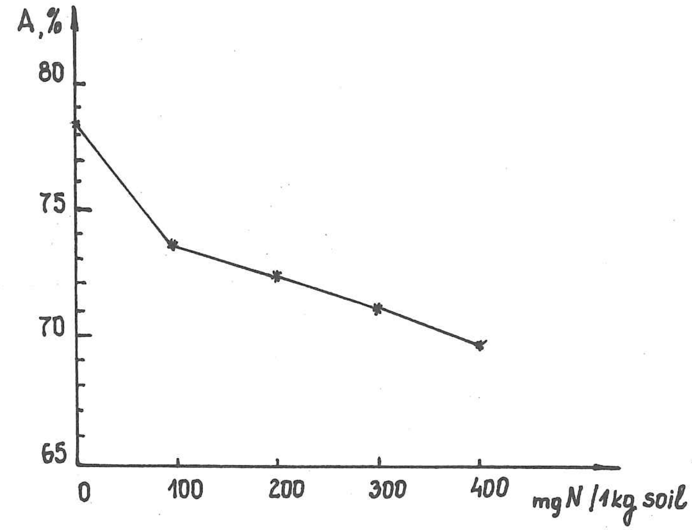

Fig. 1. Relationship between N-fertilizer rate and absorptance A% in garden bean plants

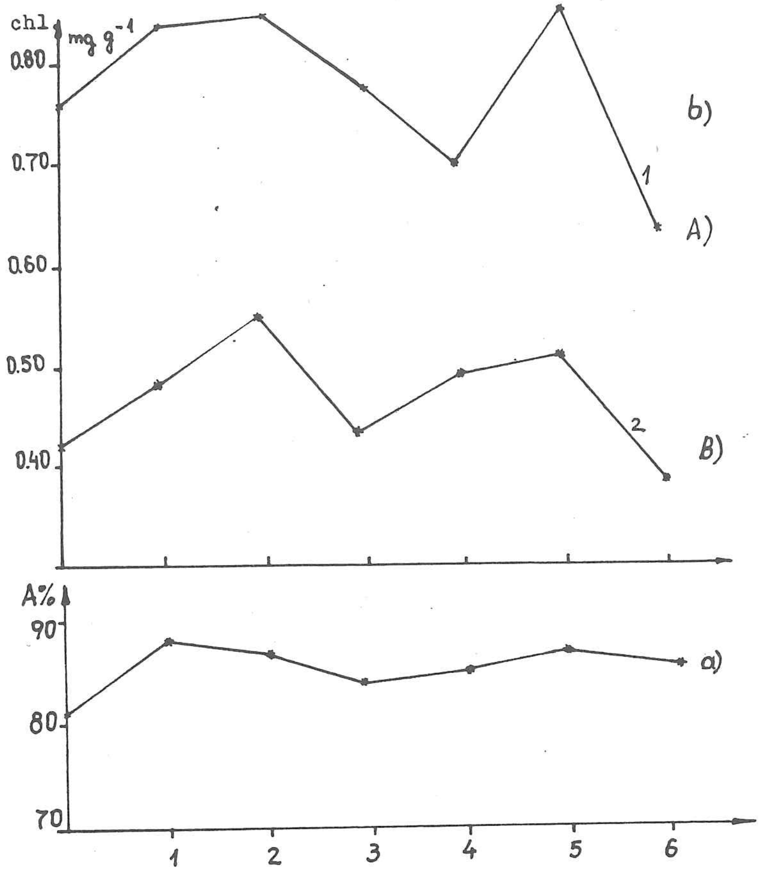

Fig. 2.(a) Relationship between absorptance A% in sugar beet and treatments with preparations with differing biological effect.

(b) Relationship between absorptance A% and the content of chlorophyll A and chlorophyll B in sugar beet (the same plants)

TRENDS IN AGRICULTURAL ENGINEERING
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SAFE TEMPERATURES FOR DRYING BARLEY

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Eighteen drying experiments on malting barley variety Jarek with initial moisture content ranging from 8 to 29 % (w.b.) and exposure time from 0.5 to 5.0 hours were carried out. Temperature in the chamber was set up 40, 50, 60 or 70 °C. In each experiment 11 samples were prepared: one sample for control germination was not treated and ten samples were removing from the chamber at regular time intervals of 0,5 h. After treatment each sample was tested on moisture content and after 3 months on germination. The relation between standard deviation of normally distributed death rate and moisture content and grain temperature was determined. Critical temperature for viability reduction of 1 % and 3 % was correlated with logarithm of moisture content and logarithm of exposure time.

barley germination; grain quality; viability modelling; viability

1. INTRODUCTION

In Czechoslovakia cereals and some other grains require to be dried before storing. For this purpose continuous driers are used. New heated air driers have a throughput from 10 to 50 t.h^{-1} when drying grain from initial moisture content 19 % to final moisture content 15 %. Only mixed-flow driers are manufactured in Czechoslovakia. The inlet air temperature ranges from 40 to 130 °C. One pass under nominal throughput takes approximately 1 hour. This time is too small for mold or insect development. But there is a danger of heat damage. Heated air driers are widely used as drying is quick and produce a more uniform product /1/.

The main factors which influence deterioration in viability during drying are: 1. species, variety and initial grain quality; 2. grain moisture content; 3. grain temperature; 4. exposure time. The aim of the paper is to determine critical temperature for a certain level of loss of viability of malting barley.

2. EXPERIMENTAL

Eighteen drying experiments on malting barley variety Jarek with initial moisture content ranging from 8 to 29 % (w.b.) and exposure time from 0.5 to 5.0 hours were carried out. Seed of barley was hand-harvested in August 1990. Experiments ran immediately. No artificial moistening was used. Grains of barley were separated from ears by hand. Chaff was removed by the air. Temperature in the chamber was set up 40, 50, 60 or 70 °C. In each experiment 11 samples were prepared: one sample for control germination was not treated and ten samples were removing from the chamber at regular time intervals of 0,5 h. Each sample was placed on a separate sieve of dimensions 420x200 mm forming grain monolayer. Into one grain on the sieve which was removed from the chamber after 5,0 h a small thermocouple was inserted. It was not necessary to fix the air temperature exactly by thermostat as both grain moisture content-time curves and grain temperature-time curves were taken into account in data processing. After heat treatment each sample was immediately tested on moisture content. Samples were left in paper bags for about 3 months for breaking of dormancy. Then samples were tested on germination. The rolled paper towel method was used for two sample lots of 100 seed per germination test.

3. THEORY

Germination G which indicate the number of viable seeds remaining in a treated sample is a function of grain moisture M, grain temperature θ, exposure time t and initial germination G_o and some constants c_1, c_2, ... c_n (Eqn. 1).

$$G = G(M,\theta,t,G_o,c_1,c_2,...,c_n) \qquad (1)$$

Roberts and Ellis /2,3,4/ have shown that under constant storage conditions, deaths in a population of seed are distributed normally (Eqn. 2).

$$G(t) = 1 - \frac{1}{\sigma\sqrt{2\pi}}\int_{-\infty}^{t'=t} e^{-\frac{(t'-\bar{t})^2}{2\sigma^2}}dt' = \frac{1}{\sigma\sqrt{2\pi}}\int_{t'=t}^{\infty} e^{-\frac{(t'-\bar{t})^2}{2\sigma^2}}dt' \qquad (2)$$

It is very useful to introduce standard normal deviate x (Eqn. 3). Ellis and Roberts /3,4/ used for x the term probit value.

$$x = \frac{(t-\bar{t})}{\sigma} \qquad (3)$$

Eqn. 2 may be re-written as

$$G(x) = 1 - \frac{1}{\sqrt{2\pi}}\int_{-\infty}^{x'=x} e^{-\frac{x'^2}{2}}dx' = \frac{1}{\sqrt{2\pi}}\int_{x'=x}^{\infty} e^{-\frac{x'^2}{2}}dx' \qquad (4)$$

Values $G(x)$ are tabulated. For t = 0 h Eqn. 3 yields the relation between mean

exposure time $\bar{t}$ and standard deviation σ (Eqn. 5).

$$\bar{t} = -x_o\sigma \qquad (5)$$

Substituting $\bar{t}$ from Egn. 5 in Eqn. 3 yields (Eqn. 6).

$$x = x_o + t/\sigma \qquad (6)$$

The rate of loss of viability measured in probit units x is according to Eqn. 6 proportional to reciprocal value of standard deviation σ. According to Ellis and Roberts /3,4/, Nellist and Bruce /5,6/ standard deviation does not depend on initial viability (Eqn. 7).

$$\sigma = \sigma(M,\theta,c_1,...c_n) \qquad (7)$$

Equations 2 to 6 are valid only in the case of constant standard deviation σ, i.e. for constant moisture content M and temperature θ.

Ellis and Roberts /3,4/ have found Eqn. 8 from sealed heating experiments.

$$\ln\sigma = 22{,}99 - 5{,}896 \ln M - 0{,}0921\ \theta - 0{,}000986\ \theta^2 \qquad (8)$$

Lescano and Tyrrell /7/ have obtained Eqn. 9 from 23 thin-layer drying tests.

$$\ln\sigma = 4{,}198 - 33{,}20 \ln M - 0{,}267\ \theta \qquad (9)$$

4. RESULTS

Because grain temperature and moisture content are varying during drying in the chamber, Eqn. 6 cannot be directly applied. Nellist /5/ suggested that the total loss of viability could be estimated by accumulating the loss predicted for each time increment by advancing along a drying curve. In each time increment standard deviation σ is calculated. The procedure has a few steps:

1. Let us consider: coefficients c_1, c_2, ... c_n in Eqn. 7 were set; curves $M = M(t)$, $\theta = \theta(t)$ were determined; viability $G(t)$ for time t was predicted. A certain probit value $x(t)$ corresponds to $G(t)$. We are trying to find viability $G(t+dt)$.
2. For moisture content $M(t)$ and grain temperature $\theta(t)$ standard deviation σ (Eqn. 7) is determined.
3. Eqn. 6 is applied for a small time increment dt (Eqn. 10).

$$x(t+dt) = x(t) + dt/\sigma \qquad (10)$$

and the probit value $x(t+dt)$ is converted to germination $G(t+dt)$.

4. In the next step we start from time $t+dt$ and repeate steps 2 and 3.

The calculation of coefficients c_1, c_2, ... c_n in the Eqn. (7) was based on the residual sums of squares of differences between predicted and experimental germination values G_p - G_e. Sums of squares were determined for germination results of all experiments

TABLE 1
Coefficients of Expressions $\sigma = \sigma(M, \theta)$ including x_o.

Expression	Coefficient					Residual sum of squares $\sum(G_p-G_e)^2$
	x_o	c_1	c_2	c_3	c_4	
$\sigma = c_1 + c_2M + c_3\theta$	2,095	25,690	-0,260	- 0,297	-	15 059
$\sigma = c_1 + c_2\ln M + c_3\theta$	1.574	113,864	-0,108	- 3,243	-	15 375
$\sigma = c_1 + c_2M + c_3\ln\theta$	1,993	82,044	-0,389	-17,589	-	14 701
$\sigma = c_1 + c_2\ln M + c_3\ln\theta$	2,454	56,961	-3,371	-11,047	-	15 591
$\ln\sigma = c_1 + c_2M + c_3\theta$	1,635	21,784	-0,278	- 0,251	-	12 599
$\ln\sigma = c_1 + c_2\ln M + c_3\theta$	1,560	119,472	-9,014	- 1,376	-	14 171
$\ln\sigma = c_1 + c_2M + c_3\ln\theta$	1,614	80,603	-0,351	-17,692	-	12 200
$\ln\sigma = c_1 + c_2\ln M + c_3\ln\theta$	1,652	68,540	-4,488	-13,248	-	11 821
$\ln\sigma = c_1 + c_2\ln M + c_3\theta + c_4\theta^2$	1.636	28,090	-5,402	-0,1114	-0.00115	12 367

(i = 1,2 ... 18) and all exposure times (j = 1,2 ... 11, i.e. t = 0; 0,5 ... 5 h) (Eqn. 11).

$$\sum_{i,j} [G_{p,i,j}(x_o,c_1,c_2,...c_n) - G_{e,i,j}]^2 \rightarrow \min \tag{11}$$

A few relations (7) for standard deviation σ were chosen. The summary including the residual sum of squares is in Tab. 1. All relations have three constants. The exception is the last relation with four constants. The best equation was found

$$\ln \sigma = 68{,}540 - 4{,}488 \ln M - 13{,}248 \ln \theta \tag{12}$$

Initial probit value x_o = 1,652 corresponds to initial germination G_o = 95,1 %.

If the germination G in the relation (2) is set to be constant, this equation represents the relation for critical temperature. Calculation of critical temperature from this equation where mean exposure time and standard deviation are expressed in equation (5) and (12) is very uncomfortable. It is better to do approximation by some simple equation. Critical temperature θ_c is a function of initial germination G_o, loss of viability ΔG, exposure time t, moisture content M. There are some coefficients c_1, c_2, ... c_n.

$$\theta_c = \theta_c(G_o,\Delta G,t,M,c_1,c_2, ... c_n) \tag{13}$$

Coefficients c_1, c_2, ... c_n are determined from residual sum of squares (Eqn. 14) for critical temperature calculated according to the Egn. (2) and Eqn. (13).

$$\sum [\theta_c - \theta_c(M,t,c_1,c_2,c_3)]^2 \rightarrow \min \tag{14}$$

Eqn. 15 fits the best.

$$\theta_c = c_1 - c_2 \ln t - c_3 \ln M \tag{15}$$

Coefficients for this equation for initial germination G_o = 95; 97; 99 % and loss of germination ΔG = 1; 3 % are in tab. 2. Effect of exposure time on critical temperature is also in Fig. 1 where critical temperature is added to the Fig. of Nellist /1/. It is

TABLE 2
Coefficients of Expressions $\theta_c = c_1 - c_2\ln t - c_3\ln M$.

Initial viability G_o	Loss of viability ΔG	Coefficient		
		c_1	c_2	c_3
95 %	1 %	112,107	4,300	19,517
	3 %	119,048	4,530	20,489
97 %	1 %	114,377	4,271	19,741
	3 %	120,976	4,539	20,659
99 %	1 %	119,737	4,536	20,535
	3 %	124,849	4,679	21,130

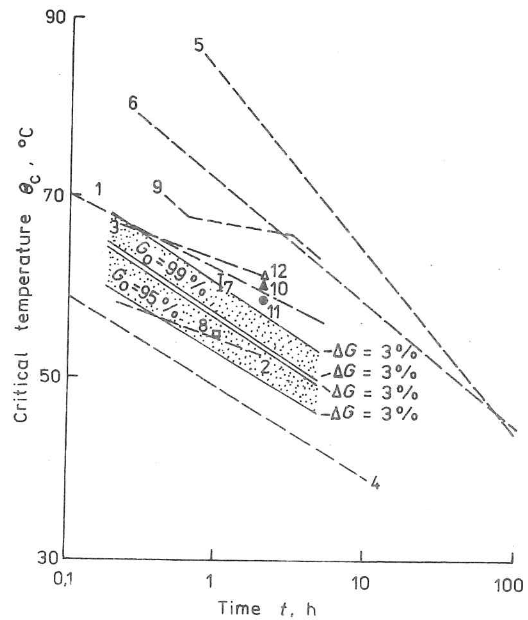

FIGURE 1. Effect of exposure time on critical temperature at a moisture content of 21 % for malting barley var Jarek (dotted) compared with Nellist's review /1/ of sealed heating experiments.

1. Wheat var Turkey Red - 25 % viability - Groves /8/
2. Wheat var Square-Heads Master - start of damage - Hutchinson /9/
3. Wheat var Square-Heads Master - complete kill - Hutchinson /9/
4. All seeds - Pticyn /10/
5. Wheat - 50 % viability (extrapolated) - Roberts /11/
6. Barley - 50 % viability (extrapolated) - Roberts and Abdalla /12/
7. Wheat - 50 % viability - Hughes /13/
8. Wheat - 97 % of control germination - Lindberg and Sorensson /14/
9. Wheat var Manitoba - 50 % viability - Watson /15/
10. Maize var Reid's Yellow Dent' - 25 % viability - Robbins a Petsch /16/
11. Maize var Longfellow Flint - 25 % viability - Robbins and Petsch /16/
12. Wheat var Kanred' - 25 % viability - Robbins and Petsch /16/

apparent that critical temperature for malting barley is in the space of Hutchinson /9/ for start of damage and complete kill of wheat. The lower initial viability is, the lower critical temperature.

5. CONCLUSIONS

Eighteen barley drying tests were conducted. Grain germination, moisture content and grain temperature data were collected. Equation for logarithm of standard deviation of normally distributed death rate curve was determined. The equation has grain temperature and moisture terms logarithmic. Critical temperature for loss of viability of 1 % and 3 % was correlated with logarithm of moisture content and exposure time.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

TURNING OF OVERLAYS

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The paper contains the results od tests of overlays machining. The wire C-508 was welded onto the basic material 14 220 using the vibration method in shielding carbon dioxide atmosphere. Wire C-508 is used in agricultural practice for overlays, which are machined before hardening. The overlay was turned by exchangeable cutting tip of sintered carbide H1. For given depth of cut and feed the effect of the cutting speed on the course of cutting edge wear was measured. On this basis the relationship between cutting life and cutting speed was determined for possibility of determining the optimum cutting speed resulting in minimum production costs. The relationship between the surface roughness and cutting edge wear was determined too.

cutting conditions; wear; sintered carbide tool; machining of overlays

1. EINLEITUNG

In spezialisierten Reparaturwerkstätten der Landtechnik wird sehr oft Renovierung der abgenutzten Teile durch Aufschweißung, und zwar in höherem Maß im Vibrationsverfahren in der Kohlendioxyd-schutzatmosphäre, verwendet. Als Zusatzwerkstoff werden drei Drahttype gebraucht: C-113 für weiche Aufschweißungen (durchschnittliche Härte 210 HB), C-508 für Flächen, die nach spanender Bearbeitung gehärtet werden (Härte bei der Bearbeitung 30 bis 44 HRC) und UNION-A 350 IG für die Flächen, die ohne weitere Wärmebehandlung hart und verschleißfest sein sollen (Härte 60 bis 65 HRC). Für die Bestimmung der optimalen Schnittgeschwindigkeit wird die Kenntnis der Formel

$T = c.v^{-m}$ ausgenutzt, wo
T ... Standzeit (min)
v ... Schnittgeschwindigkeit (m/min)
m ... Exponent
c ... Konstante.

Auf Grund der Kenntnis dieser Formel und weiterer ökonomischen Größen (Preis der Werkzeugmaschine, Preis des Werkzeugs, Lohn, Schärfenkosten, Gemeinkosten usw.) kann mit Hilfe der in

/1/ angeführten Formeln Schnittgeschwindigkeit bestimmt verden, bei der die Bearbeitungkosten minimal sind.

2. VERSUCHSDURCHFÜHRUNG

2.1 Grundwerkstoff

Als ein aus oft benutzten Werkstoffe wurde Stahl 14 220 (0,14-0,19 C; 1,10-1,40 Mn; max. 0,35 Si; 0,8-1,1 Cr; max 0,04 S; max 0,04 P; max 0,07 P+S) gewählt. Die Walzenproben hatten 53 mm Durchmesser und 310 mm Länge.

2.2 Zusatzwerkstoff und Aufschweißungsdurchführung

Es wurde Draht C-508 (Richtzusammensetzung 0,25 C; 0,9 Mn; 0,9 Si; 0,9 Cr) vom Durchmesser 1,2 mm benutzt. Zur Aufschweißung wurde ein Schweißautomat NVE 301, Stromquelle Kv 220 und Schweißvorrichtung PSH 02 verwendet. Die Aufschweißbedingungen, waren den in der Praxis benutzten ähnlich. Zur Erhaltung der gleichen Härte der Aufschweißungen wie in der Praxis wurden auf die Probe Teilaufschweißungen von der Länge 40 mm und dem Abstand 20 mm aufgetragt, und zwar die folgende Aufschweißung erst nach erkalten der vorigen. Härte der Aufschweißungen war 30 bis 40 HRC. Diese verhältnismäßig große Streuung wiesen auch Aufschweißungen in der Praxis aus.

2.3 Drehen der Aufschweißungen

Zum Drehen wurde Hartmetall H1 in Form einer Wendeplatte SNUN 120408 und Halter NAREX 22 3852.1 2525 benutzt. Daraus folgt die Schneidegeometrie: $\alpha = 8^0$, $\gamma = -8^0$, $\varkappa = 45^0$, $\lambda = -5^0$. Die Prüfungen läuften bei den Vorschüben 0,1 und 0,2 mm/U; der Schnittiefe 0,8 mm und den Schnittgeschwindigkeiten 122,7; 172,8 und 341,9 m/min durch.

2.4 Verschleißmessen der Schneide

Mit Bezug auf den Verschleißcharakter wurde die Größe VC (Bild 1) gemessen, und zwar die Verschleißbreite bis 2 mm mit Rücksicht auf die Dicke der Wendeplatte. Dazu wurde Messmikroskop Zeiss gebraucht.

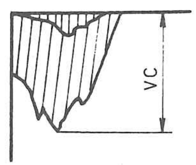

Bild 1. Beispiel des Schneideverschleißes

2.5 Oberflächenrauhigkeitsmessen

Rauhigkeitsmessen wurde auf Talysurf 6 (Taylor Hobson) in Zusammenarbeit mit dem Lehrstuhl für spanende Fertigung ČVUT in Prag durchgeführt.

2.6 Abgemessene Werte des Schneideverschleißes

Aus Raumersparungsrücksichten werden abgemessene Werte des Verschleißes nicht angeführt und die Resultate werden im Bild 2 für die Schnittgeschwindigkeit 122,7 m/min, im Bild 3 für 172,8 m/min, im Bild 4 für 241,9 m/min dargestellt, das alles bei dem Vorschub 0,1 mm/U, und im Bild 5 für 172,8 m/min bei dem Vorschub 0,2 mm/U. Die Standzeitwerte wurden für VC = 0,6; 1,0; 1,5 und 2,0 mm festgestellt. Die entsprechenden Werte werden in Tafeln 1 und 2 angeführt.

2.7 Abgemessene Rauhigkeitswerte bei verschiedem Verschleiß

Abgemessene Rauhigkeitswerte Ra bei verschiedenem Schneide-

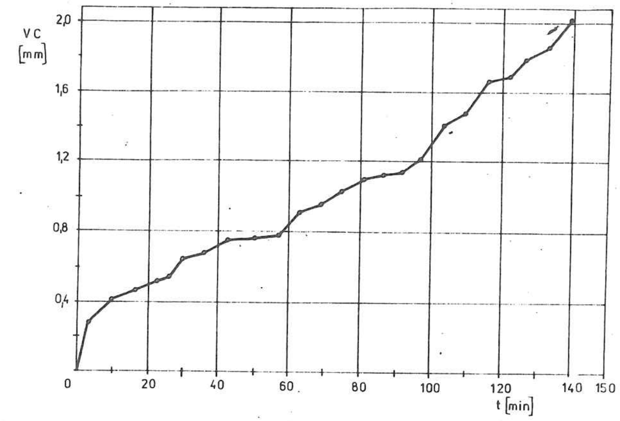

Bild 2. Verlauf des Schneideverschleißes bei v = 122,7 m/min, s = 0,1 mm/U (1 Versuch)

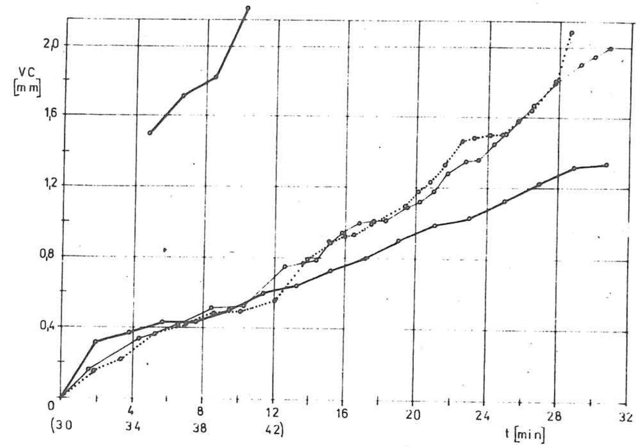

Bild 3. Verlauf des Schneideverschleißes bei v = 172,8 m/min, s = 0,1 mm/U (3 Versuche)

verschleiß VC bei dem Vorschub 0,1 mm/U werden für die Schnittgeschwindigkeit 172,8 m/min im Bild 6, für 241,9 m/min im Bild 7 dargestellt.

3. AUSWERTUNG DER EXPERIMENTE

Auf Grund der Standzeitwerte wurden die in Tafel 3 und 4 angeführte Formeln gewonnen.

Graphische Darstellung der oben angeführten Formeln zeigt Bild 8.

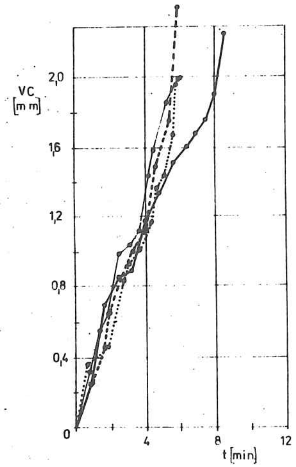

Bild 4. Verlauf des Schneideverschleißes bei v = 241,9 m/min, s = 0,1 mm/U (4 Versuche)

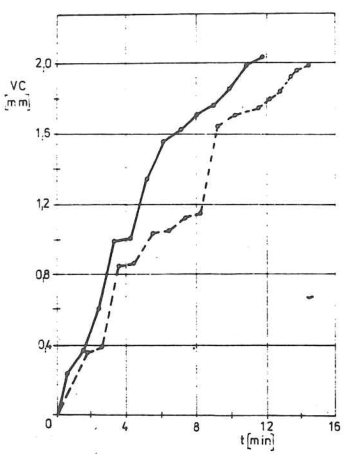

Bild 5. Verlauf des Schneideverschleißes bei v = 172,8 m/min, s = 0,2 mm/U (2 Versuche)

Tafel 1. Standzeitwerte T für verschiedene Verschleißwerte VC bei dem Vorschub 0,1 mm/U

Versuch Nr.	Schnittgeschwindigkeit (m/min)	Standzeit T (min) für den Verschleiß VC (mm)			
		0,6	1,0	1,5	2,0
1	122,7	32	73	113	139
2	172,8	11,0	17,9	24,7	28,6
3	172,8	10,4	17,4	25,0	30,4
4	172,8	11,0	22,0	34,2	39,5
5	241,9	2,1	3,7	5,3	6,0
6	241,9	1,6	3,0	4,6	5,8
7	241,9	2,0	3,3	4,6	5,6
8	241,9	1,7	3,6	6,0	8,0

Tafel 2. Standzeitwerte T für verschiedene Verschleißwerte VC bei dem Vorschub 0,2 mm/U

Versuch Nr.	Schnittgeschwindigkeit (m/min)	Standzeit T (min) für den Verschleiß VC (mm)			
		0,6	1,0	1,5	2,0
9	172,8	1,9	3,2	6,5	11,3
10	172,8	3,0	5,3	8,7	14,6

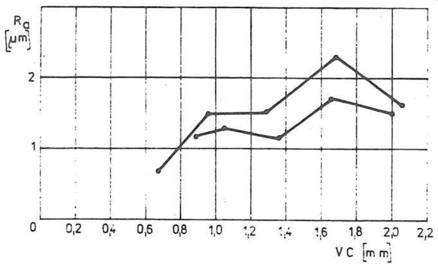

Bild 6. Verlauf der Rauhigkeit Ra bei verschiedenem Verschleiß VC bei v = 172,8 m/min

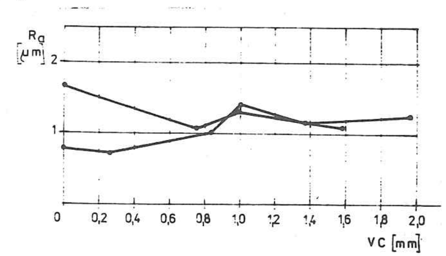

Bild 7. Verlauf der Rauhigkeit Ra bei verschiedenem Verschleiß VC bei 241,9 m/min

Tafel 3. Abhängigkeit Schnittgeschwindigkeit v - Standzeit T für den Vorschub 0,1 mm/U

VC (mm)	Abhängigkeit v (m/min) - T (min)
0,6	$T = 2,582 \cdot 10^{11} \cdot v^{-4,68}$
1,0	$T = 5,079 \cdot 10^{11} \cdot v^{-4,68}$
1,5	$T = 7,554 \cdot 10^{11} \cdot v^{-4,68}$
2,0	$T = 9,148 \cdot 10^{11} \cdot v^{-4,68}$

Tafel 4. Abhängigkeit Schnittgeschwindigkeit v - Standzeit T für den Vorschub 0,2 mm/U

VC (mm)	Abhängigkeit v (m/min) - T (min)
0,6	$T = 7,259 \cdot 10^{10} \cdot v^{-4,68}$
1,0	$T = 1,259 \cdot 10^{11} \cdot v^{-4,68}$
1,5	$T = 2,207 \cdot 10^{11} \cdot v^{-4,68}$
2,0	$T = 3,827 \cdot 10^{11} \cdot v^{-4,68}$

4. DISKUSSION

4.1 Abhängigkeit Schnittgeschwindigkeit - Standzeit

In vorigen Jahren wurden Versuche /2/ bis zu dem Grenzverschleißwert VC = 0,6 mm durchgeführt. Die bestehenden Versuche sollen die Möglichkeit weiterer Ausnützung der Wendeplatten erproben. Neue Versuche entsprachen gut den vorigen. In den Folmeln ist Unterschied im Exponent in Hundertstel, unterschied in den Konstanten entspricht verschieden Härten der aufgetra-

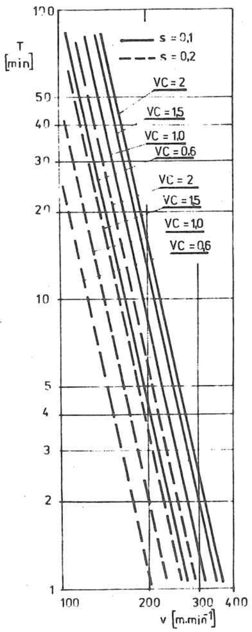

Bild 8. Verlauf v - T für verschiedene VC-Werte beim Vorschub s = 0,1 und 0,2 mm/U

genen Schichten.

Grenzwert VC = 2 mm wurde mit Rücksicht auf die Dicke der Wendeplatte (4,8 mm) und auf die Möglichkeit ihrer Wendung gewählt. Graphische Darstellung im Bild 8 zeigt, daß beim Schruppen (Vorschub 0,2 mm/U) die Ausnützung der Wendeplatte bis VC = 2 mm zweckmäßig ist - die Abstände der Geraden für verschiedenen Verschleiß sind markant. Dagegen beim Schlichten (Vorschub 0,1 mm/U) ist deutliche Verkleinerung der Abstände bei höheren Verschleißwerten sichtbar. Daraus folgt, daß bei dem Verschließ 1,5 oder 2 mm nur kleiner Unterschied in den Standzeiten ist. Ursache dieser Unterschiede liegt in verschiedenen Verschleißverläufen, was Bilder 3 und 5 zeigen.

4.2 Abhängigkeit Schneideverschleiß - Rauhigkeit

Diese Abhängigkeit zeigen Bilder 6 und 7. Beide werden für den Vorschub 0,1 mm/U dargestellt, weil beim Schruppen die Rauhigkeit unwichtig ist. Die Bilder zeigen, daß am Anfang bei neuer Schneide die Rauhigkeit sehr unterschiedlich ist. Nach dem Einlauf setzt sich die Rauhigkeit auf cca Ra = 1 um fest. Später hat die Rauhigkeit mäßig steigernde Tendenz. Die Steigerung ist aber nicht regelmäßig, die Rauhigkeit schwankt nach der augenblicklichen Form der abgenutzten Schneide (siehe Bild 1), aber stets wird der Rauhigkeitswert für Schlichten erfüllt.

5. SCHLUßBEMERKUNG

An dem Lehrstuhl Werkstoff und Maschinenbautechnologie wurden die Versuche der spanenden Bearbeitung von Aufschweißungen durchgeführt. Es wurde Draht C-508 im Vibrationsverfahren in der Kohlendioxyd-schutzatmosphäre aufgeschweißt. Es wurde mit Wendeplatte aus Hartmetall H1 gedreht bei den Vorschuben 0,1 und 0,2 mm/U bei der Schnittiefe 0,8 mm. Schneideverschleiß wurde bis VC = 2 mm gemessen. Es wurden Formeln für die Abhängigkeit Schnittgeschwindigkeit - Standzeit ermittelt für die Verschleißwerte VC = 0,6; 1,0; 1,5 und 2,0 mm als Unterlage (mit anderen Angaben) zur Bestimmung solcher Schnittgeschwindigkeit, bei der die Bearbeitungkosten minimal sind. Zugleich wurde die Oberflächenrauhigkeit gemessen, die um Ra = 1,5 um schwankte. Nur einmal während der Versuche wurde der Wert 2,5 um überschritten. Das erfüllt Richtlinien für Schlichten.

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METHOD OF DETERMINATION OF DIAGNOSTIC OPTIMUM INTERVAL

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In the paper there is briefly described the method of determination of diagnostic optimum interval. The method is based on the minimalisation of costs - cost on diagnostic and the losses arisen in consequence of bad technical conditions of an object of diagnostic. Criterion of determination of diagnostic optimum interval is the minimum total unit cost on the diagnostic. This method is applied to the technical diagnostic of combustion engines.

regular preventive technical diagnostic; diagnostic optimum interval; costs on diagnostic; losses of fuel

At application the regular preventive technical diagnostic there is always necessary to decide what interval of diagnostic will be used. In the practice this problem is solved mostly intuitionally; although necessities of machine are taken into account (technical aspect), economical aspect is mostly neglected, so the interval of diagnostic is determined without respecting of the actual economic situation (the price of fuel, oils, spare parts, new machines and so on). In this paper a possible method of determination optimum interval of diagnostic is described which takes both mentioned aspects into account and the kernel of solution is based on the optimalisation of costs connected with diagnostic. For illustration this method is applied to the technical diagnostic of combustion engines.

The length of period of a diagnostic interval is dependent on two main groups of costs - on costs on diagnostic and losses arisen in consequence of bad technical conditions of an object of diagnostic. From point of view of the length of diagnostic interval these two groups have contradictory affects. The more often technical diagnostic will be applied (a shorter interval of diagnostic) the more the costs on diagnostic will increase, but an object of diagnostic will be maintained in better technical conditions and so losses will decrease. The method of determination of those costs will always depend on specific factors of the object of diagnostic, in the case of a combustion engine we can use following presumption: the worse technical conditions of the engine will be, the higher specific consump-

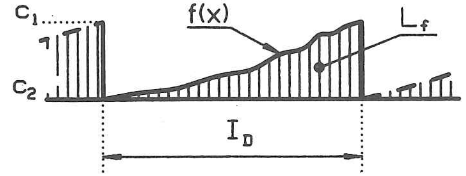
tion of fuel will be, too and so we will have to give additional costs on fuel. It means that this engine will work with losses of fuel.

This method determines the optimum interval of the preventive diagnostic based on mutual affects of costs mentioned above and consists of three basic steps :

1) Determination of losses arisen in consequence of bad technical conditions of an object of diagnostic.
2) Determination of costs on diagnostic.
3) Final solution of the optimum interval of diagnostic by the method of minimum total costs on diagnostic.

1. DETERMINATION OF LOSSES

As have been mentioned above, losses which arise in consequence of bad technical conditions will increase with prolongation of the diagnostic interval. This can be demonstrated in a graph (*fig. 1*) :



A general equation for calculation of losses :

$$L_f = \int_0^{I_D} f(x)dx \tag{1}$$

L_f ... losses arisen in consequence of increased specific consumption of fuel [Kčs]
c_1 ... specific consumption of fuel before diagnostic [g.kWh^{-1}]
c_2 ... specific consumption of fuel after diagnostic [g.kWh^{-1}]
I_D ... interval of diagnostic [w]
f(x) ... general function of increasing of specific consumption during the time of machine operation

Because an expansion of specific consumption of fuel between two diagnostics can have both progressive and degresive trends (it depends on construction of engine, working conditions of machine, system of maintenance and repairs, and so on), we can use for calculation linear course. So we can calculate losses :

$$L_f = \frac{I_D \cdot (c_1 - c_2) \cdot P_e \cdot k_v}{2 \cdot h \cdot 1000} \cdot C_f \quad /Kčs/ \tag{2}$$

P_e ... maximum power output [kW]
k_v ... plant factor of engine [-]
h ... specific masse of fuel [g.cmm^{-3}]
C_f ... price of fuel per litre [Kčs]

The increasing of c1 to a value not much different from c2 again is influenced (except of the length of diagnostic interval) first of all by reliability of engine and quality of operational care of an engine (maintenance, operation,...). If we get a constant 'K' which will represent those features into the calculation we can write :

$$c_1 = K . I_D + c_2 \qquad (3)$$

K ... constant which represent operational reliability and quality of operational care of engine

And after a substitution into equation (2) :

$$L_f = \frac{I_D^2 . K . P_e . k_v}{2 . h . 1000} . C_f \qquad /Kčs/ \qquad (4)$$

For calculation of unit losses of fuel we can write an equality :

$$u_f = \frac{I_D . K . P_e . k_v}{2 . h . 1000} . C_f \qquad /Kčs.w^{-1}/ \qquad (5)$$

2. COSTS ON DIAGNOSTIC

Into costs on diagnostic there is necessary to include all items of costs which are connected with diagnostic of engines. They can consist of those items :

- costs on diagnostical equipment
- labour costs
- indirect costs
- costs on idle time of machines

If we label this costs C_D, we can calculate unit costs on diagnostic :

$$u_D = \frac{C_D}{I_D} \qquad /Kčs.w^{-1}/ \qquad (6)$$

Number of items of costs C_D always depend on a considered system of diagnostic and so it is always necessary consider which items of costs will be involved into total sum of costs.

3. DETERMINATION OF OPTIMUM DIAGNOSTIC INTERVAL

The principle of establishing of optimum diagnostic interval can be described with the help of the following equation :

$$u = u_f + u_D \quad \text{---}\!\gg \quad \min \qquad /Kčs.w^{-1}/ \qquad (7)$$

u ... total unit costs [Kčs.w^{-1}]

The principle is in finding minimum of summary function 'u': it means in finding such a diagnostic interval in which there is minimum sum of total unit costs.

Graphical image (*fig.2*) :

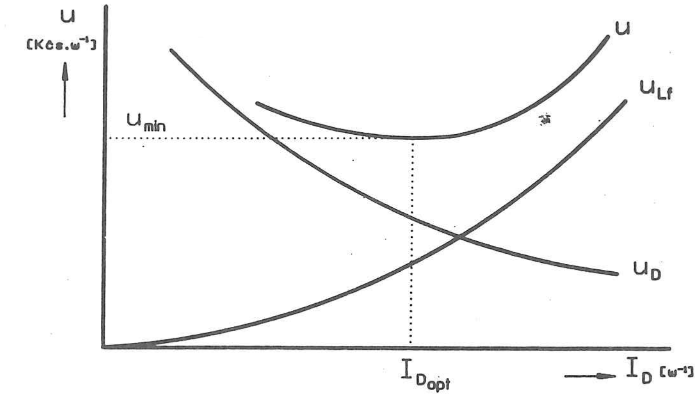


Fig.2: Determination of diagnostic optimum interval

This method of determination of optimum diagnostic interval can't be used in general - for instance for machines or parts of machines which could considerably endanger safety of operation. But justification of economical view can be shown in following example :

If price of fuel increases for instance two times and other prices are still the same, the losses of fuel which arise in consequence of bad technical conditions of engine will be of higher importance. Then it will be advisable to get short the diagnostic interval to such extend, so that increased costs on diagnostic were covered by decreasing of losses of fuel, which means determination of new minimum of total cost 'u' :

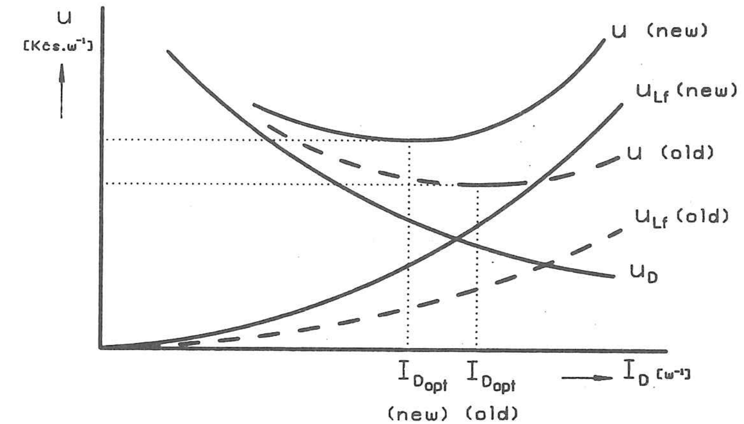


Fig.3: Determination of the new diagnostic optimum interval

TRENDS IN AGRICULTURAL ENGINEERING
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DIAGNOSTIC OF ECONOMY USING DIESEL ENGINES.

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Economy of diesel engine's usage is immediately connected with its technical state. The complex indicator of technical state is specific fuel consumption. It can be measured without dismantling. It is calculated from own moment of inertia (known) and from engine's angular speed and fuel consumption (measured during acceleration). Computer is able to calculate torque, power and specific fuel consumption in the whole range of measured angular speed.
Key words: specific fuel consumption,torque,power,speed torque and specific fuel consumption curve

There is more than 500.000 diesel engines with fuel consumption two millions tons per year in Czechoslovakia now. The most of them works unefficiently compared with world standard. It is caused mostly by age of the engines. The best world producers of diesel engines provides engines with specific fuel consumption about 200 grams fuel per 1 kilowatt-hour useful work. The new Czechoslovak engines have specific fuel consumption in the range from 230 to 240 g/kwhr. The technical condition of engines increases consumption. The measuring in civil and agriculture industry shows that average specific fuel consumption of lorries is 260 g/kwhr and tractors is 280 g/kwhr. Economic loses are considerable and they are at least 300.000 tons per year. It has the negative consequences in ecology, because burning one liter of oil needs about ten cube meters of the air and produces harmful waste product. It is difficult to reach the specific fuel consumption which is given by engine producer. If the increasing is caused by gradually, commonly growing defect, it can be removed by periodical maintenance depending on the length of engine's usage. A lot of defects are irregular. They often don't cause any more serious problems except increasing specific fuel consumption.

For instance the bad setting of the start of injection too far advanced or retarded for 3 degrees causes about 5% increase of specific fuel consumption. For users this situation is not remarkable, it doesn't cause any engine's harm and it doesn't force user to fix it.

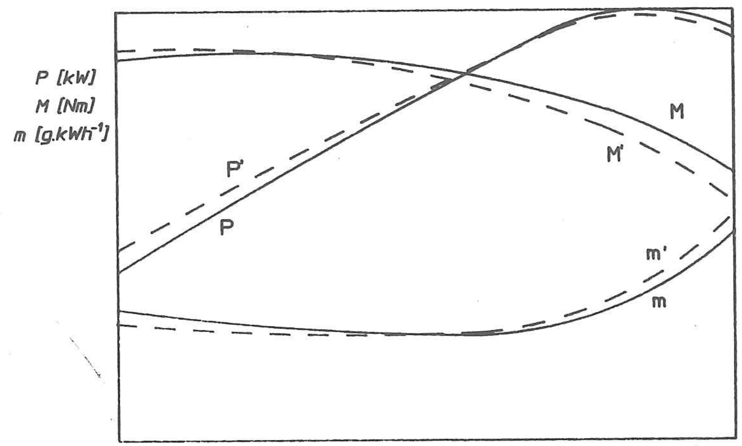

Fig.1 The influence of the start of injection (too retarded)

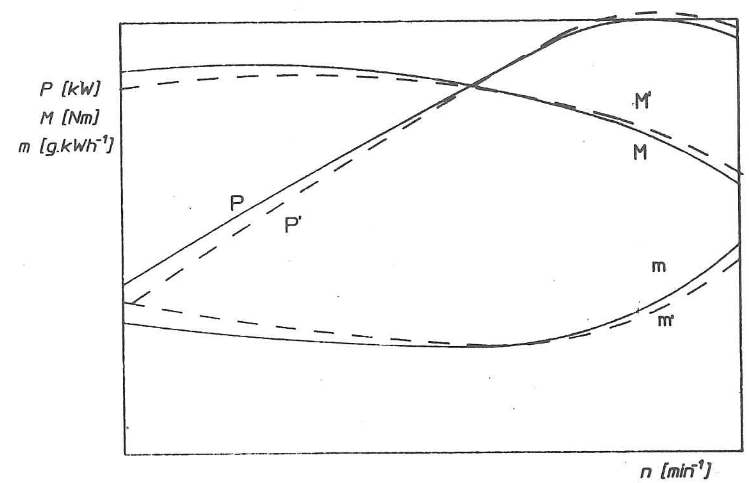

Fig.2 The influence of the start of injection (too advanced)

If the for cylinder engine has one cylinder with bad fuel injector(injector sticking or defective), which loses of 50% delivered fuel, it causes increase of specific fuel consumption the whole engine for 20%. Another bad result in this case is dilution of lubricated oil, which increases dètrition of bearings.

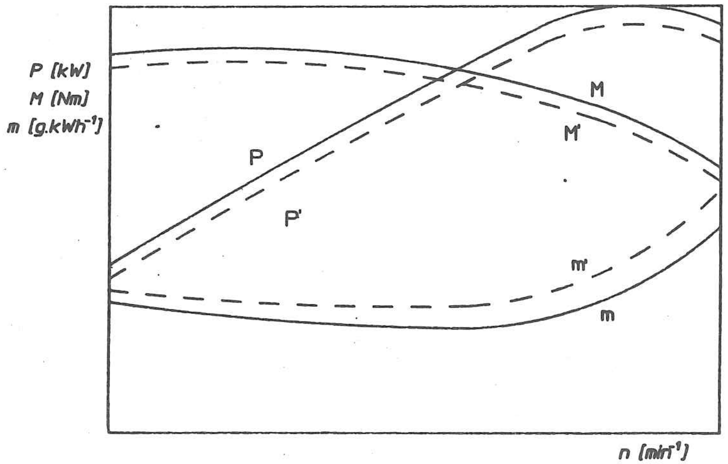

Fig.3 The influence of the fuel injector (bad spraying)

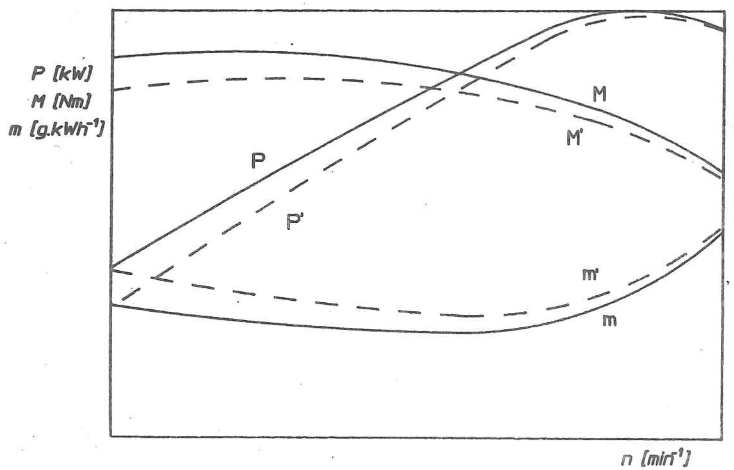

Fig.4 The influence of the loss of compression

The poor engine compression (defektive engine valves, excessive pistons clearance), incorrect control engine's working temperature, incorrect setting injection pump's delivery characteristic change (it can be caused by its detrition), the unwilling course of fuel injection (it can be caused by wrong injection pump's valve function), wrong fuel delivery correctors, leaks in fuel system, water in fuel, air lock in fuel system, choked filter on supply lines, faulty fuel supply pump, injection pump trouble (sticking delivery valve or incorrect tappet adjustment), controls regulating fuel supply of injection pump out of adjustment, increased resistance in inlet or exhaust conduit e.t.c. every time leads to the increasing of specific fuel consumption.

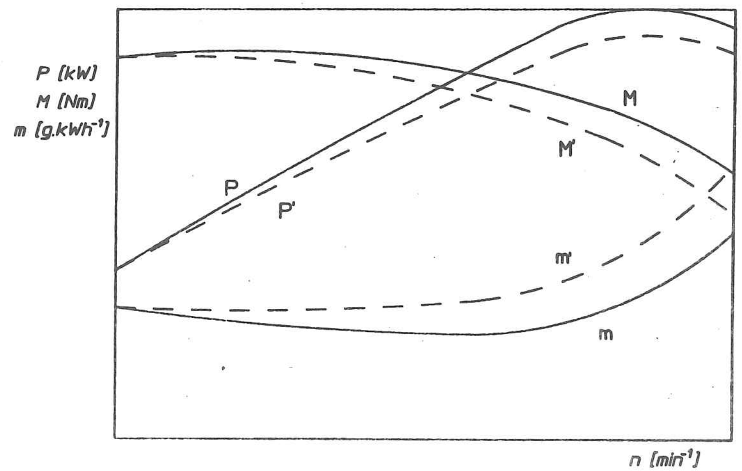

Fig.5 The influence of the air cleaner (choked)

Generally we can say, that almost every engine's failure (except detrition of crank-shaft's bearing) is tightly connected with increasing of specific fuel consumption. In time detection of increasing specific fuel consumption helps in many cases to discover the first stadium of mechanical failure.

The height of specific fuel consumption is important diagnostical signal which should be measured precisely, easily and relatively frequently, for instance during every change of motor oil. It prevents loses caused by increased fuel consumption and it reduces danger of occurrence mechanical failures.

Economy of operation can be expressed by specific fuel consumption. This complex signal indicates the whole motor technical stadium. The specific fuel consumption is measured by using either classical engine breaks or acceleration methods.

At present the modern acceleration methods of measuring the power and specific fuel consumption have almost the same precision as classical ones, but they are cheaper, more flexible and the measuring is quicker (it is not necessary motor dismantling).

Authors have developed and now test practice measuring equipment based on personal computer. It controls and evaluates signals from the cycle and fuel sensors.

During the measuring using a acceleration method engine is loaded by own moment of inertia and own passive resistance. During speed up the motor's angular speed, acceleration and fuel consumption are measured. We are able (using known moment of inertia) to calculate torque, power and specific fuel consumption in the whole range of measured angular speed.

Now this measuring equipment is tested in the frame of diagnostical method. The measuring methodology is designed in order to correct or eliminate random defects. It leads to precision + - 1 % of power, + - 1.5 % absolute fuel consumption and + - 2 % specific fuel consumption. The precision can be increased if the measuring is repeated. It doesn't significantly extend measuring time, because the measuring itself last less than a minute.

The shortness of measuring is significant especially during testing efficiency of done repair. In many cases it helps to achieve the better engine's parameters than if we use detail diagnostic methods. The proper evaluating of obtained data and comparing with the standard can help us not only to find parameters of the measured motor. In many times we are able to find the defect. For this purpose we are developing an expert system, which will provide the best way of diagnostic and repair method.

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AUTOMATIZATION OF TECHNOLOGICAL PROCESSES IN CATTLE-FARMING

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We have designed an apparatus for controlling and recording the parameters of cow milking, an automatic milking machine operation mode control system that changes the pulsation frequency and the milking machine time period relation-ship with respect to an animal milk-yield intensity, an arrangement that enables measuring temperature of milk taken out from each udder lobe and average temperature of milk, an automatic weighting-machine for determine the weight of animals.

control; record; a milk intensity sensor; electromagnetic pulser; an animal milk-yield intensity curve.

Effectiveness of dairy cattle production nowdays is decreasing due to inefficiency of milking facilities and big labour expenditure for producing and processing milk. One of the ways of enabling to raise effectiveness of cattle production is automatization of technological processes of keeping and producing milk.

Zootechnic and selecting work is carried out with consideration of individual properties of cows manifestating themselves under machine milking. At present it's rather difficult to rate the fitness of a separate cow for machine milking as well as the properties of existing milking facilities and that one which is being designed due to absence of certain important objectively received parameters of milking process. Therefore we designed an apparatus for controlling and recording the parameters fo cow milking. It contains an operator's desk with a key-board giving and indicating the commands, a milking intensity sensor, a sensor of milking machine frequency pulsation, an electromagnetic pulser, an information process block, a recorder and a power unit.

The apparatus is transportable. The sensor of a milk-yield intensity is fixed right at a machine milking operator's working place and is switched on in the break between the milking machine and the milk pipe-line. Frequency pulsation sensor is arranged in the same place. Other units of the apparatus are placed either in a milking parlor or in a special room.

When using the apparatus after the milking of each animal the following information is being brought onto the printer: the inventory number of the cow, the time of preparation of a cow to milking, the gap time between finishing the preparation and fixing the milking machine, the time of machine milking, the time of idle milking, the total milk-yield for the 1st, the 2d and the 3d minute of milking, the milk-yield during additional milking. An animal milk-yield intensity curve is being registered by a recorder; the moment of additional machine milking and moment of finishing the milking being set either by an operator's signal or automatically.

In the process of cow-milking by modern milking machines there is a discrepansy between the ability of a milking machine to take out milk and ability of a cow to yield milk. Milk-yield of an animal in the process of milking is changing, a milking machine operation mode being unchanged. This brings about a milk-yield diceliration reflex of cows and the decrease in their productivity.

In order to rectify these drawbacks we designed an automatic milking machine operation mode control system that changes the pulsation frequency and the milking machine time period relation-ship with respect to an animal milk-yield intensity. In the end of milking after finishing the milk-yield the milkin machine stops automatically. The system

contains a milk-yield intensity sensor, an electronic control unit and an electromagnetic pulser which is fixed at an operator's working place.

Farm tests of the milking system showed that a milking machine with an automatic milking control system insures high completeness and intensity of milk-yielding and also keeps up the growth of milk productivity and reduces the cases of udder lobes diseases and traumatizing.

When keeping a diary herd it's very important to detect the cases of mastitis. We think the method of detecting the cases of mastitis through difference in temperatures of milk taken out from different udder lobes seems efficient.

W We designed an arrangement that enables measuring temperature of milk taken out from each udder lobe and an average temperature of milk. Five temperature sensors are inserted in the collector of a serial milking machine. They are connected to an electronic measuring unit. The latter has an indicator panel for indicating the milk temperature, a switch to bring out on the panel the needed temperature. In addition the unit has digital outlets for connecting the printer and an analogous outlet for connecting the recorder.

To determine the weight of animals we designed an automatic weighting-machine. It contains a platform over which the animals are passing, animal presence sensors, a control and indication unit. The platform may be situated on the technological passage-ways in the way of animal traffic. No stops of animals is needed. The control and indication which displays the individual weight of an animal, the number of animals which are being weighted and the total weight of animals having passed over the platform. The unit has also an outlet for information input into a computer.

TRENDS IN AGRICULTURAL ENGINEERING
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PARAMETER OPTIMIZATION OF THE ELECTRONIC HYDRAULIC SYSTEM CONTROL OF TRACTOR LIFTSYSTEM MECHANISM BY APPLYING THE PLANING EXPERIMENT METHOD

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In the presented work, for the adopted system work, quality estimation and defined optimization criteria, the optimization of the electronic hydraulic system of the automatic control of the tractor hydraulic liftsystem, by applying the experiment planning method and by their computer simulation, has been made. The plans for mathematical process planing have been chosen from the group of plans of regression analysis, and in this case a special type of the central composition plan of the second order - rotatable plan.

The proposed method was applied in the development of the electronic hydraulic system control of the tractor liftsystem "Hydronic".

Key word: hydraulic liftsystem, optimization, mathematical model, regressional analysis, experiment planing, simulation.

LIST OF SYMBOLS

A_c - CROSS SECTION OF THE CYLINDER ROD
F - TRACTOR TRACTION FORCE
F_v - AXIAL FORCE ON CYLINDER PISTON ROD
h_c - CYLINDER PISTON ROD STOKE
K - ELEMENT GAIN COEFFICIENT PD
K_Q - FLOW GAIN COEFFICIENT
k_F - FORCE MEASURING ELEMENT GAIN COEFFICIENT
k_p - POSITION MEASURING ELEMENT GAIN COEFFICIENT
k_m - COEFFICIENT OF FORCE AND POSITION SIGNAL "MIXING"
k_r - GAIN COEFFICIENT OF REGULATOR
K_o - GAIN COEFFICIENT OF OBJECT
T_1 - OBJECT TIME CONSTANTS
T_D - PD TIME CONSTANT
T_r - PROPORTIONAL MAGNET TIME CONSTANT
p - LAPLACE OPERATOR
r - SOIL HARDNESS
x_z - GIVEN VALUE
z_p - FIELD SURFACE PROFILE
ε - REGULATOR DEAD ZONE
ω_h - HYDRAULIC UNDUMPED OWN FREQUENCY
ξ_h - HYDRAULIC DAMPNESS FACTOR
σ - STANDARD DEVIATIONS

1. INTRODUCTION

As the result of authors investigation, the electronic hydraulic system of the tractor liftsystem control "Hydronic" has been developed. The aim of such system is to maintain the given work depth of the implement within the limits of the optimal deviations. By this we achieve the additional effects which influence to the improvement of technoeconomic indicators of tractor performance. The stated effects are realized by the regulation of the tractor traction force and by the position of the implement in relation to the tractor.

Besides the system has to provide the automatic control in different conditions and with different types of implements. In order to provide the required work regime in all work conditions, we have foreseen the possibility of system basic parameters adjustment.

The hypotheses placed in this investigation consists of the following: during the development and application of the electronic hydraulic system of the tractor liftsystem control, it is possible, for the defined criteria of the system quality, (dispersion minimum of the regulated value), to make the choice of optimal values of the system adjustable parameters.

2. METHOD OF WORK

For the investigation of the flow process control of the electronic hydraulic system, we have applied the plans for mathematical modeling from the plan group of regression analysis. The approach to the modeling consists of the following.

If in any investigation object set of k of independently changeable values $(x_1, x_2, \ldots, x_k)$ has been seen, we shall have the aim function:

$$\eta = \varphi\,(x_1, x_2, x_3, \ldots, x_k) \qquad (1)$$

which comprise the technical, technological and economic effects, quality and reliability as well as the other output values of the object (system, process).

The values x_i can be changes according to the wish, within the experimental plan X.

Besides the controlled factors, the object (system, process) is influenced also by the vector Z of the disturbance, and than the aim function gets (1), i.e. its measured values Y present the random values.

On the basis of experience, of the previous investigations or recommendations, we choose the approximate mathematical model:

$$\eta = \eta(x_1, x_2, x_3, \ldots, x_k;\ \beta_1, \beta_2, \beta_3, \ldots, \beta_d) \qquad (2)$$

for which we suppose to describe in an adequate the studied object (process, system). Model (2) describes sufficiently correct the real unknown analytical model (1).

The unknown coefficients values β_i are estimated on the basis of experimental result, by coefficient b_i contained in the regression model

$$\hat{y} = \hat{y}(x_1, x_2, x_3, \ldots, x_k;\ b_1, b_2, b_3, \ldots, b_d) \qquad (3)$$

By modeling the agricultural machines and their control systems, the models (2) and (3) are usually presented by the polonium models.

$$\eta = \beta_0 + \sum_{i=1}^{k} \beta_i x_i + \sum_{i=1}^{k} \beta_{ii} x_{ii}^2 + \sum_{i<j}^{k} \beta_{ij} x_i x_j + \quad (4)$$

and

$$\hat{y} = b_0 + \sum_{i=1}^{k} b_i x_i + \sum_{i=1}^{k} b_{ii} x_{ii}^2 + \sum_{i<j}^{k} b_{ij} x_i x_j + \quad (5)$$

Models (4) and (5) can have any degree, kind of equitation and degree of complexity.

When a designed experimental plan was carried out, we approach to the regression and dispersion model analysis.

Regressional and disperssional analysis is carried out on the model (5). In our case, the composition rotatable plan was chosen.

2.1. Procedure of optimum determination

In this case we use the method of a classical mathematical analysis as the analytical method of optimization.

The procedure of optimum determination consists of the following.

We observe the aim function $F_c=F_c(x_1, x_2, \ldots, x_k)$ without limitations, which is continuous and differentiable in the field of defining (domain of function) D. In this case the stationed points vector is determined by equitation system:

$$\frac{\partial F_c}{\partial x_i} = 0, \qquad x_i = x_{io}, \qquad i=1,2,\ldots, k \qquad (6)$$

By solving the optimization tasks by which the mathematical model of optimization contains the certain number of limitation equitations we use the method of Lagrange multiplicators.

3. INVESTIGATION RESULTS

The presented method was applied in the optimization of the electronic hydraulic control system, by the experiment simulation on the computer.

System mathematical modeling has comprised: aggregate tractor - plough, hydraulic cylinder controlled by proportional valves, proportional magnet, measuring elements (for the force and position) and electronic regulators.

The procedure of the aggregate mathematical modeling tractor - plough has comprised: presenting of the principal scheme of the object, determining the equivalent system with reduced masses and inertia moments which present the corresponding physical object model, the method choice for making movement equitations and the choice of the generated coordinates, linearization of the obtained differential equitations and their presentation in the operation or matrix - vector form. The results of these analysis have served for the adoption of the corresponding machine model for tillage as the object in the automatic control system.

In the first phase the of dynamic hydraulic system analysis we start from the linearized model, then to introduce in the model the different non linear static characteristics.

Presenting the non linear system by non linear static characteristic and linear dynamic model, we suppose that the linear model is the same for all work regimes. By the adoption of such simplification, non linear phenomena are built in the model through the static transformations.

By the use of the given non linear model (Fig. 1.), the system was analyzed by a direct simulation on the computer.

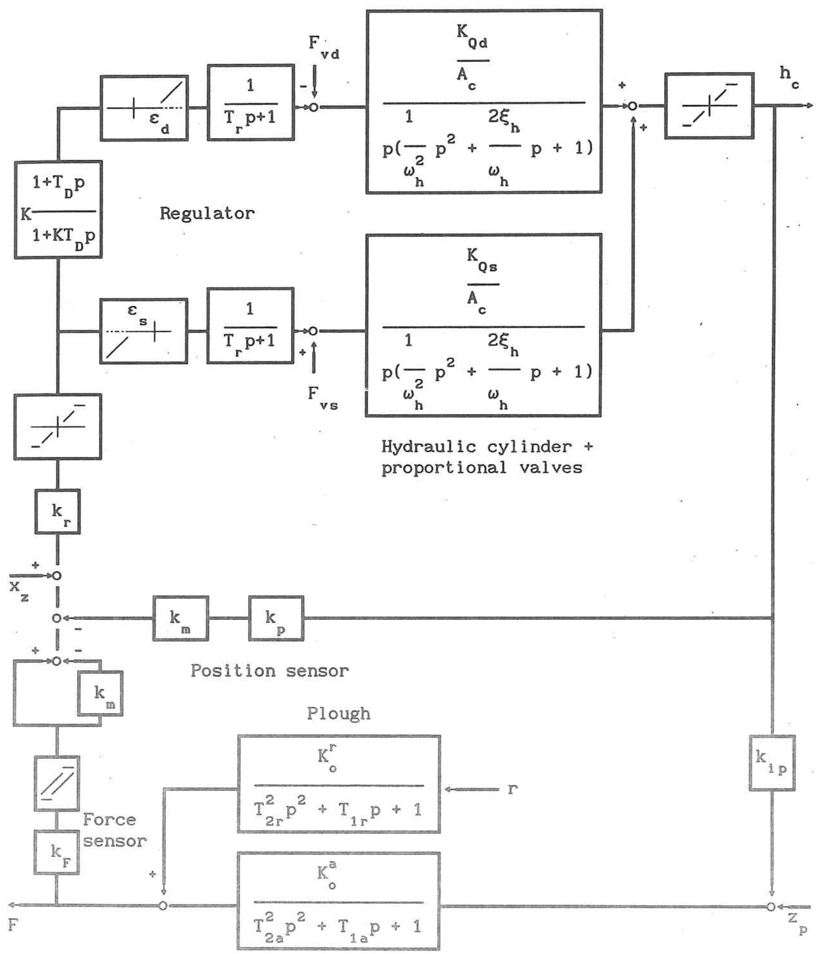

Fig. 1 Structural scheme of non linear system control

The different dynamic of hydraulic cylinder by lifting and lowering of the hydraulic liftsystem has been taken into consideration. Two dead zones can also bee seen, different at lifting and lowering. In principle, the possibility of the dead zone adjustment has been foreseen by only by lifting (adjustment of the "system sensitivity"). Non linearity of Zone of saturation of the regulator and cylinder movement have been taken into consideration. Force measuring elements comprise nonlinearity of hysteresis type. In the branch of "lifting" PD was introduced. The different influence of vertical forces by lifting and lowering the implement has been taken into consideration also. Other elements of the regulation circuit are linear, with transfer functions shown on the structure scheme.

By determining the values of adjustable parameters of the system, it is necessary to chose the work quality indicators which are obtained from the fulfillment of the technological process. It is necessary to take into consideration that different mutually connected processes are at the same time which determine the automatic control of system work in the whole. In a particular case, by the optimization of the system parameters it is necessary to take into consideration the change of the implement work depth, sliding of the drive wheels, fuel consumption etc. Optimization complex criteria for control systems of the hydraulic lift system is not elaborated. This is why as the basic criteria of the system optimization, which works in the conditions of random disturbances, the minimum of dispersion of the regulated values are adopted, taking into account the limitations on the basis of other indicators (agrotechnical, energy and other requirements). For the force system regulation, criteria DF ⟶ min determines the minimum of dispersion of the traction force at the limitations which are valid for depth variability of the implement (tillage depth variations in the field of permitted deviations).

Table 1. Optimal valued of adjustable parameters

FACTOR LEVEL	EXPERIMENT					
	I			II		
	FACTORS					
	k_r	k_m	ε	k_r	k_F, v/kN	k_p, V/m
-1.682	26.59	0.13	0.08	26.59	0.0064	1.96
-1	30.00	0.20	0.25	30.00	0.0200	4.00
0	35.00	0.30	0.50	35.00	0.0400	7.00
+1	40.00	0.40	0.75	40.00	0.0600	10.00
+1.682	43.41	0.47	0.92	43.41	0.0736	12.04
LIMITATION	OPTIMUM					
σ_{hc}=6 mm	33.27	0.47	0.91	64.27	0.0617	8.440
σ_{hc}=8 mm	42.32	0.24	0.48	71.57	0.0569	6.529
σ_{hc}=10 mm	48.05	0.16	0.00	78.50	0.0541	4.435

The optimization, in this case, consists in finding the extremely values of y function depending on the changeable model system parameters.

The experiment plan comprised the change of the following factors: gain coefficient of the regulator (k_r), force gain coefficient (k_F), position indicator gain coefficient, coefficient of "mixing" so force and position signal (k_m) and dead zone opf the regulator (ε).

The rotatable experiment plan was carried out by model simulation from Fig. 1 on the computer.

On the basis of investigation results of the system tractor - implement in real exploitation conditions, the spectra density of signal has been determined, signal of traction resistance, and then for the need of simulation, by the programmed realized block pseudo random signal and corresponding filter, realized signal test of the same spectra density.

On the basis of experiment results, after decoding, we obtained two regression functions of the second order, for standard force deviations in tractor linkages (σ_F) and for standard deviation of the hydraulic cylinder stroke (σ_{hc}).

The extreme points (optimum) are determined by the use Lagrange undetermined multiplicator, by which the second regression equitation (shc) is adopted as the limitation equitation. By this we have taken into consideration the agrotechnical requirement, that by a minimum of the regulated value - force, the change of the machine depth stays within the limits of the permitted deviations.

The optimal parameters value, for different limitations values, are given in Table 1.

4. CONCLUSION

On the basis of the carried rotatable plan in which the different adjustable parameters were changed, the regression dispersion functions have been determined, i.e. standard deviations of the tractor traction force and cylinder rod stroke. By the adoption of optimization criteria - minimum force dispersion, by finding the extremun of regression functions for limitation case, of the permitted cylinder stroke, the optimal values of the changeable factors were determined.

The presented method was applied in the development of the electronic hydraulic system of the automatic control of the tractor liftsystem "Hydronic".

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TRENDS IN AGRICULTURAL ENGINEERING
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APPLICATION OF INFORMATION TECHNOLOGIES IN RURAL REGION OF THE WORLD

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This paper emphasizes that it is important both for undeveloped and middle developed countries to cover the rural regions with information and telecommunications techniques. Two-way telematic infrastructure improves informability and communicability of human community - increases its inventiveness and entrepreneurship. In this way, natural and human resources are activated and part of rural population stays in village encouraged to micro industrial and service sectors. At the same time, application of high technologies in agriculture should progress at optimal speed. In developed countries also, telematic infrastructure in rural regions is increasing quantitivly and qualitatively caused by new migration process city - village.

Key words: high technologies, information technologies (IT), agriculture, information + telecommunication = telematic, rural telecommunications, GDP, Gnp, developed countries,integrated services digital network (ISDN), interactive educational video and software.

1) INTRODUCTION

The developed countries base their whole macro and microeconomics policy on introduction of high technologies (electronics, information technologies, new materials, biotechnology unconventional energy sources, energy saving etc.). They increase the work productivity, enable the products diversification and save all resources what results in a greater competitive capability on the market. Undeveloped and middle developed countries due to financial, staff, technological and structural limitations will not be able to apply high technologies in industry in terciar sector, and specially not in agriculture (1).

Some economic and social indicators clearly show the gap of underdevelopment. From Table 1. it can be seen that 2 622 000 000 inhabitants or 50,5% of the whole population, has the participation in agriculture in GDP with more than 30% but at the same time, the average Gnp per capita is only US$ 330 (the low Gnp is directly reflected to the education structure - over 40% of illiterate population, small daily quantity of calories taken through the food - under 2400 cal. Fig. 1 and 2). The situation is not much better with the second, or the third group of countries, so that it can be concluded that a big participation in agriculture in GDP is the characteristic of poverty.

Tab. 1. Share of agriculture in GDP, 1989,and Gnp per capita (8)

SHARE OF AGRICULTURE IN GDP, 1988	NUMBER OF COUNTRIES	Gnp US$ 000 000 1989	POPULATION 000 000 1989	%	Gnp PER CAPITA US$ 1989
30% or more	56	870 000	2 622	50.5	330
20 - 29 %	25	436 000	543	10.5	800
10 - 19 %	33	886 000	466	8.9	1 900
6 - 9 %	17	1 186 000	331	6.4	3 590
less than 6 %	39	14 623 000	843	16.2	17 340
without data	15	1 496 000	391	7.5	3.820
WORLD TOTAL	185		5 191	100,0	

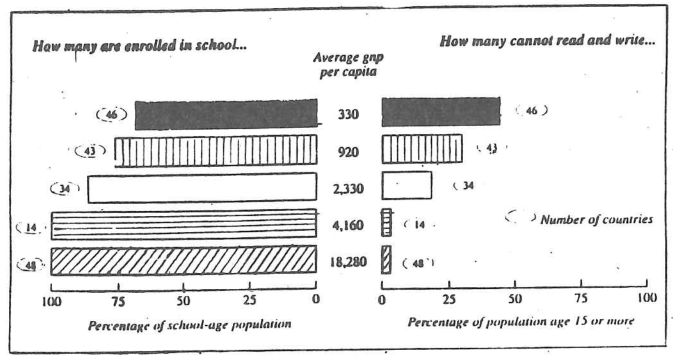

Fig. 1 Illiteracy rate, 1985 (8)

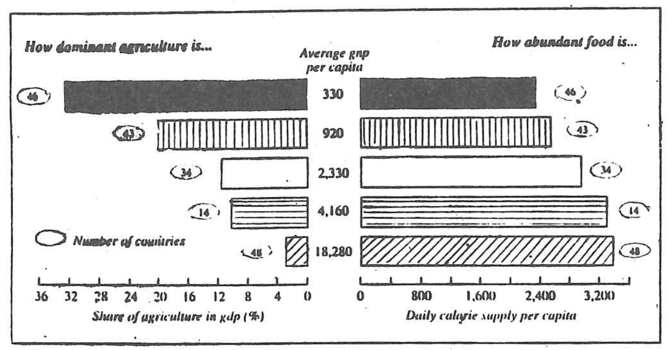

Fig. 2 Daily calorie supply per capita, 1988 (8)

Thanking to the policy of agriculture subvention, or applied high technology, the developed countries practically eliminated the import of food (so that the importance of agriculture in the total structure is marginated and the number of employed is at the average 4-5%). The underdeveloped countries with US$ 330/per capita have got a higher priority for drinking water supply, better food, health protection, electrification, traffic facilities etc., than to introduce high technologies and, at the same time, they have the problem of the surplus of manpower from rural regions.

When a bigger portion of the world population is going to enter into the transfer of high technologies? Is there any sense to talk about the application of information technologies (IT)* in rural regions of the world? There is the sense to talk about the mass computer and telecommunications application since these are specifically high technologies that rise the level of knowledge and direct the individuals in a team work in business and inventive activity.

2) SOURCES OF INFORMATION AND PROCESSING OF INFORMATION IMPORTANT FOR AGRICULTURE

Already in ancient time, there was such a quantity of knowledge about agriculture that in the first century, Junius Moderatus Collummella created the first agricultural encyclopedia. It consisted of 13 volumes and had approximately 1 million alphanumeric signs. A sudden increase of knowledge about agriculture happened only in the XX century, so that JLZ agricultural encyclopedia in 1973, consisted of already 20 million alphanumeric signs or 160 million bites (Fig. 3). The increasing curve of the agricultural knowledge has an exponential character (shape y=1/x2 or tangens hyperbolic) and in the last decade of the XX century /6/ its increase is specially accelerated. The information volume connected today to agricultural problems (technical technological, genetic, economics business, educational, ecological etc. character) surely exceeds even 10.000 Mb.

The basic problem in essence is how to come to the right necessary information for the certain problems - today this is achieved by a computer technique, by data base retrieval. The same importance has data (information) processing i.e. problems, which appear in each concrete real situation, solution. Due to the complexity of the „living" world the necessity for information processing in agriculture gets the enormous dimensions. The example for this is the choice of the optimal agrotechnique, assortment, fertilization etc. adequate in ideal case to each soil plot. 200 hundred years ago it was enough to deal with some parameters in order to achieve the optimal yield on this level of knowledge. Today we meet the problem of processing about fifty variables Fig. 4 that must give the answer for economically acceptable - healthy bioagriculture /6/.

3) THE DEVELOPMENT OF RURAL TELECOMMUNICATIONS

Radio and television are the typical representatives of one-way communication media. They contribute to the formation of public opinion, they can give useful advises (also to farmers), but mostly they force people passively to slave to programmed sound and picture (satellite and cable television give only a bigger choice of programs). In rich countries, mass media are nearly perfect, but in underdeveloped and developing countries, they have developed as relatively cheap, central -

* According to the new terminology (9), the information technology (IT) is understood as the connection of a computer with fast telecommunications that transfer and process data, sound and picture (the term telematic is similarly used - telecommunication plus informatics). In a wider sense IT consists of computers, process automation, robotism and metrology from one side, and the whole complex of communication (telecommunication) technique, i.e. connections between the machines (apparatuses) or machines and men or between men themselves, from the other side.

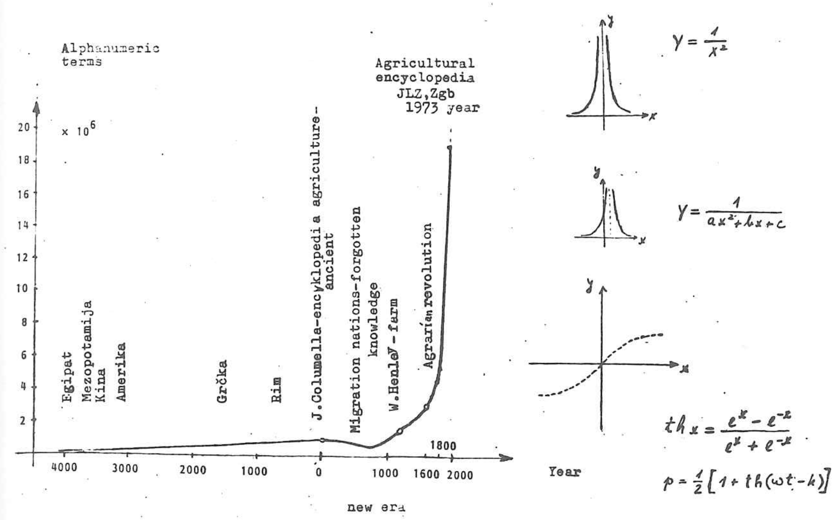

Fig. 3 Volume of agricultural information through history of mankind

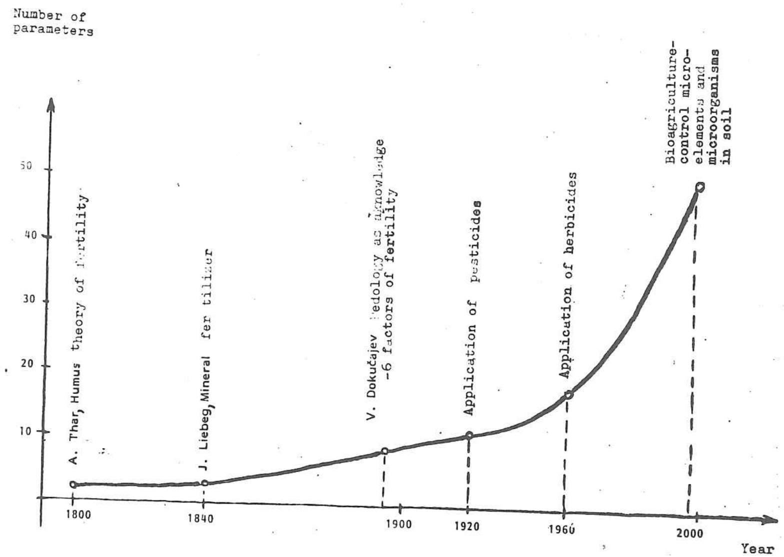

Fig. 4 Number of parameters or volume of information about soil that had to be desposed in determine period of history of mankind in cause to realize optimal fertility and yield

isticly organized infrastructure by which the basic information of human communities, even in secluded areas are covered.

A complete different situation is in two-way communication media, telephone and telegraph being with a longer tradition, and recently data transfer gets more and more important role. Two-way communication requires from the participant to change the passive state into active - to participate in information exchange. Each two-way communication is nearly always, more or less, the learning process /7/ and being a bigger numbers of individuals involved, the level of knowledge of such union increases, and with that, the further development possibility. The modern techniques of two-way telecommunications are media which, if they reach each individual, give endless possibilities of correspondence combinations - they create new knowledges, initiatives and actions.

In developed countries the importance of telephone - telegraphic communications has been noted, and after the II World War, great efforts have been made for their development. In year 1982 twenty two developed countries already had 60 telephones per 100 inhabitants (Fig. 5). However, the main telephone and telegraphic net was realized in urban centers since the construction of telephone-telegraph network in rural regions was much more expensive and the income from rural connections relatively small. During the past decade the pressure in the developed countries was raised that rural telecommunications have to be constructed much quicker, since it was proved on many samples that the public telecommunications became the basic accelerators of rural regions development. In Italy it was estimated that, investments in rural telecommunications were the key element for the improvement of social and economic development - specially rural and underdeveloped south of Italy. Special satellites are also used that give numerous information from wide areas, important for agriculture and forestry. Australia and Finland connected by telephone network each rural household and each farm. Now another problem has appeared. The rural user is not satisfied only with the telephone service any more, he requires new kind of services, data transfer and different sophisticated services being the most important, the ones that are on the disposal to the subsribers of ISDN in cities. Today it is already possible to realize on one telephone connector data transfer, teletex and videotex services. In the developed countries majority of farmers dispose with local computer information system, but they make the pressure to Post Telephone Cable Companies to enable them to get included into data transfer network, i.e. to be able to use the centralize agricultural data base (since they dispose with „fresh„ information). It is stated that in Canada, agricultural and forestry business competitiveness is increased, and that the migration process city -village is in source, by which the „business space„ to rural areas is widened.

The general poverty in underdeveloped countries, is drastically manifested in telecommunications. 2,5 billion people in underdeveloped countries have got less than 1 telephone/100 inhabitants (mainly in cities) and according to the existing growth factors, it is expected that by the end of the XX century it is going to be 1 telephone/inhabitant. This is 60 times less than in developed countries. Rural areas, where lives the majority of population, is totally not comprised by telephone network /6/. The activation of human resources, which are nearly inexhaustible, and big agricultural and forest regions, is not possible without two-way telecommunications.

The prices of modern radio, cellular, satellite and optical rural telecommunications, are falling down on the world market (10), what enables the underdeveloped countries to make the first step in the high technology application. This is the first process link through which the stepping out from the poverty can be started.

As the fast construction of rural telecommunications can be expected, the equipping of individual farmers by local information systems will be important. There are today computers equipped with compact discs of 660 Mb capacity and interactive software. Fillips developed interactive video,

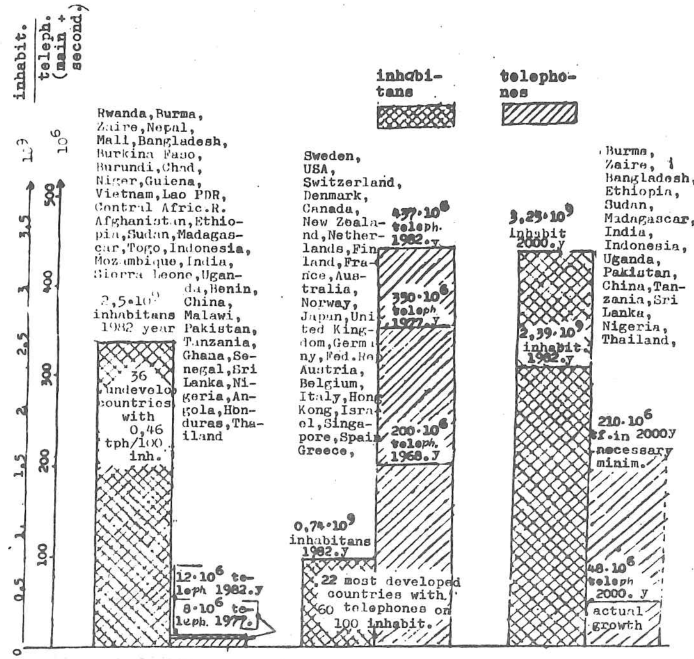

Fig. 5 Paralell presentation of growthing trends of telephones in developed and undeveloped countries of the world

audio, text and graphic system (CD-I) which gives the exceptional possibilities for farmers education /3/. The interactive audio visual techniques and software can speed the learning process for 40% in relation to the standard techniques (under the condition that heir prices are acceptable for wide use) /7/.

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Tab. 1. Share of agriculture in GDP, 1989 and Gnp per capita (8)

SHARE OF AGRICULTURE IN GDP, 1989	NUMBER OF COUNTRIES	Gnp US$ 000 000 1989	POPULATION 000 000 1989	%	Gnp PER CAPITA US$ 1989
30% or more	56	870 000	2 622	50.5	330
20 - 29 %	25	436 000	543	10.5	800
10 - 19 %	33	886 000	466	8.9	1 900
6 - 9 %	17	1 186 000	331	6.4	3 590
less than 6 %	39	14 623 000	843	16.2	17 340
without data	15	1 496 000	391	7.5	3.820
WORLD TOTAL	185		5 191	100,0	

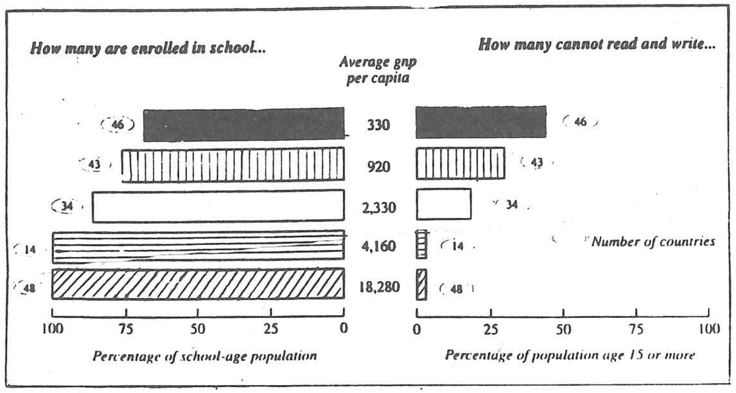


Fig. 1 Illiteracy rate, 1985 (8)

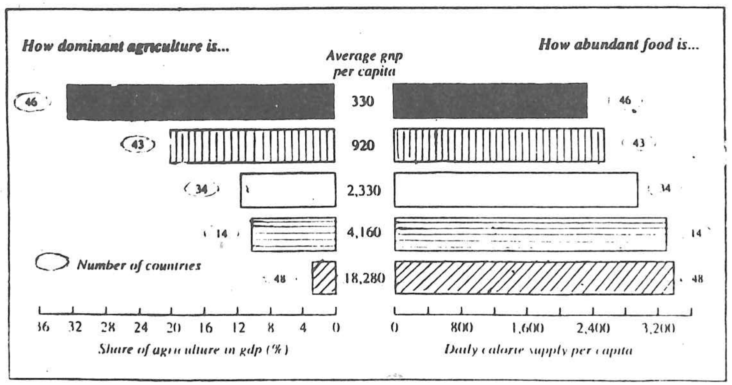
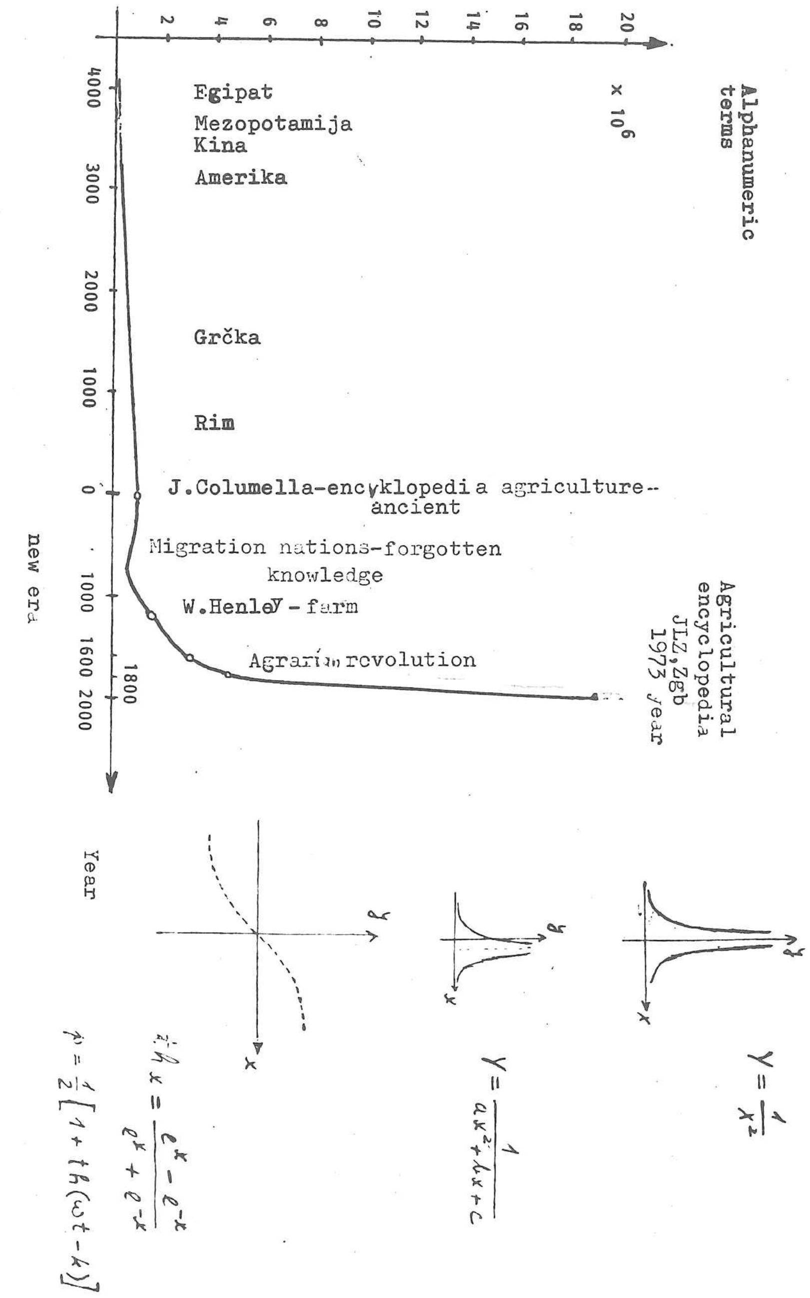


Fig. 2 Daily calorie supply per capita, 1988 (8)



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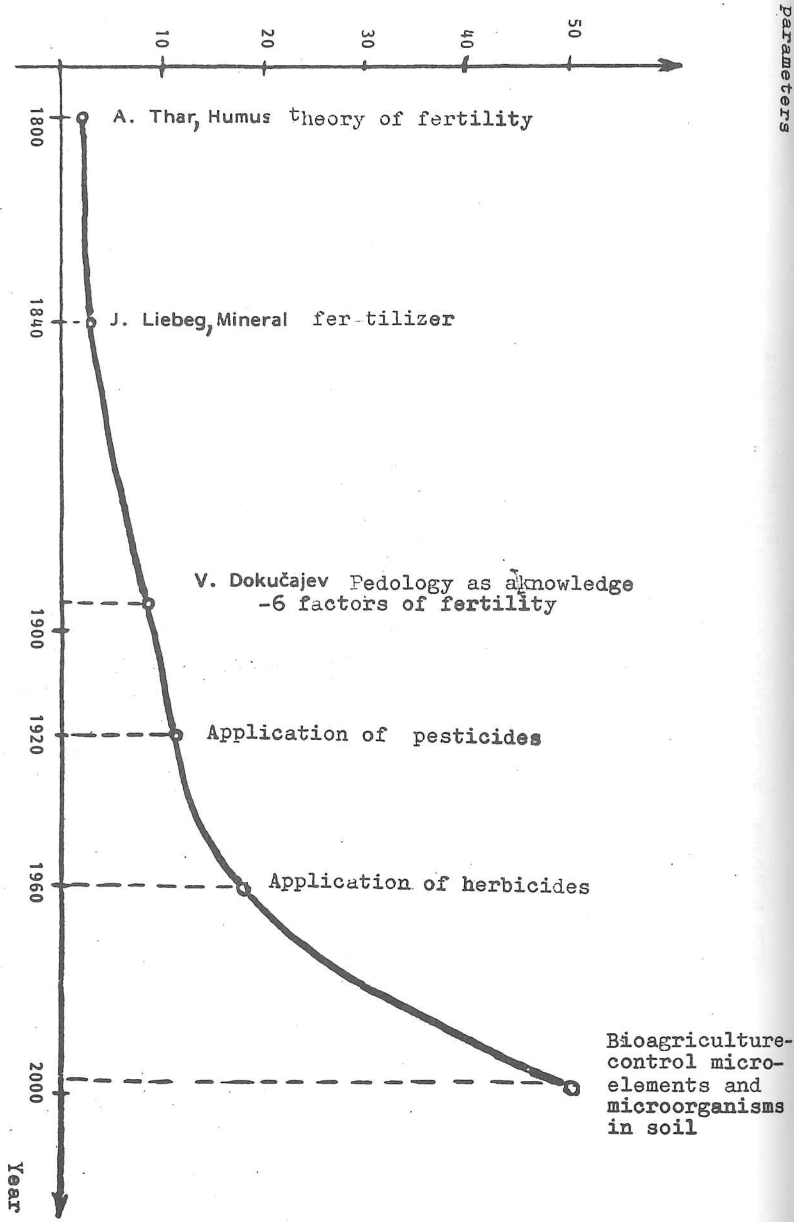

Fig. 4 Number of parameters or volume of information about soil that had to be desposed in determine period of history of mankind in cause to realise optimal fertility and yield

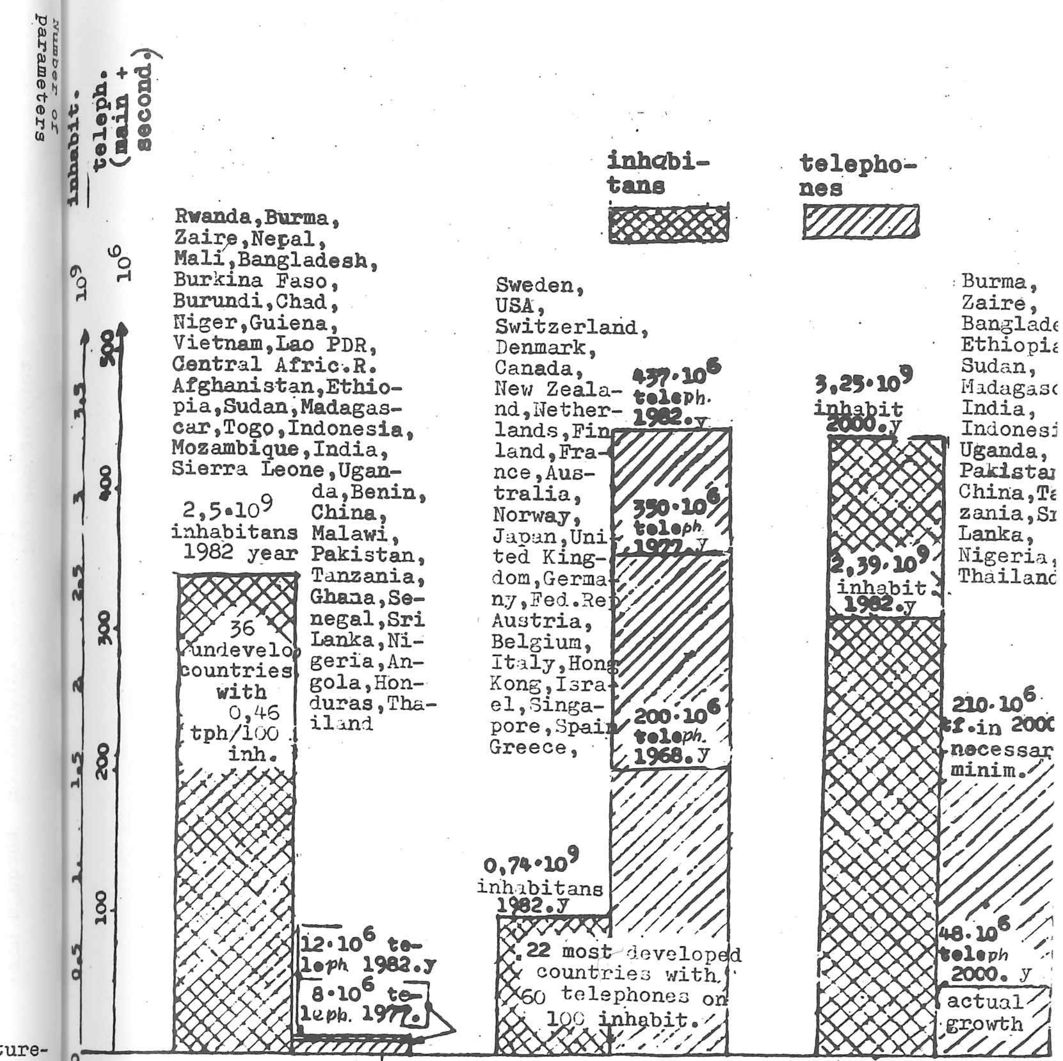

Fig. 5 Paralell presentation of growthing trends of telephones in developed and undeveloped countries of the world

TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

PROGRAM SYSTEM FOR COMPUTER AIDED MACHINERY MANAGEMENT

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New farming systems in Czechoslovakia evoke changes in the management of agricultural enterprises and understandably in the utilization of machinery. It is advisable to improve the process of strategic and operational machinery management. One of the most important ways is the utilization of computers (Computer Aided Machinery Management). The target version of the program system will be composed of the following modules:

1. Catalogue of farm machines and prescriptive coefficients.
2. On-farm machine-index-keeping system.
3. Technical-economic consideration of farm machinery.
4. Calculation of need and structure of onfarm machinery.
5. Strategy of purchase, second hand buying and wrecking of machinery.

Considering the progress which has taken place the module 1 and 4 are made out; the program module 2 and 3 have been completed; the program module 5 is near completion.

1. INTRODUCTION

New farming systems in Czechoslovakia evoke changes in the management of agricultural enterprises and understandably in the utilization of machinery. The most important changes are those connected with proprietary relationships.

It can be expected that two kinds of businessmen will result from the new conditions:

- businessmen who work with farm machines;
- farmers.

Each kind of businessman has, in a certain measure, a different view of machinery utilization which comes from how they see profitability. A common feature for both businessmen is an effort to increase profit by all possible means. As a matter of general principle there will be three main questions:

1. reducing costs (of farm machinery);
2. intensifying production while respecting environmental requirements and market demand;
3. improving motivation of workers.

It is advisable to improve the process of strategic and operational machinery management. One of the most important ways is the utilization of computers (Computer Aided Machinery Management).

The above-mentioned claim is supported by two facts:

1. in the near future there will be an increase in the supply of farm machines on the market;
2. there will be an effort to reduce the number of managers and skilled workers in the diminished and transformed enterprises, which are out to keep with the first-rate strategic management of technical development (strategic machinery management).

All these facts and new tendencies have been leading our research team to the development of a program system for computer aided machinery management. Under the computer aided machinery management we consider: selection, financial and performance appraisals (cost, profit etc.), purchase, selling and wrecking of machinery and on-farm machine-index-keeping.

2. STRUCTURE OF THE PROGRAM SYSTEM

The program system for computer aided machinery management must make possible:

a) permanent survey on available farm machines and their technical, operational and economic data;
b) on-farm machine-index-keeping and evaluation of operation of these machines (actual costs, incomes, profits, performances, order keeping and executing) in conjunction with the activity of tenders;
c) carrying out of the technical-economic consideration and mrenewal of farm machinery.

Formulated requirements would be ensured by the program system, whose architecture is presented in the fig. 1.

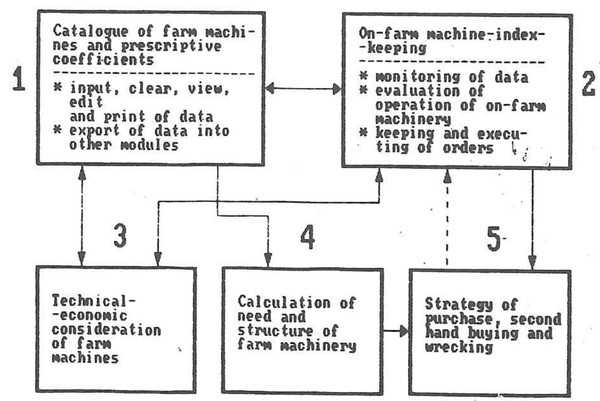

Fig. 1 Programe System for Computer Aided Machinery Management

Essentially there is a set of program modules in fig. 1. All modules are connected with each other by means of a data base, whose nucleus has been created on the basis of the catalogue of farm machines, prescriptive coefficients, and the on-farm machine-index-keeping system.

The target version of the program system will be composed of the following modules:

1. Catalogue of farm machines and prescriptive coefficients.
2. On-farm machine-index-keeping system.
3. Technical-economic consideration of farm machinery.
4. Calculation of need and structure of onfarm machinery.
5. Strategy of purchase, second hand buying and wrecking of machinery.

3. DESCRIPTION OF THE PROGRAM MODULES

3.1. Catalogue of farm machines and prescriptive coefficients

The catalogue of farm machines and prescriptive coefficients is based on a set of data files which are served through a control program system.

The contents of the catalogue correspond to the data of known catalogues transformed into computer form. Besides technical, operational and economic data there is recorded more specific data about each machine (e.g. operational experiences). This system also enables entering the data base of the catalogue of the Research Institute of Agricultural Machinery in Prague for the use of designers.

The catalogue of prescriptive coefficients contains data connected with plants, machinery costing, and work operations. There is a set of about 80 principal work operations (including available user access), which are carried out in agriculture (especially in plant production). The structure of data is created for using as an input into the module for technical-economic consideration.

Possibilities of the control program system cover:

1. input, clear and full editing of data in data base;
2. viewing of catalogue;
3. connecting of data files, reindexing and checking of key duplicity;
4. export of data into other program modules;
5. outputs of data;
6. transfer of data into and from ASCII files.

3.2. On-farm machine-index-keeping

Essentially the on-farm machine-index-keeping system enables filing necessary data on a farm machine (separately on mobile energetic machines and on other machines). The structure of data is designed in part to the needs of creating a strategy of purchase, second hand buying and wrecking of machinery. This data includes: prices, replacement dates, strategy of depreciation, interest on investment, annual fixed taxes, insurance, storage; and prescriptive coefficients for appraisal of variable costs: fuel, lubrication, maintenance, repair; and for the deciding the value of a machine. Also, the evaluation of operation of these machines in relation to the activity of tenders is included in the system of keeping and executing orders.

For the time being the system of evaluation of operation of machines and of the activity of tenders was created and realized for needs of a partial economic hire of machines on the basis of completing funds-flow (costs, income, profits).

The system for keeping and executing of orders will enable a computer aided keeping of orders and balancing between the demand and the supply of work operations. We suppose creating a heuristic model, which will assist the manager in the executing of orders.

3.3. Technical-economic consideration of farm machinery

The module for carrying out the technical-economic consideration is based on selection of agricultural machinery. This one is determined by technical factors such as field performance, environmental factors such as timeliness and economic factors such as profitability. That's why the module enables:

- comparison of machines, machine-lines (technologies) and machinery services;
- calculation (appraisal) of technical, environmental and economic data on machines.

Under the comparison of machines, machine-lines and machinery services we consider a multi-criterial comparison of:

- two or more machines or tractor-machine systems;
- two or more machine-lines (technologies ensured by them).

Instead of this an equivalent machinery service can be taken into consideration (work or leasing).

Used criteria are:

- total costs;
- investment costs;
- need of human labour;
- two subjective criteria (e.g. technical, aesthetical).

One can compare all variants using the multi-criterial method PATTERN.

Calculation of technical, environmental and economic data on machines are aimed at following actions:

- calculation of machine-work prices;
- calculation of:
  - minimal and optimal (seasonal) performance of a machine;
  - fixed, variable and total direct and indirect costs;
  - appropriate time for second hand buying and the actual value of the machine (respecting elected depreciation strategy);
  - appropriate price (for a concrete enterprise) of a new machine;
  - rate of profit.

In calculating the program consideration of the time-value of money (rate of interest on capital and inflation) was taken into account.

3.4. Calculation of need and structure of on-farm machinery

This program module enables the calculation of the optimal number of farm machines for an agricultural enterprise.

The structure of this module is based on the prescriptive coefficients of need (results from annual performance) per 1000 [ha] of land. It has its own local data base furnished with a data-base-control system. The foundation is created by a catalogue of machinery standards into which the data from the catalogue of machines can be exported.

Input values are the following:

- obligatory inputs:
  - × farm and arable land;
  - × structure of farm and arable land;
  - × area of chosen work operations;
- voluntary inputs:
  - × alteration of prescriptive coefficients which are filed in the data base;
  - × number and structure of on-farm machines.

Output values are the following:

- types of machines;
- enumerated number of machines;
- difference between enumerated and contemporary number of machines;
- export of data into the module for the development of a strategy of purchase, second hand buying and wrecking of machinery.

3.5. Strategy of purchase, second hand buying and wrecking of machinery

Development of a strategy of purchase of new machines, second hand buying, and wrecking of old machines is a significant activity of every enterprise. This decision ensue from the structure and from the results of operation of on-farm machinery and must be linked to the calculation of need and structure of new (calculated) on-farm machinery.

Principles and criteria for creation of the above-mentioned strategy are the following:

- balance of performances;
- equilibration of annual investment;
- simultaneous purchase of new technologies, and, on the contrary, second hand buying or wrecking of unnecessary technologies;
- respecting the valid depreciation strategy and economic advantage of second hand buying;
- total operation costs;
- further subjective criteria.

The setting up of this program respecting external and limitable conditions, is preliminary and up to now this problem has not been successfully set in the program. Only a heuristic model will be eligible.

4. CONCLUSION

The program system for computer aided machinery management has been created for the needs of large agricultural enterprises and for advisory service centers, which provide services to private farmers. These advisory services will be gaining the upper hand after 1992 in Czechoslovakia, when the transformation will be completed and new businesses can launch their ventures.

Considering the progress which has taken place the catalogue of farm machines and the module for calculation of need and structure of on-farm machinery are made out; the program module for technical-economic consideration and the on-farm machine-index-keeping system have been completed; the program module for the development of a strategy of purchase, second hand buying and wrecking and the system for keeping and executing of orders are near completion.

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TRENDS IN AGRICULTURAL ENGINEERING
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ADIABATIC COOLING OF THE AIR FOR VENTILATION IN ANIMAL HUSBANDRY

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This study summarises results of tests of special water spraying apparatus equipped by two types of nozzles for adiabatic cooling and humidifying provided by dispersed water. The difference between both types of nozzles has been shown primarily in efficiency of the apparatus and in the volume of unevaporated discharge water.

air cooling; temperature; humidity; nozzle; adiabatic efficiency; water consumption

1. INTRODUCTION

One of the principal questions of environmental control is regulation of temperature and humidity conditions. It is necessary at times to bring down high air temperatures in some animal houses, storage spaces and work places, but it could also be suitable in some cases to increase air humidity.

In terms of energy conservation, adiabatic cooling and humidifying is an advantageous and technically very simple way of air conditioning provided by dispersed water.

During the direct contact of the air with water in a heat insulated system, mutual heat and mass transfer occurs. The result of these processes is a removal of sensible heat from the air by the evaporation of water which causes a lowering of temperature and a rise in the humidity of the air.

2. METHOD

Tested were two types of water spraying apparatae. The first is a device with a special water pressure nozzle which was developed at the Department of Mechanics and Machinery of the Faculty of Agricultural Engineering in Prague (Fig. 1). Its characteristic water-flow is dependent on pressure as illustrated in Fig. 3.

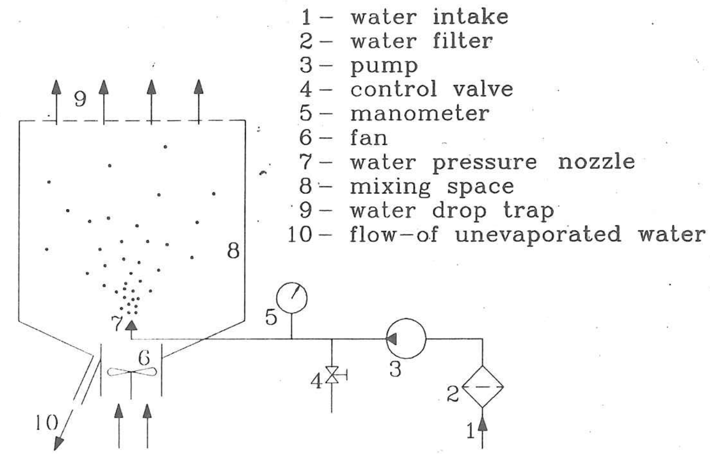


Fig. 1 Apparatus with water pressure nozzle

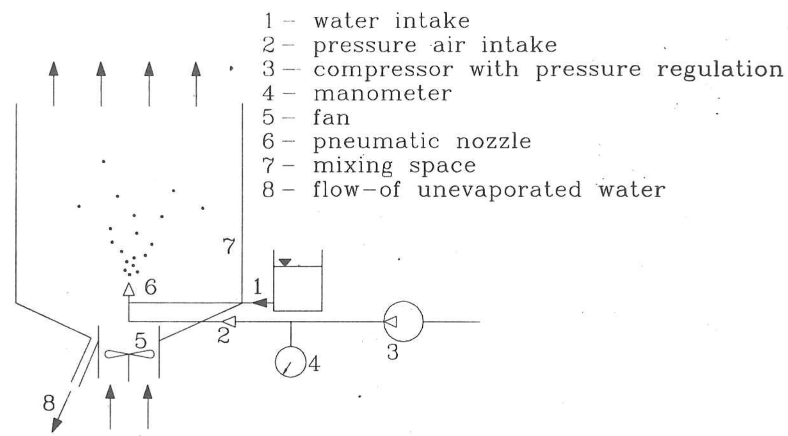


Fig. 2 Apparatus with pneumatic nozzle

The second is a device with a pneumatic nozzle which is used in hatcheries (Fig. 2). Its characteristics as determined for a given case is illustrated in Fig. 4.

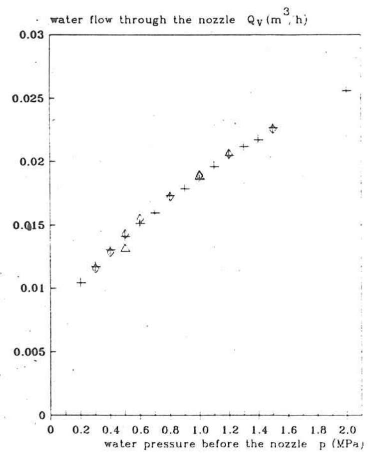


Fig. 3 Characteristics of water pressure nozzle

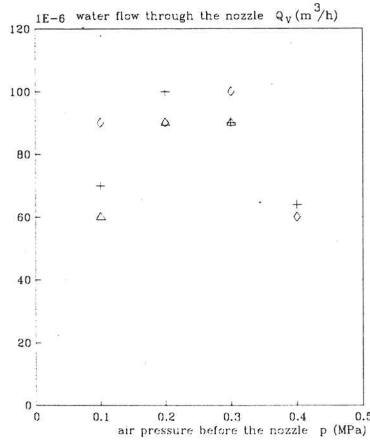


Fig. 4 Characteristics of pneumatic nozzle

3. RESULTS

Parameters of the air flowing through the apparatus were measured dependent on the shape of mixing space, the water pressure, the air in the nozzles and on the temperature and flow of intake air.

The effect of the apparatus tested in the conditions with air temperature from 25° to 30° C and relative humidity about 30% is evident from the Figures 5, 6, 7, and 8. The graphs show the dependence of differences in air temperatures Δt and of differences in relative humidities $\Delta \varphi$ on water pressure or air pressure p before the nozzle before and after adiabatic cooling. Different signs are used for different air flows Q_v going through the apparatus.

For evaluation of the efficiency of the apparatus the approximate formula was used:

$$\eta = \frac{t_1 - t_2}{t_1 - t_{ad}} = \frac{\Delta t}{t_1 - t_{ad}}$$

where: t_1 (°C) - air temperature before the apparatus
t_2 (°C) - temperature of cooled air
t_{ad} (°C) - temperature of extreme limit of adiabatic cooling relevant to the state of air before the apparatus (14÷18°C)
Δt (°C) - difference of temperatures at inlet and outlet of air.

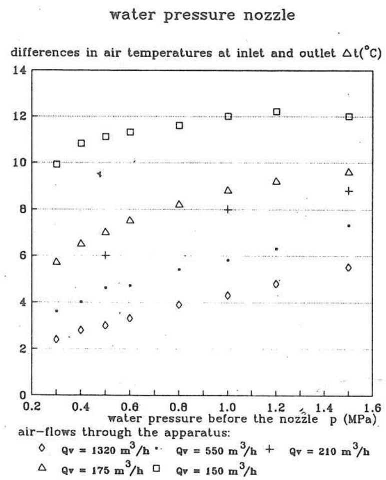


Fig. 5 Dependence of differences in air temperatures on water pressure

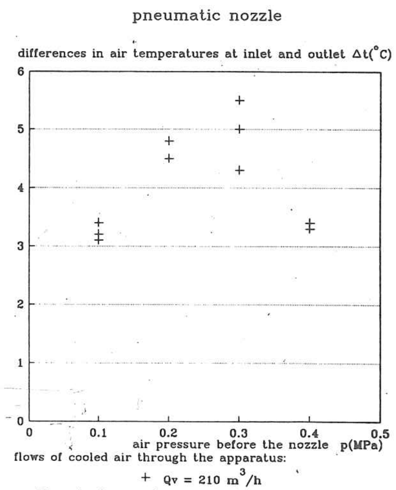


Fig. 6 Dependence of differences in air temperatures on air pressure

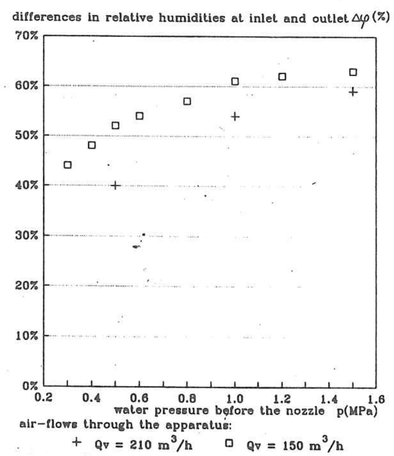


Fig. 7 Dependence of differences in air humidities on water pressure

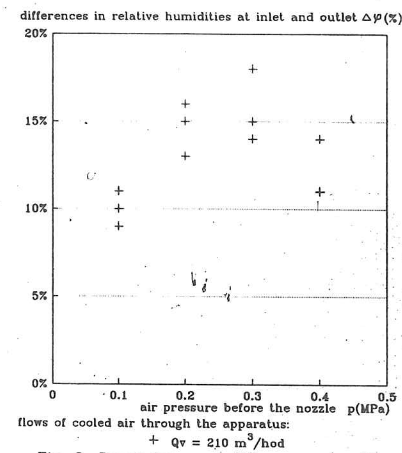


Fig. 8 Dependence of differences in air humidities on air pressure

This adiabatic efficiency attained from 87% to 20% for air flows from 150 to 1300 $m^3 h^{-1}$. E.g. if the air flow was 210 $m^3 h^{-1}$ average value of adiabatic efficiency was 66% for the apparatus with water pressure nozzle (water pressure before nozzle 0,5 MPa), and 47% for the apparatus with pneumatic nozzle (air pressure before nozzle 0,3 MPa).

The difference between the two types of nozzles has been shown primarily in the volume of unevaporated discharge water. This volume was about 2.10^{-2} $m^3 h^{-1}$ for the water pressure nozzle with the highest pressure being about 90% of supplied water (Fig. 3), while that same volume for the pneumatic nozzle was only 3.10^{-5} $m^3 h^{-1}$, that is, only 30% of the supplied water (Fig 4).

4. CONCLUSION

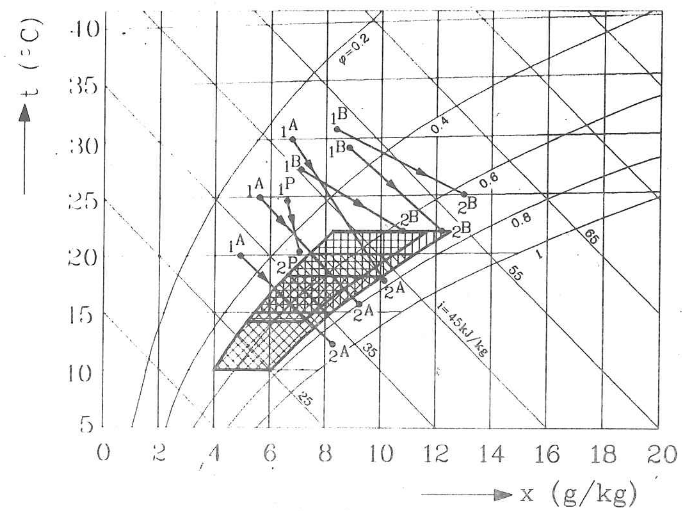
It follows from graphs and calculations that it will be necessary to evaluate a suitable way of air cooling from several points of view. The water pressure nozzle has 150 times a greater consumption of water than the pneumatic nozzle with approximately the same cooling effect. This could be an important subject of evaluation of these devices in regions with a shortage of water.

The effect of a device is considerably dependent on the quantity of cooled air by one nozzle. More economical will be a greater number of nozzles side by side with a wide flow of air at minimal speed. The price of nozzles is also important. The water pressure nozzle produced from corundum ceramics is several times more expensive than the brass pneumatic nozzle.

The dependence of temperature decrease Δt and relative humidity increase $\Delta \varphi$ on the pressure before the nozzle is not so significant that it should be necessary to use extremely high pressure. An optimum pressure of air for the pneumatic nozzle is 0,3 MPa. An optimum pressure of water for the water pressure nozzle is 0,5 MPa which corresponds to the common pressure of a water-supply system. The energetic demands of both types of apparatae could be determined from the recommended operating mode.

The cooling and humidification of air is suitable only for several species and categories of domestic animals bred in our climatic conditions, primarily during a warm summer season. One example is the breeding of hens. Čierny /1/ states that our climatic conditions necessitate the cooling of air in houses for hens from 1000 to 1200 h and humidification about 1300 h.

The graph of Fig. 9 shows that it is impossible to achieve optimum parameters by using this type of cooling with sprayed water in cases when the air temperatures are about 30° C and relative humidities are over 35%. For this reason this type of cooling together with humidification is even more advantageous in the countries with tropical and subtropical dry climates.



hens

cows

fattening pigs

riding horses

1A,B air state before different types of apparatae with water pressure nozzle

1P air state before apparatus with pneumatic nozzle

2A,B air state after different types of apparatae with water pressure nozzle

2P air state after apparatus with pneumatic nozzle

Fig. 9 i–x diagram of optimum parameters for animals /2/ and cooling.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

THE CONSTRUCTIVE DESIGN OF A MULTIPLE DISC CUTTING MILL

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The constructive design of a multiple disc cutting mill, however, is complicated. A mathematical model of the comminution process in this type of mill does not exist up to now because of the rather complex correlations. The aim of this contribution is to find regularities by the help of experimental investigations using two types of grain, which allow the calculation of the comminution process in a multiple disc cutting mill in dependence on the constructive mill parameters.

1. THE DESIGN OF MILL

The chief point of the multiple cutting mill for grainy materials is that the device consists of a set of working discs mounted coaxially on a shaft (fig 1), and the discs have holes of grinding edges arranged on diameters which increase from the inlet to outlet of material from the comminution area, and the velocity between adjacent discs is a comminution velocity.

The multiple disc cutting mills belong to that group of devices in which the process is performed at a linear speed of the grinding edge of appr. 1 m/s, and comminuted material still remains within the cutting area. Continuous contact of material with the grinding

elements and its lower linear velocity are the two basic requirements for a high process effectiveness [1, 2, 3].

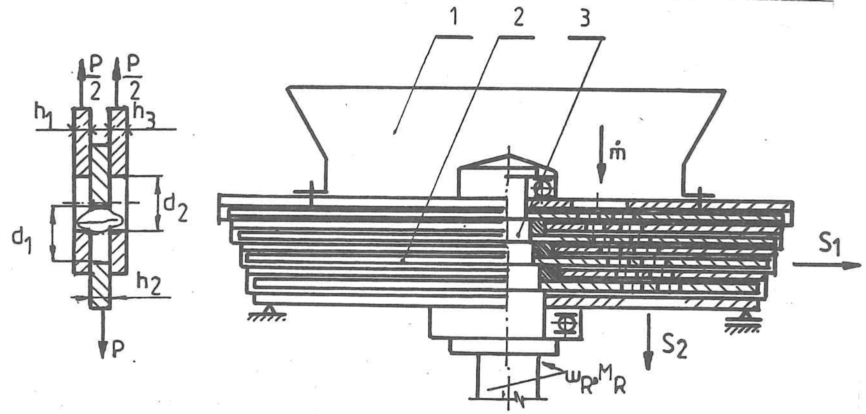

FIG. 1 THE MULTIPLE DISC CUTTING MILL

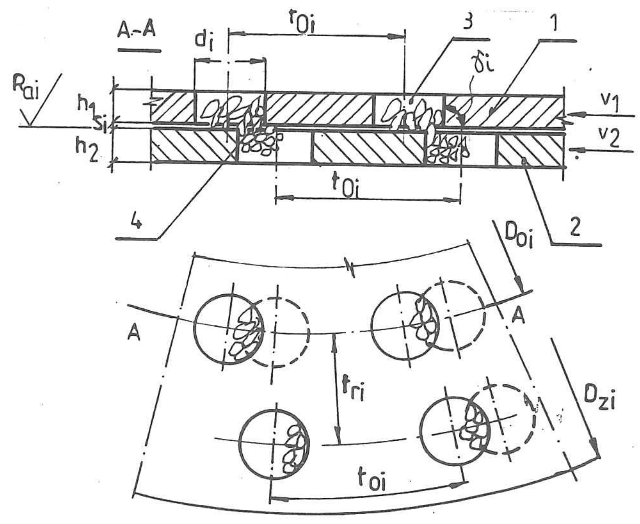

FIG. 2 TECHNOLOGICAL QUASI-SHEARING

It was assumed that grains would be comminuted on the basis of technological quasi-shearing (fig. 2). The state of load and the plastic strain of grains may occur on one or two edges formed by holes made in the discs, which are in a state of relative motion (model according to fig.2).

The comminution takes place due to displacement of disc 1 whth speed v_1 in relation to the disc 2 moving with speed v_2 (fig.2). Comminuted material 4 which flows through holes 3 is plastically strained by the edges of two holes in adjacent discs. The comminution velocity is equal to the difference of linear velocity of particles on these discs.

The grinding process was carried into effect using a cutting mill in the shape of a working assembly as in fig.1. A grain in bulk was fed through the hole in the top fixed plate, and after comminution the product was released through the slot between the discs, and/or after vertical passing through the pack of discs with holes.

As examined design features for the multiple disc cutting mill of grains the following ones were assumed:

-geometrical design features of grinding assembly, i.e. (fig.2):

--disc thickness h_i,

--slot between discs s_i,

--diameter of holes in discs d_i,

--cutting-edge angle of transferring and grinding holes γ_i,

--circular pitch of holes t_{oi},

--radial pitch of holes t_{ri},

--disc surface roughness R_{ai},

--disc outer diameter D_{zi},

--pitch diameter of holes in discs D_{oi},

--stable design features of elements connected with accomplishment of process in model and machine conditions C_{ks};

-design features of motion, i.e. (fig.2):

--linear velocity of holes in discs v_i,

--difference of angular velocity between discs $\Delta\omega_i$,

--performance curves related to kinematic non-uniformity Δk, dinamic one Δd, motion one $\Delta\eta$ and to efficiency η of selected elements of driving line,

--method of control of angular velocity of multiple disc cutting mill shaft (fig.3) as variable $-b_{sc}$, stepwise $-b_{ss}$, and mixed one b_{sm},

--state of kinematic ratio i_{ki} and dinamic one i_{di};

-method of bulk flow through cutting mill, i.e. (fig.1):

--passing through slots between discs S_1,

--passing through pack of discs with holes S_2,

--passing through slot and alongside of disc pack $S_{1/2}$.

2.MODEL OF MILL

Assuming that the grain is a complicated structural component of the grinding assembly MR (fig.3), the presented model may be described with inputs (MR, P, S, U) and outputs of an aim shape (C).

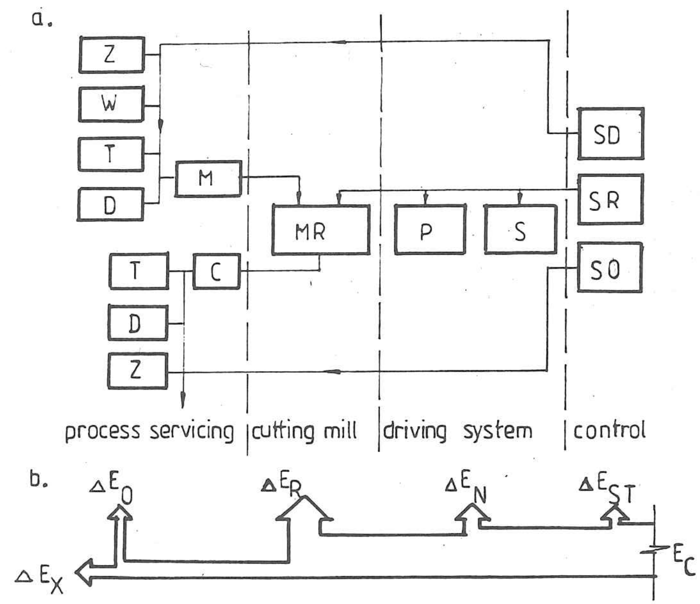

FIG.3 MODEL OF COMMINUTION PROCESS

Within the range of input variables the following assumptions are distinguished:

-the design of the grinnding assembly MR relates to a solution existing and being searched in consideration of the assumed level of accomplishment of the aim C,

-the design is a mathematically describeable system of states and structures of the grinding assembly and its phisical models,

-the performance curves of the driving system N relate to power transformation and transmission, and to levels of uniformity - considering the comminution effectiveness C,

-the grain strength Wz relates to the kind and course of plastic strain in grains being comminuted, as results of the action of determined load,

-the investigations are accomplished assuming an effect time and intermediate variables T, P on the technical state and mutual internal relations.

In the elements of design and identification of many phenomana, which take place during the comminution, an energy balance supplemented by specific analytic descriptions [1, 2, 3] is most often used. Thus, it may be written that the set of substantial factors has the following form:

(1) $I=\langle Cg,\ Cm,\ Cd,\ Cr,\ \eta'_N,\ Zi,\ \zeta,\ U\rangle$,

where:

Cg -geometrical features of grinding elements,

Cm -material features of grinding elements,

Cd -dinamic features of elements in mutual relations,

Cr -motion features of grinding and comminuted elements,

η'_N-inefficiency in driving line,

Zi -sort of comminuted grain,

ζ -resultant vector of flow resistance,

U -load resulting from growing stronger of transport and shaped reactions, and reactions from control operations.

Therefore, a semantic model of the comminution effectiveness reduced to the level of energy consumption has a form:

(2) $E=f(Ck,\ Cr,\ Wz,\ \eta'_N,\ \Delta Ep)$,

where:

Ck -specific design features influencing energyconsumption,

Cr -features of grinding element movement, conditioning comminution and energy-consumption level,

Wz -strength of comminuted material causing resistance determined with strength tests in model conditions,

η'_N-overall inefficiency of driving line,

ΔEp-difference of energies between actual and model conditions.

3. RESEARCH MODEL OF COMMINUTION

On introducing necessary reductions there appears a new energetic model of comminution process which is expressed by the following formula (fig.3):

(3) $E_C=\Delta E_{ST}+\Delta E_N+\Delta E_R+\Delta E_O+\Delta E_X$

where:

E_C -total energy supplied to system,

ΔE_{ST}-energy assigned for process control,

ΔE_N -energy lost in driving system,

ΔE_R -energy lost in cutting mill,

ΔE_O -energy assigned for process servicing,

ΔE_X -energy dissipated in system (vibrations, heat, sound, waves, etc.).

For design elements of multiple disc cutting mill construction the most important are phenomena occuring in the grinding and driving assembly. The design formulation of energetics problems simplifies the relationship (3) to a form:

(4) $E_C=\Delta E_N+\Delta E_R$,

what according to the relationship, with assumption that the $E_C=E_E$ - electrical energy, allows one to determine an energy necessary for machine comminution of grains as;

(5) $$E_{R\lambda}=\int_0^T P_R(t)\, v(t)\, dt; \qquad \text{for } P_R>0,\ v>0,$$

where:

P_R -grinding force, N,

v -comminution velocity, m/s,

$E_{R\lambda}$-energy necessary for mechanical deformation of grain sample during cycle to predetermined comminution degree, J,

T -cycle duration, s.

At the same time there occurs the following relationship (fig.3):

(6) $$E_{R\lambda}=E_E\cdot \eta_S\cdot \eta_P$$

wehre:

η_S-motor mechanical efficiency, -,

η_P-transmission mechanical efficiency, -,

E_E-energy supplied at system input, J.

With stabilized motion, for full motion cycle or its multiple it may be assumed that:

(7) $$E_{R\lambda}=E_{T\lambda}+\Delta E_M$$

where:

$E_{T\lambda}$-energy needed for mechanical deformation of grain sample, in model conditions, to predetermined degree of comminution, J,

ΔE_M-increase in energy losses for accomplishment of comminution in machine conditions, J.

Increase in energy for accomplishment of the comminution in machine conditions may be expressed in a coefficient form:

(8) $$E_{T\lambda}=\alpha_R\cdot E_{R\lambda}; \qquad \alpha_R=E_{T\lambda}/E_{R\lambda},$$

where:

α_R-factor of energetic relations as measure of model accomplishment in machine conditions, -.

Comparing the relationships (6) and (7), it may be possible to determine an increase in energy for the comminution accomplishment

in machine conditions:

(9) $$\Delta E_M=E_E\cdot \eta_S\cdot \eta_P - E_{T\lambda}$$

The model described by the relationship (9) refers to the accomplishment of the process by the grinding assembly. It includes the energy dissipations which do not relate directly to the comminuted material deformation.

It results from the energy conservation law that the kinetic energy of the grinding element before comminution is transformed, just when this element contacts with the particle, into (7):

(10) $$E_{T\lambda}=E_T+E_m+E_p$$

where:

E_T-kinetic energy of working element after deformation of grain, J,

E_m-kinetic energy of material particles after comminution, J,

E_p-energy used for performing deformation work, J.

From the relationships (7) and (10) a complexity of effective work concept results. A various character of the usability results from the first relationship, and a complexity of the phenomen on results from the second one - even in model conditions it may be possible to experimentally determine the E_p only. The above relationships, first of all the (10), allow one to unmistakably classify all, what is not connected with deformation, to the group of machine resistances. The concept of machine resistance includes the energy consumption:

of the lost motion , of the flow accomplishment during the comminution, and of the mechanical transmission ratios - as basic factors of the design.

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TRENDS IN AGRICULTURAL ENGINEERING
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A MATHEMATICAL MODEL OF THE COMMINUTION PROCESS IN MULTIPLE DISC CUTTING MILL

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Using experimental data for the application of a multiple disc cutting mill as comminution machine a model was put up, which was suitable for finding the necessary machine parameters for constructing a multiple disc cutting mill. The following part investigates the comminution of grain itself with the optimal usability (digestibility) being the product-side aim. The precalculations of the comminution result with respect to the process data (comminution, transportation, separation) of a multiple disc cutting mill form the centre of this contribution.

1.A MATHEMATICAL REVIEW OF THE COMMINUTION PROCESS CHARACTERISTICS

Using the formula for general comminution resistance in the form:

(1) $$P_R=k_j.v_R+\sigma_{max}.F_R+\varepsilon.F'_R.v_R^2,$$

where:

k_j -coefficient of lost motion resistance, $kg.s^{-1}$,

v_R -cominution velocity, $m.s^{-1}$,

σ_{max} -maximum stresses in place of reaction of grinding element to material, $N.m^{-2}$,

F_R, F'_R-comminution section area, m^2,

ε -factor of proportionality, $N.s^2.m^{-4}$,

we can obtain a simplified formula for the energy-consumption of comminution including, however, the majority of factors mentioned in the relationship [1] as being essential:

$$E_E = \frac{(k_j \cdot v_R + \sigma_{max} \cdot F_R + \varepsilon \cdot F'_R \cdot v_R^2) \cdot v_R \cdot t}{\eta_S \cdot \eta_P} \qquad (2)$$

where:

t -comminution time of predetermined relative section, s,

E_E -electrical energy, J,

η_S -motor mechanical efficiency, -,

η_P -transmission mechanical efficiency, -.

The formula (2) comprises basic elements of the efficiency-energetic model for multiple disc cutting mills. It also has a general meaning. The maximum stresses, among other things, are connected with specific design features of cylindrical, disc, knife, ball and beater cutting mills which are met. Moreover, the above mentioned factors of proportionality depend also on geometrical, material and dinamic design features.

The relationship (2), like other models which are met till now, does not include specifity of the comminution for fodder purposes connected with increasing the feeding effectiveness [1, 2].
Using definition of a biological comminution index [1, 2] and numerical index of corn grain comminution efficiency [3], the general energetic model is reduced to a form:

$$e_R = \frac{(\eta_{bio} - \eta_Z) \cdot E_{gross} \cdot \eta_S \cdot \eta_P}{(k_j \cdot v_R + \sigma_{max} \cdot F_R + \varepsilon \cdot F'_R \cdot v_R^2) \cdot v_R \cdot t \cdot M_k} \qquad (3)$$

where:

η_{bio}-index of biological value determined on the basis of screen

analysis and in vitro digestibility for comminution product,

η_Z -index of grain digestibility before comminution, -,

E_{gross}-average content of gross energy in 1 kg of dry grain in bulk, e.g. rye-15,7 MJ/kg, wheat-16,2 MJ/kg, wheat-rye-16,1 MJ/kg, oat-16,5 MJ/kg [3], MJ/kg,

M_k -multiplication factor of bulk test - if denominator components relate to data different than 1 kg, -.

For a predetermined range of biological value of individual dimensional groups of the comminution product there is a possibility of energetic index calculation [3]:

$$\eta_{bio} = f_{<0,5} \cdot \eta_{bio<0,5} + f_{0,5-1,5} \cdot \eta_{bio0,5-1,5} + f_{>1,5} \cdot \eta_{bio>1,5} \qquad (4)$$

where:

η_{bio} - index of biological value for comminution product, -,

$\eta_{bio<0,5}$, $\eta_{bio0,5-1,5}$, $\eta_{bio>1,5}$ - index of biological value for product fraction of given dimensions, -,

$f_{<0,5}$, $f_{0,5-1,5}$, $f_{>1,5}$ - part of fraction of given dimensions, -.

Thus calculated, the index of biological value for comminution product is a numerical range determined with proper probability or mean value for the examined aim criterion. The knowledge of that index makes it possible to calculate a ratio of the increase in energy released due to the comminution to the outlay born to get this energy. In consideration of the analysis of a complicated technical system [1], it is necessary, to this end , to take momentary measurements of mechanical efficiency of the motor and transmission.
Direct connecting of the drive and comminution system permits a definition of the overall efficiency in a form:

$$\eta_O = \eta_S \cdot \eta_P \cdot \eta_R, \qquad (5)$$

where:

η_0-overall efficiency of technical system for comminution, -,
η_R-comminution relative efficiency as measure of model accomplishment in actual conditions (α_R) [1], -.

To carry out a procedure connected with modelling the multiple disc method of comminution, an experiment is needed which allows determination of:

- -work necessary to mechanical deformation of the grain to predetermined dimensions,
- -stresses at multi-edge deformation of different corn grains in variable motion conditions.

However, the model verification in machine conditions needs investgations of:

- -characteristics of the multiple disc comminution depending on the grain sort and the design features of motion,
- -energetic comminution indexes depending on the process parameters,
- -mechanical efficiency of the driving system depending on the structure of the multiple disc cutting mill and comminuted material.

The results of the so carried out experiment will make-up data concerning the process and material which will be used to assist the designing of the multiple disc cutting mills for grains.

The design specifity of themultiple disc cutting mills needs additionally special procedures for calculation of the comminution section and flow of material. The comminution section F_R and F'_R (in accordance with the relationship (3)) is determined using the basic relationship for the effective surface between the edges of grinding holes (fig.1).

2. MODEL OF THE COMMINUTION AREA

Circular arcs taking part in the comminution are described by the following relationships (fig.1):

$$(6)\quad \begin{cases} y=b_1-[R^2-(x-a_1)^2]^{1/2} & \text{-lower arc} \\ y=b_2+[R^2-(x-a_2)^2]^{1/2} & \text{-top arc} \end{cases}$$

where:

a_1, a_2, b_1, b_2-coordinates of grinding hole centres,
R -radius of grinding hole.

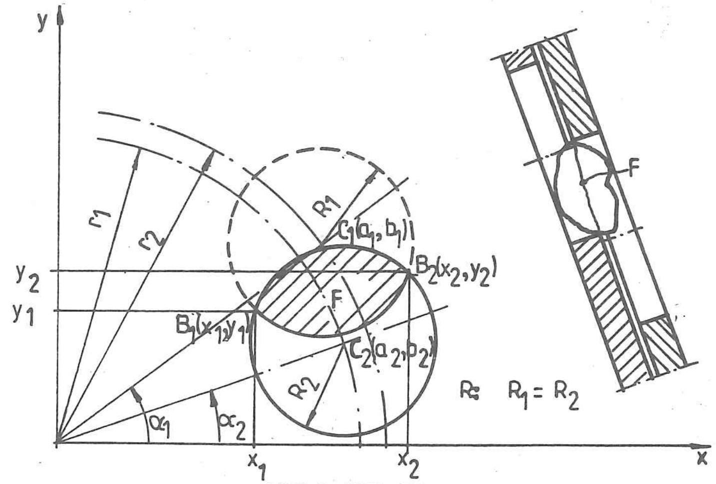

FIG.1 THE COMMINUTION AREA

The area between grinding hole edges:

$$(7)\quad S=\int_{x_1}^{x_2}\{b_2+[R^2-(x-a_2)]^2]^{1/2}\}dx-\int_{x_1}^{x_2}\{b_1-[R^2-$$

$$+(x-a_1)^2]^{1/2}\}dx = b_2\int_{x_1}^{x_2}dx+\int_{x_1}^{x_2}[R^2-(x-a_2)^2]^{1/2}dx -$$

$$+b_1\int_{x_1}^{x_2}dx+\int_{x_1}^{x_2}[R^2-(x-a_1)^2]^{1/2}dx$$

The area S is maximal when the circle centres $A(a_1;b_1)$ and $B(a_2;b_2)$ lie on the same straight line and $\Delta\alpha=\alpha_1-\alpha_2=\omega_1 \cdot t-\omega_2 \cdot t= t(\omega_1-\omega_2)=>0$; for $\alpha_1=\omega_1 t$ and $\alpha_2=\omega_2 t$, there is a case in which there occurs mainly a transport of material without grinding with edges. The area S is equal to zero when the following relationship occurs:

$$[(a_1-a_2)^2+(b_1-b_2)^2]^{1/2}=2R,$$

and $\Delta\alpha=t(\omega_1-\omega_2)=>max$;

it is the end of comminution which results from the area of the interedge-reaction. As ω_1 and ω_2 the angular velocities of adjacent discs with holes are denoted.

3. THE GENERAL ENERGETIC MODEL

The comminution is accomplished when the following condition is fulfilled:

$$(8) \quad \begin{cases} [(a_1-a_2)^2+(b_1-b_2)^2]^{1/2} < R \\ \text{and } \Delta\alpha < \Delta\alpha_{max}. \end{cases}$$

Being aware that:

$$F_R=\Psi . S \quad \text{and} \quad F'_R=k.F_R,$$

the general energetic model of multiple-plate comminution of the corn grains for the fodder has a form:

$$(9) \qquad e_R=\frac{(\eta_{bio}-\eta_Z).E_{gross}.\eta_S.\eta_P}{(k_j.v_R+\Psi.S(\sigma_{max}+k.\varepsilon.v_R^2)/.v_R.t.M_k}$$

where:

Ψ-coefficient of filling the section area with comminuted material, -,

k-coefficient of secondary reactions between disc surfaces-determined experimentally.

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TRENDS IN AGRICULTURAL ENGINEERING
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The following is a presentation of a method for the approximate determination of the total air pollution caused by combustion engines operating in the agricultural sector, which, to date has not been as closely observed in this respect as, for example, normal traffic. The situation in Czech agriculture in 1986 is used as an example, together with the possible improvements at present. This example demonstrates that air pollution caused by these engines is very significant.

concentration of emissions; engine; tractors; vehicles

1. INTRODUCTION

Transport is the biggest user of combustion engines, with agriculture in second place in every country. During the past ten years there have been approximately 130 000 tractors, 33 000 trucks, 15 000 combine harvesters and 16 000 other mobile machines working in Czech agriculture /3/, in total roughly 190 000 combustion engines, mostly very efficient. Output, installed in tractors only, is higher than 5,1 million kilowats, therefore, on average, each engine has an output of approximately 50 kW. All of these engines contribute to pollution.

Differences between the effects of combustion engines in transport and these in agriculture are as follows:

1. Air pollution caused by transport is worst in urban conglomerations and along highways and roads, according to the concentration of vehicles in these localities. In general, the use of engines in agriculture is not concentrated, except on short access roads and during their operation in confined spaces, so harmful emissions are dispersed over large areas of fields.
2. The operating modes of cars and trucks remain the same, most of the time, over the same geographical conditions, e.g. on roads, motorways, in town, lowland areas or mountains, etc. But engines in agriculture perform in wide range of operational mode changes due to the type of work being done e.g. a tractor pulling a plough for deep tillage or with a light sower, with a trailer for road transport or a combine harvester etc.

European standards for harmful exhaust emissions EEC regulation 15, 24, 40, 47, 49, are applied to vehicle engines. These standards must be adhered to the vehicle homologation. The testing of toxic emissions concentrations in operation is carried out in different ways in different countries: according to national standards, traffic regulations, etc. Diesel engines in tractors and in other agricultural machines are tested in accordance with EEC regulation 24 only. There is no special test for agricultural engines. So the various operating modes of such machines and the resultant levels of harmful emissions have not been examined; therefore there are no standards set down for regulating these emissions. The one simplifying factor in this problem is that with very few exceptions all engines working in Czech agriculture are diesel which increases accuracy of determining air pollution.

Determining air pollution

For the exact determination of air pollution we must either measure a huge amount of emissions or have the following informations:

1. The types of agricultural work in which combustion engines are used.
2. Time recordings of engine modes during each type of work.
3. Time or area covered or to and from side distance in which engine works.
4. Values of exhaust emissions analysis in individual engine modes.
5. Numbers of each type of engine used.
6. Coefficients including all conditions of engines, soil and climatic conditions.

From this basic information could be drawn up a standard test for the combustion engine in agriculture. At present we do not have such informations. We have to use any method possible in this situation.

The limit of diesel engine particles is in accordance with EEC regulation 24; limits of harmful gaseous emissions are in accordance with EEC 49. This later standard is determined for vehicle engines only but the nature of the test allows its application on some other types of engines. It is true that the test does not define special operational and time behaviour of engines in agriculture, but it does include a well defined measurement of engine loading, especially the type of field operation, that predominate in agriculture. Therefore, it is possible to apply these tests to agricultural machinery.

EEC regulation 24 states the limit of smoke in the form of absolute or relative smoke opacity values. This limit applies to all types of engine performance. EEC regulation 49 presents a 13-mode cycle that includes two different load characteristics for operating modes of rate power and maximal torque; each has 5 points. The test is completed by 3 points of engine idling. The limits of this test are values of the "specific emissions" of three harmful gases: CO, NO_x and HC. These limits are being gradually decreased. Initially these limits were: CO = 14 g/kWh, NO_x = 18 g/kWh, HC = 3.5 g/kWh in eighties. They have now been reduced to: CO = 11.2 g/kWh, NO_x = 14.4 g/kWh, HC = 2.4 g/kWh.

The following relationships are valid for specific gaseous emissions:

$$\underline{CO} = \Sigma([9.66E-4 \,.\, CO.(M_a+M_f).w]) \;/\; \Sigma(P_e \,.\, w) \qquad (1)$$

$$\underline{NO_x} = \Sigma([1.587E-3 \,.\, NO_x.(M_a+M_f).w]) \;/\; \Sigma(P_e \,.\, w) \qquad (2)$$

$$\underline{HC} = \Sigma([4.78E-4 \,.\, HC.(M_a+M_f).w]) \;/\; \Sigma(P_e \,.\, w) \qquad (3)$$

where:

$\underline{CO}, \underline{NO_x}, \underline{HC}$ - g/kWh - specific concentrations of individual emissions or specific emissions

CO, NO_x, HC - ppm_v - exhaust concentrations of individual emissions
M_a, M_f - kg/h - mass of consumed air resp. fuel
w - - - statistical weight factor of test

Analogous equation is valid for specific emissions of particles /1/:

$$\underline{C} = \Sigma[(0.861.M_{ar} + 0.77.M_f).C.w] / \Sigma(P_e . w) \quad (4)$$

where:
$\underline{C}$ - g/kWh - specific emission of particles
C - g/m^3 - concentration of particles per exhalations unit
M_{ar} - kg/h - mass of consumed air with correction on atmospheric conditions

2. RESULTS

The results of this test on individual types of engine multiplied by installed output and operating time, taking into consideration the condition of the engines, give relatively exact values of the total emissions.

Therefore, it is necessary to know all the technical data of the engines including specific emissions, and all statistical data, e.g. the number of individual types of machines and their operating times.

An analysis of the 29 diesel engines most commonly used in our agriculture shows that values of specific concentrations of emissions being determined for 6 types. As an example, we can take two serial-produced engines tested in the laboratory of our department (see table 1):

Table 1.

Engine	CO	NO_x	HC
	g/kWh		
Z-7201	11.4	14.7	1.4
Z-7202	13.8	16.2	1.6

Measurements of HC showed that values of concentrations in no case reached the limit.

From the point of view of design and other technical similarities we can take into consideration that the mean specific gaseous emissions of adjusted new engines approached upper limit, values of emissions of particles are approximately 1.5 g/kWh.

The analysis of fuel consumption of these 29 types of engine indicated that - if individual types had the same representation - the mean value of specific fuel consumption m_{pe}, from the technical data, was 250 g/kWh. Real values were not known. Data were a little misrepresented but it was also possible to take this value as authoritative.

The technical condition of engines worsens little by little during their operation. Engine parts wear out and adjusting conditions are changed, especially in high-pressure parts of fuel injection systems. Both processes have a negative effect on both deterioration of emission parameters and on increase of fuel consumption. Some results of long-term research into engine operation in agriculture, presented in many student dissertations and research works by our department, evidence that specific emissions of C, CO and HC increase by approximately 30 %.

From all these fact follows: In 1986, engines in agriculture operated with mean values of CO = 19 g/kWh, NO_x = 18 g/kWh (NO_x emissions were somewhat lower but it is possible to calculate with limit value), HC = 5 g/kWh and particles C = 2 g/kWh. Fuel consumption was increased by about 10 - 20 %. Therefore it was possible to calculate with the value of mean specific fuel consumption m_{pe}= 285 g/kWh.

It is possible to carry out an approximate calculation of emission without statistical data of engine types number. But we must know the total fuel consumption of the vehicle or machine fleet.

Specific emissions and specific fuel consumption have the same dimensions, g/kWh. If we know both the parameters, we also know their mutual relationship i.e. mean specific emission CO = 19 g/kWh and mean specific fuel consumption m_{pe}= 285 g/kWh, then their ratio $\underline{co}$ is:

$$\underline{co} = CO/m_{pe} = 19/285 = 6.6E-2 \quad (0.066) \quad (5)$$

If this ratio is valid for specific value then it is valid for the value of time fuel consumption and for total fuel consumption.

Example:

An engine has m_{pe}= 285 g/kWh and output P_e = 50 kW. Fuel consumption per hour is:

$$M_f = m_{pe} . P_e = 0.285 . 50 = 14.25 \text{ kg/h}$$

CO emission per hour is therefore

$$CO_h = \underline{co} . M_f = 6.6E-2 . 14.25 = 0.94 \text{ kg/h}$$

If the total fuel consumption per year for this engine is 14.25 tons (14.25 kg/h, 10hours per day, 100 days per year) then the CO emission of this one engine is:

$$CO_y = \underline{co} . M_f . H . D = 6.6E-2 . 14.25 . 10 . 100 = 940 \text{ kg/y}$$

If we know total the fuel consumption of the whole fleet, we can determine the total amount of emissions per year.

Coefficients for individual emissions can be calculated:

$$\underline{co} = 6.6E-2 \quad (6)$$

$$\underline{no} = NO_x/m_{pe} = 18/285 = 6.3E-2 \quad (7)$$

$$\underline{hc} = HC/m_{pe} = 5/285 = 1.75E-2 \quad (8)$$

$$\underline{c} = C/m_{pe} = 2/285 = 7E-3 \quad (9)$$

A table of fuel consumption for individual sectors of agriculture was compiled from a Czech Ministry of Agriculture database. It was possible to compile the table with the values of individual emissions on the basis of presented data and using calculation method (se table 2).

Sector	Fuel consum.	Emissions			
		CO	NO_x	HC	C
	t/year				
Agriculture total	675 300	44 975	42 544	11 818	4 727
Plant production	343 800	22 897	21 659	6 016	2 407
Livestock production	114 000	7 592	7 182	1 995	798
Transport of persons	15 500	1 032	977	271	109
Interplant handling	89 000	5 927	5 607	1 558	623
Other activities	112 700	7 506	7 100	1 972	789

Table 2.

Emissions concentration for individual seasons, other time data, certain types of machine, etc., can be determined by analogy so statistical data are as attainable.

Table 2 confirms a large amount of individual harmful emissions emitted into the air in 1986. Reduction of this amount is possible for two reasons: specific fuel consumption is now lower, only 230 - 240 g/kWh; limits of specific emissions are lower by about 20%. If all users will persevere with checking and maintenance of the fuel injection system and other parts of engines in such a way that values of specific fuel consumption remain at 240 g/kWh (it is possible now), then, with the same number and output of engines, the total consumption of fuel will decrease by about 15%. If engine producers will observe the EEC 49 R standard for this year, and they are trying for,then all coefficients for individual emissions will change in the following:

$\underline{co}$ = 11.2/240 = 4.667E-2
$\underline{no}$ = 14.4/240 = 6E-2
$\underline{hc}$ = 2.4/240 = 1E-2
$\underline{c}$ = 1.5/240 = 6.25E-3

After calculation the results are in table 3.

It is quite clear from comparison of both tables, and also from fig. 1, that the reduction in the amount of harmful emissions is very significant.

Agriculture total	Fuel consum.	Emissions			
		CO	NO_x	HC	C
year	t/year				
1986	675 300	44 975	42 544	11 818	4 727
1992	568 674	26 540	34 120	5 686	3 554

Table 3.

COMPARISON OF TOTAL EMISSIONS IN YEARS 1986 AND 1992

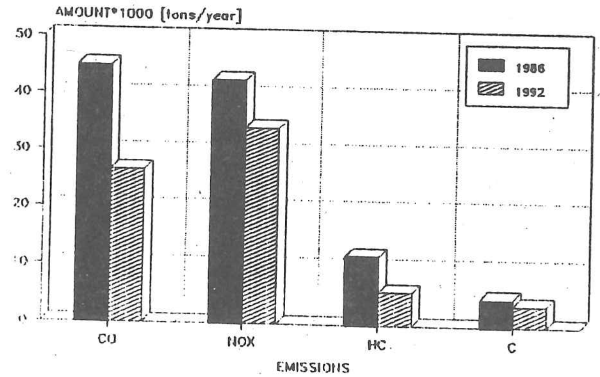

Fig.1

3. CONCLUSION

The above method for approximate determination of harmful emissions can be used generally. The method is more exact the more the required data are used. Results, presented in this article, demonstrate that air pollution caused by combustion engines in Czech agriculture is very significant. It is necessary to include these results in the overall evaluation of air pollution over large areas, regions or states.

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TRENDS IN AGRICULTURAL ENGINEERING
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DEPENDABILITY ACCELERATED TESTS

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The accelerated test allows to reduce the time for the determination of the required dependability parameters. The main issue is how to transform the results of the accelerated test to the normal conditions of operation. The majority of transformation methods are based on the extrapolation of the parameters through the monitoring of changes in the working mode. This method compares the results of the field test with those of the accelerated test and determines the factor and function of the acceleration for double- and multistate items.

accelerated test; laboratory and field test; time acceleration factor and function; double- or multistate item; dependability

1. <u>INTRODUCTION</u>

Determination of the required parameters of dependability under field conditions as a rule time-consuming and lengthy. The results usually become available long after the item began to be produced on mass. Dependability data thus lose their topical significance for the producers because in such conditions their response to the requirements identified in field (failures or new requirements for dependability traits) are delayed and costly.

This logically gives rise to the need for reducing the time require to perform a dependability <u>determination</u> or <u>compliance</u> test (a test used to establish the value of a characteristic or a property of an item or a test used to show whether or not a characteristic or a property of an item complies with the stated requirement [1]).

2. <u>THE ISSUES OF ACCELERATED TESTS</u>

<u>The dependability censored test</u> is a test completed before failure of all the items tested [2]. At such a test, when the values of the dependability indicators of doublestate items are to be estimated, it is as a rule necessary to know the function of the probability density distribution of the random quantity of the basic set of items studied; with multi-state items the accuracy of prediction of the technical state declines. These factors reduce the applicability of the test and do not, by their nature, belong among the dependability accelerated tests [3].

The <u>dependability accelerated test</u> is a test in which the stress level applied is chosen to exceed that stated in the reference conditions in order to shorten the time duration required to observe the stress response of the item, or to magnify the response in a given time duration [1]. In other words, the accelerated test allows to estimate the required parameters within a time shorter than the operating time of the item (than the length of the dependability field test).

In the sense of [1] and [2] the <u>acceleration</u> of the tests is achieved through carrying them out under stricter conditions. According to [4] <u>"test mode"</u> is involved, defined as a vector characterized by a set of components which are a function of time and represent a set of values of involved climatic, mechanical, electric, thermal and other factors. It can be said that the regime affords an all-round quantitative expression of the conditions of testing the item, regardless of whether the test is performed in field or laboratory. As a result of using different test mode there are differences in the rate of development of failures, the time of duration of the tested items operation is shortened, and the functional parameters of reliability are changed.

It is often claimed that the accelerated laboratory test may replace or eliminate the field test under standard conditions. This is a mistake because it is impossible, without knowing the results of the field tests, to compare the dependability data or to obtain sufficiently accurate acceleration factor or even the acceleration functions. This raises the question whether in such circumstances the accelerated tests have any sense at all. Nevertheless, the importance of such tests for the manufacturers is indubitable and can be derived for two different stages of testing [5].

1. During the <u>startup</u> period of any dependability tests, it is useful to organize the accelerated tests and field tests parallely. Less efforts and means will be needed if the program of accelerated and field tests is differentiated:

a) at the <u>accelerated tests</u>, all parameters of reliability, durability and maintainability are to be monitored; the time of operation is as a rule recorded expressed in units of time,

b) during the <u>field tests</u>, all the parameters of reliability and durability will be recorded; some data from the accelerated tests relating to the <u>maintainability</u> parameters may be used (it is not necessary to determine all data anew - e.g. the man-hours of preventive maintenance, diagnosis, man-hours of some dismantling operations during repairs etc).

c) field tests have to be conducted under any typical conditions of the field use of the item in different machines and equipment; laboratory tests may sometimes have only one option of work mode. Conversion and comparison of the parameters obtained under laboratory and field conditions may provide the factors or functions needed for field applications (e.g. different factors or functions for transformation to apply to different field conditions can be obtained from a single laboratory accelerated test).

2. When dependability tests are repeated owing to minor changes in the item's design, the dependability accelerated tests become a basis for estimating the parameters of reliability and durability. In the reliability and durability tests the data for the required parameters are acquired as follows:

a) compare the data obtained from the accelerated testing of all design and make options of the item (e.g. comparing an original and improved type),

b) use the data from the comparison to forecast (through calculation) the changes likely to occur in the field operation parameters for all types of field operations for which the field tests have been performed with the original design (make option).

Hence, this is an easy way for the manufacturer to obtain the data needed for an all-round quality assessment of any new design or make of the item simply on the basis of the accelerated test without having to perform the lengthy field tests again: the accuracy will obviously be sufficient for making decisions relating to the reasonability of changes in the make of the item.

3. PRINCIPLE OF TRANSFORMING THE RESULTS OF ACCELERATED TESTS

It follows from the survey of the standardized dependability parameters that the following parameters can be used for the transformation of the results of accelerated tests for different type options of field operation modes:

1. Parameters expressed in units of operating time shorten in the stricter mode of the accelerated tests: the same level of the technical state parameter is obtained in a shorter operating time in the accelerated tests. The non-operating time, expressed in units of time and relating to the time of restoration of the item studied, does not depend on the mode of the tests.

2. The absolute values of the probability parameters do not change: they always stay within the (0; 1) interval. If expressed by functional parameters, their development varies with operating time: different operating times are assigned to the same probability value of the phenomenon studied. The ratios of the different operating times can be used for the transformation of the dependability parameters.

3. The parameters of technical state, expressed by structure or operating parameters, do not change in their absolute values during the accelerated tests, different values of operating time being assigned to the unchanging value of the parameter. Again, the ratios of these operating times can be used to transform the dependability parameters.

4. The data on the maintenance man-hours and duration times of upkeep interventions do not vary with the mode of the tests. The data recorded in the accelerated tests can be directly used for the determination of standardized parameters.

The cost items relating to a single restoration (complete overhaul) do not vary during the accelerated dependability tests. The costs relating to the risk of critical failure generally depend on the level of loss per one critical failure and on the probability of the rise of such a failure. Neither the magnitude of such losses nor the probabilities of the failure do depend on the stricter mode of the tests. The only change, again, is the reduction of operating time, corresponding to the given probability level and, thereby, to the given value of costs relating to the risk of critical failure. The costs incurred with increasing defect (wear) depend on the change in the technical state parameter. At the accelerated tests the absolute interval of change in technical state is maintained and what only happens is that the operating time changes, corresponding to the same level of diagnostic signal and thereby to the same level of costs incurred through increasing wear. These considerations of course apply to both the cumulative cost items and the maintenance man-hours. In unit expression (with the reduced operating time in the numerator) these cost items increase depending on the stricter mode.

The principle of the transformation (conversion) of the parameters expressed in units of operating time or general time is that a relationship is sought between the quantities of operating time in the accelerated tests and in field tests, always at the same level of technical state, given by the value of probability of failure or diagnostic signal. This means that a different value of operating time is assigned to the same value of probability of failure or diagnostic signal - see Figs. 1 and 2.

The principle of determining the factor or function of acceleration for double- and multistate items is obvious from the annexed figures.

4. CONCLUSION

The results of the brief investigation into the issues of dependability accelerated tests can be summarized as follows:

a) the constituent items not depending on the more exacting operating modes (probability data, structure and operation parameters and costs proportionate to these quantities) represent the unifying criterion of transformation of dependability parameters;

b) the transformation (conversion) should be performed with data expressed in units of operating time or other time or other time units (operating time, technical life and others);

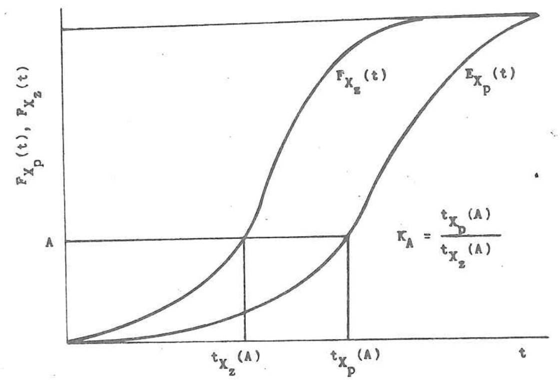

Fig. 1 Principle of the determination of the acceleration factor for doublestate items

$t_{Xz}(A)$ - operating time at accelerated test for probability of failure A, $t_{Xp}(A)$ - operating time at field test for probability of failure A, t - operating time, $F_{Xz}(t)$ - function of failure probability obtained from the accelerated tests, $F_{Xp}(t)$ - function of failure probability obtained from the field tests, K_A - acceleration factor for failure probability A

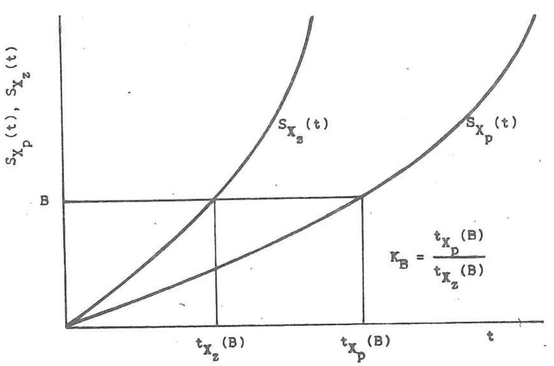

Fig. 2 Principle of the determination of the acceleration factor for multistate items

$t_{Xz}(B)$ - operating time at accelerated test for parameter of technical state B, $t_{Xp}(B)$ - operating time at field test for parameter of technical state B, t - operating time, $S_{Xz}(t)$ - function of technical state parameter obtained from the accelerated tests, $S_{Xp}(t)$ - function of technical state parameter obtained from the field tests, K_B - acceleration factor for technical state parameter B

c) some parameters (man-hours, unit costs, non-operating time and others) can be calculated by means of transformed data;

d) the acceleration factor or functions cannot be obtained from only the accelerated test: there must be a combination with the field test; the dependability accelerated test in itself is only applicable to the evaluation of changes in the design and make of the item.

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TRENDS IN AGRICULTURAL ENGINEERING
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Ein neues System für die Bodenprobenentnahme und -aufbereitung zur N-Untersuchung

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Quantification of plant nutrients especially NO_3-nitrogen in the soil becomes more and more an essential part of arable farming under environmental aspects. The common method of soil sampling and analysing turned out as a very expensive and time consuming procedure. In a fist step sampling of soil (undisturbed samples) was mechanized by the "Bayer. Landesanstalt für Landtechnik". Further more a so called soil mill was constructed for the processing of soil samples. The intention of future efforts concerning automation of soil investigation is to set up a new system including N-analysis on the field.

environmental protection; automation of soil investigation; soil sampling and processing; soil mill; N-analysis;

1. Einleitung

Für die Umsetzung der Ziele eines umweltgerechten Pflanzenbaues spielt die Bodenuntersuchung und der gezielte Stickstoffeinsatz (geringere Aufwandsmenge, weniger N-Verluste) eine wichtige Rolle. Die bisherige Vorgehensweise für die Bodenuntersuchung ist von der Probenahme bis zur Bereitstellung einer Düngeempfehlung in Abb. 1 schematisch dargestellt.

Das gesamte Verfahren verursacht einen erheblichen personellen sowie materiellen Aufwand sowohl auf dem Feld als auch im Labor. Die Zeitspanne von der Bodenprobenahme bis zur Düngeempfehlung umfaßt in der Regel mehrere Tage bis hin zu einigen Wochen.

2. Probenahme

Als erster Schritt bei der Automatisierung der Bodenbeprobung und -untersuchung wurde an der Bayer. Landesanstalt für Landtechnik die Entnahme von ungestörten, d.h. in der Horizontierung erhaltenen Bodenproben, aus den Tiefen 0-30 cm, 30-60 cm und 60-90 cm gelöst. Gleichzeitig bei der Entnahme werden die Proben in Kartuschen verpackt (Abb. 2).

Wie die Abb. 3 zeigt, müssen aber noch weitere Arbeitsschritte zusammengefaßt bzw. ersetzt werden, um den Zeitraum von der Bodenprobenahme bis zur bedarfsgerechten N-Düngung auf wenige Stunden zu verkürzen.

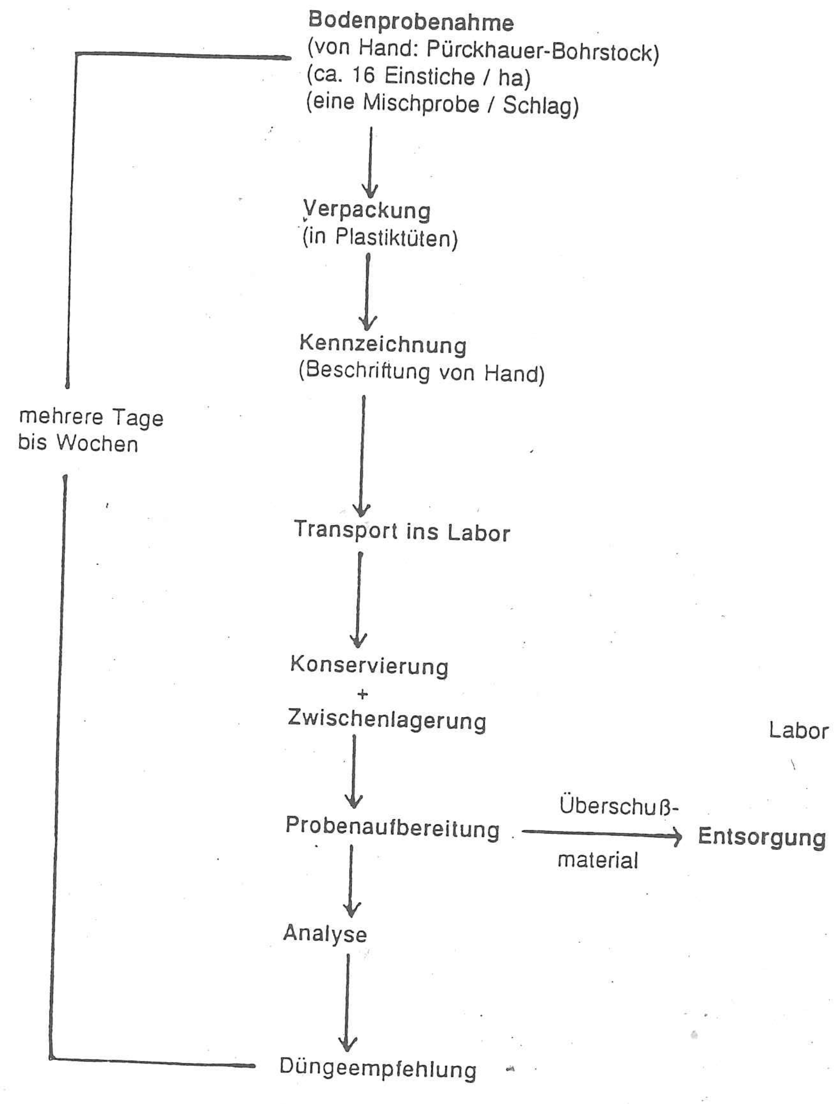

Abb. 1: Bisheriges Ablaufschema der Bodenuntersuchung.

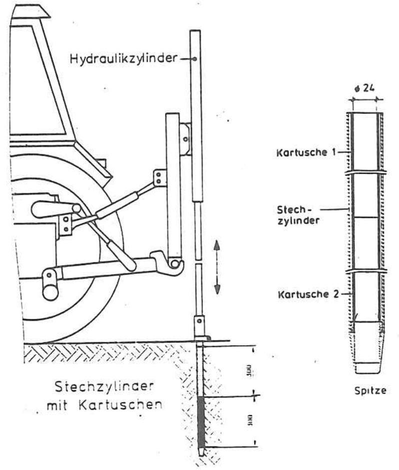

Abb. 2: Bodenprobenentnahmegerät der Bayer. Landesanstalt für Landtechnik mit Stechzylinder und Kartuschen.

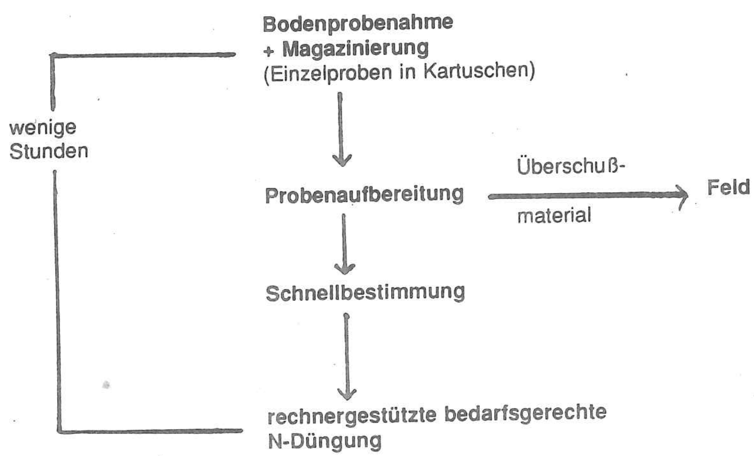

Abb. 3: Automatisierte Bodenbeprobung und N-Schnellbestimmung, für eine bedarfsgerechte Düngung.

3. Probenaufbereitung

Bodenproben weisen je nach Standort eine starke räumliche Heterogenität auf. Durch eine Untergliederung einzelner Schläge in Teilbereiche lassen sich derartige Inhomogenitäten ausgleichen (Auernhammer 1990 /1/, Auernhammer et al. 1991 /2/, Schnug et al. 1990 /3/). Für die Verpackung der Einzelproben müssen folglich verwechslungsfrei gekennzeichnete Kartuschen und entsprechende Magazine für die Aufbewahrung und den Transport der Proben entwickelt werden.

Die ungestörten Einzelproben (150-200 cm^3) müssen vor der Analyse von Steinen befreit und homogenisiert werden. Diese Aufbereitung sollte erst unmittelbar vor der N-Untersuchung erfolgen, da ansonsten Übergänge zwischen den einzelnen N-Formen zu Verfälschungen der Ergebnisse führen können.

Die Vermahlung unterschiedlicher Bodenarten und die Entnahme eines aliquoten Anteils je Probe für die Analyse ermöglicht eine weitere Standardisierung in der Probenhandhabung und verringert den Probenfehler. Entsprechende Geräte existieren derzeit noch nicht. Den Ausgangspunkt für die Weiterentwicklung eines Gerätes zur Aufbereitung von Bodenproben unter verschiedenen Verhältnissen stellt die Erdmühle am Bodenprobenahmegerät dar (Abb. 4).

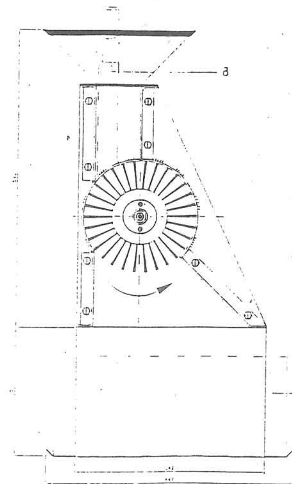

Abb. 4: Vorderansicht der "Erdmühle" des Bodenprobeentnahmegerätes der Bayer. Landesanstalt für Landtechnik.

Diese Erdmühle ist Bestandteil des bisherigen Bodenprobenentnahmegerätes zur Aufbereitung von Bodenproben ausschließlich auf dem Feld. Da die momentane Praxis der Bodenprobenahme einschließlich des Transportes und der Aufbereitung sehr unterschiedliche Organisationsformen und Verfahrensweisen aufweist, wurde als Grundsatz für alle weiteren Entwicklungen auf diesem Gebiet durch die Bayer.

Landesanstalt für Landtechnik eine modulare Verknüpfungsmöglichkeit aller Einzelkomponenten (Entnahmesysteme, Probenaufbereiter, ...) angestrebt. D. h. im speziellen Fall des Gerätes für die Aufbereitung von Bodenproben mußte nach einer Lösung gesucht werden, unter stationären Bedingungen große Mengen an Boden aufzubereiten.

Die vorhandene Erdmühle erwies sich für einen derartigen Einsatz aufgrund folgender Probleme als nicht geeignet:

1. zu geringe Leistungsfähigkeit, da der Durchsatz auf den kombinierten Einsatz an einem Bodenprobenentnahmegerät ("System Weihenstephan") abgestimmt ist,
2. eine unbefriedigende Materialannahme der Aufbereitungsbürste (jede Erdprobe muß von Hand mit einem Stößel nachgeschoben werden) und
3. eine hohe Lärmentwicklung, die beim Arbeiten in geschlossenen Räumen nicht zumutbar ist.

In mehreren Entwicklungsschritten wurden als Anpassungsmaßnahmen für den stationären Betrieb (z.B. im Labor oder beim Ringwart) folgende technischen Modifikationen vorgenommen, die das ursprüngliche Gerät tiefgreifend verändert haben:

1. Kombination einer Stahlbürste mit einer Kunststoffrolle,
2. Antrieb durch einen Elektromotor und
3. Integration einer Reinigungseinrichtung.

Die Anordnung der einzelnen Bauteile ist aus Abb. 5 ersichtlich.

zu 1. und 2.
Durch die Kombination der Stahlbürste mit einer Kunststoffrolle wurde die Materialannahme wesentlich verbessert. Ein Nachschieben von Hand ist nicht mehr erforderlich. Die Kunststoffrolle übernimmt dabei die Funktion eines "fördernden Reibbodens" (Differenzgeschwindigkeit an den Oberflächen). In den bisherigen Probeeinsätzen wurde die Leistungsgrenze im Bezug auf den möglichen Bodendurchsatz nicht erreicht.

zu 3.
Der Antrieb über einen Elektromotor zeichnet sich durch eine hohe Laufruhe aus. Als weitere konstruktive Maßnahme ist der Abstand zwischen Bürste und Rolle so eingestellt, daß kein Kontakt zustande kommt. Beide Modifikationen haben zu einer deutlichen Reduzierung des Geräuschpegels beim Betrieb des Probenaufbereiters geführt. Kurzfristige Störgeräusche treten nur noch auf, wenn die Reinigungseinrichtung betätigt wird. Diese ist nötig geworden, um Verklebungen an der Bürste bei besonders lehmigem und feuchten Probenmaterial wieder zu beseitigen.

Die Sauberhaltung des Aufbereiterinnenraumes konnte zudem durch eine Verengung bzw. außermittige Materialzuführung über den Einfülltrichter entscheidend verbessert werden, sodaß derzeit eine klare Probentrennung möglich ist ohne Materialverschleppungen.

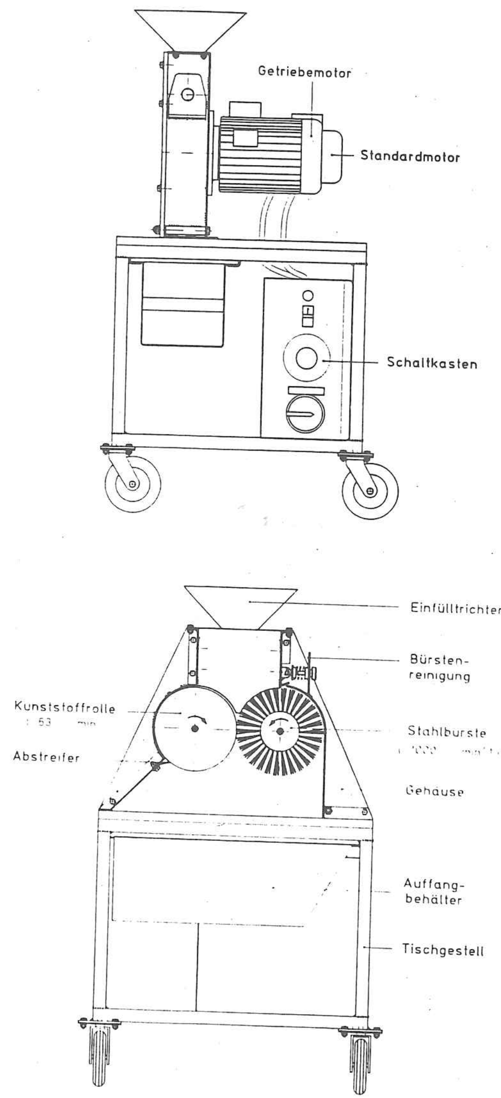

Abb. 5: Schematische Darstellung des stationären Bodenprobenaufbereiters.

Der gefertigte Prototyp des stationären Erdprobenaufbereiters befindet sich derzeit im Erprobungseinsatz (Abb. 6). Bisher sind keine Probleme im Bezug auf die Funktionssicherheit aufgetreten. Lediglich ein älterer Typ der verwendeten Stahlbürsten mußte gegen einen neueren Typ wegen übermäßigen Verschleißes ausgetauscht werden.

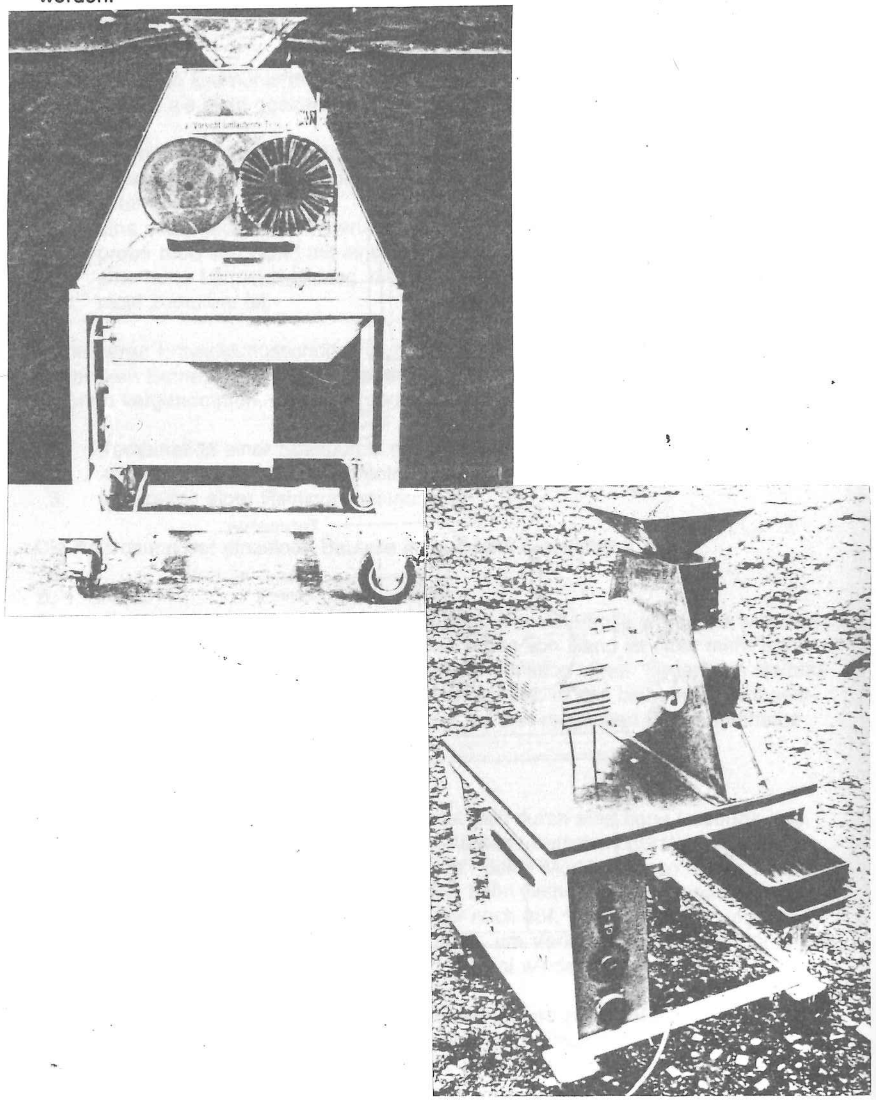

Abb. 6: Prototyp für die stationäre Aufbereitung von Erdproben.

4. Zukünftige Entwicklungsschwerpunkte

4.1 Probenteilung

Für die Bodenuntersuchung werden derzeit unter Praxisbedingungen ausschließlich Mischproben verwendet. Die Anzahl an notwendigen Einzelproben je zu untersuchende Fläche beträgt mindestens 15. Das Gesamtvolumen an Bodenmaterial übersteigt in der Regel die erforderliche Untersuchungs- und Rückstellmenge ganz erheblich (Tab. 1).

Bodenprobenentnahme mit	Werkzeug Ø (mm)	Probenvolumen (15 Einstiche, 90 cm tief, cm^3)	Probenüberschuß* abs. (cm^3)	rel. (%)
Stechzylinder "System Weihenstephan" (maschinelle Entnahme)	28	8313	7813	1563
Pürkhauer, einteilig	20	4241	3741	748
Pürkhauer, dreiteilig	22, 27, 31	7680	7180	1436
Stechzylinder, "System Weihenstephan" (Handentnahme)	20	4241	3741	748

* benötigte Untersuchungsmenge: ca. 500 cm^3 (100 %)

Tab. 1: Theoretische Bodenvolumina bei unterschiedlicher Probenahme für die N_{min}-Untersuchung.

Die Überschußmenge an Boden beträgt systembedingt bei maschineller Entnahme mit dem "System Weihenstephan" (sehr gute Probenqualität) 7813 cm^3 (1563 %) und liegt damit im Maximum verglichen mit einfacheren Handentnahmesystemen. Ein Entwicklungsschwerpunkt für das Jahr 1992 soll daher die Probenteilung in Ergänzung zur Probenaufbereitung sein.

4.2 Schnellbestimmung von N

Neue quantitative Schnellbstimmungsverfahren wie z.B. reflektometrisch (ähnlich der Photometrie, jedoch nicht in wässriger Lösung, so daß eine Probenzentrifugation unterbleiben kann können zukünftig eine Analyse von Bodenproben direkt vor Ort ermöglichen (Abb. 3). Allerdings bedürfen derartige Verfahren noch eines Methodenvergleichs. Bei der Konzeption eines Bodenbeprobungssystems müssen die Anforderungen an die Probenaufbereitung, Verpackung, Kennzeichnung und Identifizierung für mögliche Schnellbestimmungsverfahren auf jeden Fall berücksichtigt werden.

5. SCHLUßFOLGERUNG

Das gesamte Verfahren der Bodenbeprobung und -untersuchung, wie in Abb. 3 dargestellt, soll sowohl einzelbetrieblich als auch überbetrieblich (z.B. Maschinenring, Lohnunternehmer) einsetzbar sein. Die Ermittlung von Verfahrenskennwerten wie Kapitalbedarf, Arbeitszeitbedarf usw. sowie eine Kosten-Nutzen-Rechnung muß Gegenstand weiterer Untersuchungen nach Abschluß der Verfahrensentwicklung sein.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

VERGLEICH UNTERSCHIEDLICHER MÄHAUFBEREITER

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A high quality of wilted gras silage guarantees a high food intake and a high milk yield based on cheap fodder. For that reason mower conditioners are used to shorten the necessary field drying period. Two systems - rollers and rotors - were compared with regard to wilting rate. The results were a more efficient conditioning of the plants by the rollers and a looser swath formed by the rotor conditioner. Therefore further developments of mower conditioners are necessary to combine both components - opening the surface of plants and laying a loose swath in a better way.

mower-conditioners (rollers, rotors); drying rate; effect of conditioning; comparison of the two systems

1. EINLEITUNG

Ökonomische und zukünftig in steigendem Maße auch ökologische Gründe zwingen in der Milchviehhaltung zu hohen Leistungen aus dem wirtschaftseigenen Grundfutter. Die Voraussetzung dafür besteht in der Gewährleistung einer gleichmäßigen und hohen Grundfutterqualität. Für die Konservierung von Grüngut ist in diesem Zusammenhang nach wie vor eine mehr oder weniger lange Trocknungsperiode auf dem Feld unerläßlich. Diese Feldphase stellt aber zugleich den risikoreichsten Teil der Halmfuttergewinnung dar. Der generelle Trend zur Anwelksilagebereitung verringert das Problem witterungsbedingter Verluste im Vergleich zur Heubereitung bereits deutlich. Darüber hinaus werden immer wieder die unterschiedlichsten technischen Möglichkeiten zur Aufbereitung von Grüngut im Zusammenhang mit der Futterkonservierung diskutiert, die nachfolgend dargestellt und eingeordnet werden sollen.

2. TECHNIKEN FÜR DIE AUFBEREITUNG VON GRÜNGUT

Für die Aufbereitung von Grüngut werden zur Zeit unterschiedliche technische Lösungen angeboten, die in der Abb. 1 in einem systematischen Überblick dargestellt sind.

2.1 Intensivaufbereitung von Grüngut

Grundsätzlich muß in eine Intensivaufbereitung und eine Aufbereitung unterschieden werden. Das technische Kriterium für die gegenseitige Abgrenzung besteht in der Gutzuführung zu den Aufbereitungswerkzeugen. Intensivaufbereiter benötigen einen gleichmäßigen und möglichst dünnen Gutstrom, der nur über eine Zwangszuführung hergestellt werden kann. Die starke Zerkleinerung des Pflanzenmaterials bei der Intensivaufbereitung macht eine Verpressung des Grüngutes zu einer Matte in der Regel unumgänglich. Die verwendeten Techniken sind entsprechend aufwendig.

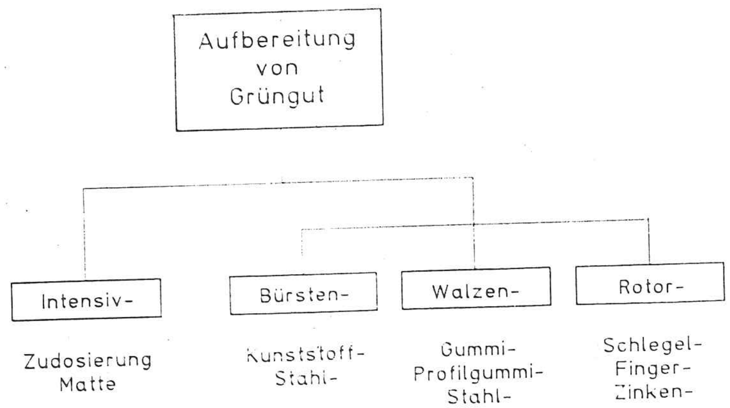

Abb. 1: Techniken für die Aufbereitung von Grüngut.

Aufgrund vieler bislang ungelöster Schwierigkeiten bei der Intensivaufbereitung von Grüngut soll an dieser Stelle auf eine Vertiefung verzichtet werden. Die Probleme mit dieser Technik lassen sich wie folgt zusammenfassen:

- aufwendige Technik,
- Gefahr der Bröckelverluste und der Futterverschmutzung (GRUBE 1988 /4/),
- Mattenformung mit Wiesengras nicht möglich,
- hohe Trocknungsbeschleunigung nur unter Laborbedingungen,
- intensive Feldbefahrung bei der Ernte (BOSMA 1991 /2/),
- spezielle Mechanisierung für Matten-handling nötig und
- Einregnen kann zum Totalverlust der Ernte führen.

2.2 Grüngutaufbereiter

Alle übrigen Aufbereiter für Grüngut haben in erster Linie in Verbindung mit einem Mähwerk als Mähaufbereiter Verbreitung gefunden. Dabei spielen im süddeutschen Raum Mähaufbereiter mit Finger- bzw. Doppelmessermähwerken und Bürstenaufbereiter keine Rolle.

Die Zusammenführung des Mähgutes auf ein unterschiedlich starkes "Polster" bei Trommel- und Scheibenmähwerken bedingt eine entsprechende Zuordnung der Aufbereitungstechniken (Abb. 2).

Während Mähtrommeln das Grüngut sehr kompakt zusammenführen, belassen Scheibenmähwerke eher eine Gutverteilung über die gesamte Mähbreite, was die Voraussetzung für eine Kombination mit Walzenaufbereitern darstellt.

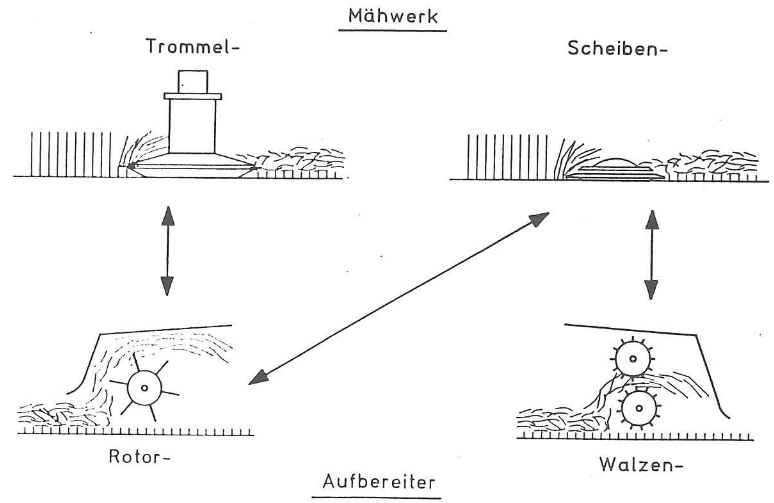

Abb. 2: Kombinationen von Mähwerken und Aufbereitern zu Mähaufbereitern nach einer Angebotsanalyse aus dem Jahr 1990.

3. Ergebnisse zur Trocknungsbeschleunigung durch die Aufbereitung von Grüngut

Die Aufbereitung von Grüngut verfolgt in erster Linie das Ziel, den Trocknungsverlauf auf dem Feld zu beschleunigen, das Wetterrisiko bei der Halmfuttergewinnung zu vermindern und die Anzahl an nötigen Arbeitsgängen zu reduzieren.

Die Wirkung von Aufbereitern auf die Wasserabgabe muß in zwei Komponenten differenziert werden:

1. Die Aufbereitung der Pflanzenoberfläche (Cuticula), um einen raschen Wasseraustritt zu ermöglichen und

2. die Ablage des aufbereiteten Pflanzenmaterials auf dem Feld, um den natürlichen Trocknungsbedingungen eine gute Angriffsmöglichkeit zu bieten.

Um eine Bewertung der verschiedenen Aufbereitungstechniken in dieser Hinsicht vornehmen zu können, wurden an der Bayer. Landesanstalt für Landtechnik mehrere Vergleichsuntersuchungen durchgeführt.

3.1 Aufbereitung der Pflanzenoberfläche

Bei einem Vergleich unterschiedlich aufbereiteter Grüngutproben, die in gleichen Mengen (2 kg Frischmasse je m²) locker und breitgestreut auf Metallgittern aufgelegt und auf dem Feld getrocknet wurden, zeigten sich deutliche Unterschiede im Bezug auf den Trocknungsverlauf (Abb. 3).

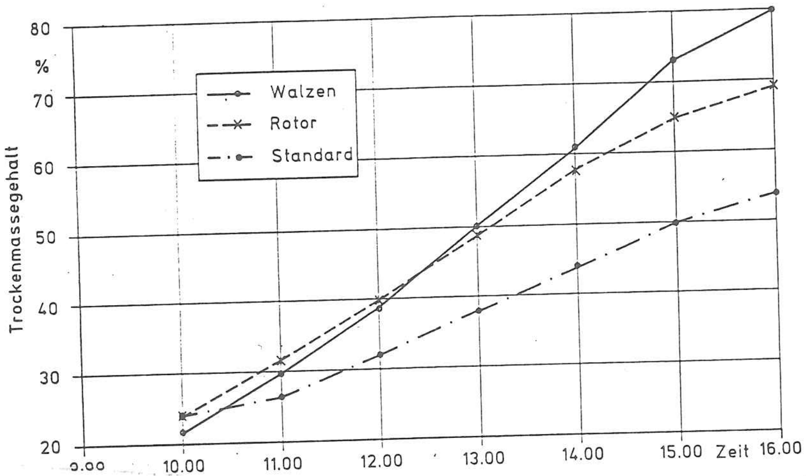

Abb. 3: Trocknungsverlauf von Grüngut beim Einsatz unterschiedlicher Aufbereitungswerkzeuge (12.07.90, 2. Aufwuchs, "Gitter-Methode", 2 kg FM/m²).

Nach dem Mähen, das gegen 9.00 Uhr beendet war, verlief die Abtrocknung aller Proben zunächst annähernd parallel bis ca. 11.00 Uhr. Um 13.00 Uhr hatte das aufbereitete Grüngut bereits einen Trocknungsvorsprung von ca. 2 h. Während sich beim unaufbereiteten Standard-Material bis 16.00 Uhr der Trockenmassegehalt nur noch auf 53,8 % steigerte, erreichten die rotoraufbereiteten Proben 68,7 % Trokkenmasse (TM) und das von speziell profilierten Gummiwalzen intensiv geknickte Material sogar 79,9 % TM.

3.2 Feldablage

Parallel zu den Bestimmungen des Trocknungsverlaufes von Grüngut mit der "Gitter-Methode" wurden am gleichen Tag Proben aus den Mähschwaden der einzelnen Mähaufbereiter entnommen, um den Effekt der Feldablage im Schwad zu ermitteln (Abb. 4).

Der Flächenbelag beim Feldversuch entsprach mit durchschnittlich 1,97 kg FM/m² demjenigen auf den Trocknungsgittern ("Gitter-Methode"). Standard-, walzen- und rotoraufbereitetes Grüngut trocknete in den Mähschwaden bis zur Probenahme um 14.00 Uhr gleich stark ab und erreichte 39,0-40,4 % TM. Am Ende des Versuchstages (16.00 Uhr) lagen die durchschnittlichen TM-Gehalte in den unveränderten Schwaden bei allen Varianten deutlich niedriger als auf den Gittern. So erreichte das Standard-Material bis 16.00 Uhr lediglich 40,4 % TM, das walzenaufbereitete 48,3 % TM und das rotoraufbereitete 53,3 % TM. Der starke Unterschied im TM-

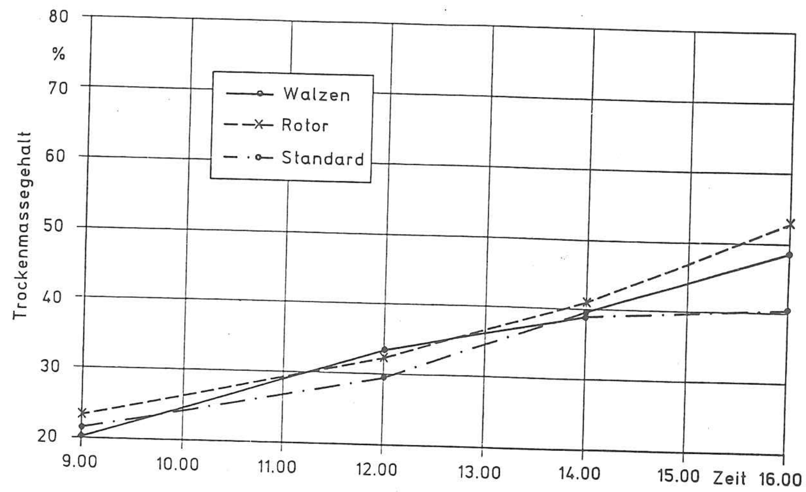

Abb. 4: Trocknungsverlauf von Grüngut beim Einsatz unterschiedlicher Aufbereitungswerkzeuge (12.07.90, 2. Aufwuchs, Schwadablage, keine weitere Bearbeitung, 1,97 kg FM/m²).

Gehalt um 16.00 Uhr beim Walzenaufbereiter (48,3 % TM im Schwad gegenüber 79,9 % TM auf dem Gitter) läßt auf eine sehr kompakte Schwadformung schließen, die eine Abtrocknung ungünstig beeinflußt. Durch das intensive Knicken der Pflanzen geht die für einen lockeren Schwadaufbau nötige Eigenstabilität verloren und das Pflanzenmaterial verdichtet sich zunehmend.

Dieser mögliche ungünstige Werkzeugeffekt der Walzen bei der Grüngutaufbereitung tritt allerdings lediglich bei der Trocknung im Schwad auf. Die lockere Breitablage, wie sie bei der Trocknung von Grüngut auf den Metallgittern simuliert wurde, erweist sich für eine gute Ausnutzung der Aufbereitungswirkung im Bezug auf die Wasserabgabe als unerläßlich. DONE et al. 1989 /3/ sowie LAMOND et al. 1988 /10/ kommen in ihren Versuchen ebenfalls zu dem Schluß, daß ab einer Arbeitsbreite des Mähwerkes von 2,0 m kaum noch eine Wirkung der Aufbereitung von Grüngut auf den Trocknungsverlauf im Schwad festzustellen ist.

Das Ziel weiterer Entwicklungsarbeiten wird es daher sein, eine effektive Aufbereitung der Pflanzenoberfläche mit einer lockeren Breitablage des Grüngutes in einem Arbeitsgang zu realisieren.

4. Zusammenfassung der Ergebisse zur Aufbereitung von Grüngut

Die Aufbereitung von Grüngut hat grundsätzlich sowohl positive als auch negative Auswirkungen. Auf der Basis eigener jahrelanger Erfahrungen und Untersuchungen zu diesem Themenbereich und nach Auswertung der umfangreichen Literatur soll abschließend eine Bewertung der unterschiedlichen Aufbereitungstechniken und eine Einordnung vorgenommen werden.

Für die Aufbereitung von Grüngut kommen derzeit hauptsächlich zwei verschiedene Systeme in Frage, nämlich Walzen- und Rotoraufbereiter. Für einen Mähaufbereiter bieten Scheibenmähwerke die besseren Voraussetzungen für eine gleichmäßige und effektive Grüngutaufbereitung. Diese werden sowohl in Kombination mit Rotor- als auch mit Walzenaufbereitern angeboten. Der Mehrpreis für einen Aufbereiter bewegt sich zwischen 3000,- bis 4500,- DM gegenüber einem einfachen Mähwerk. Walzenaufbereiter kosten etwa 1000,- DM mehr als vergleichbare Rotoraufbereiter.

Im Bezug auf den Trocknungsverlauf bereiten Walzen die Pflanzenoberfläche (Cuticula) besser auf als Rotoren. Allerdings kann sich dieser Effekt erst dann zeigen, wenn die natürlichen Trocknungsfaktoren optimal angreifen können, wozu eine lockere Breitablage und häufiges Wenden gehören. Bis zu einem TM-Gehalt von 40 % (Anwelksilage) treten keine Unterschiede zwischen Walzen- und Rotoraufbereiter hinsichtlich der Trocknungsbeschleunigung auf (Höhn 1987 /6/, Hadders 1983 /5/). Unter guten Trocknungsbedingungen ist durch eine Aufbereitung mit einem Trocknungsvorsprung bis zur Anwelksilagebereitung von 1,5 bis 2 h zu rechnen.

Die zusätzlichen Bröckelverluste durch eine Aufbereitung von Grüngut bei der Silagebereitung bewegen sich in der Größenordnung von 5-10 % TM. Tendenziell verursachen Rotoraufbereiter dabei höhere Verluste als Walzenaufbereiter (Jeppsson 1981 /7/, Koegel et al. 1985 /9/, Hadders 1983 /5/). Die richtige Einstellung der Aufbereitungsintensität stellt dabei bis heute ein ungelöstes Problem dar.

Die Gärfutterqualität wird durch den Einsatz von Mähaufbereitern nicht beeinflußt. Der Schmutzeintrag erfolgt durch die Mähwerke, die Aufbereiter mischen lediglich mehr oder weniger intensiv ein (Ahmels et al. 1988 /1/). Der Einfluß der veränderten Pflanzenstruktur auf die Futteraufnahme kann jedoch nur in aufwendigen Fütterungsversuchen überprüft werden.

Der zusätzliche Leistungsbedarf für die Aufbereitung beträgt ca. 10-15 kW bei einer Arbeitsbreite des Mähwerkes von 1,8 m. Das Leistungsangebot der üblichen Grünlandschlepper (60 kW) reicht maximal für eine Arbeitsbreite von 3,5 m (Klinner et al. 1980 /8/). Damit kann eine Flächenleistung von ca. 3,5 ha/h erzielt werden.

Die Anschaffung eines Aufbereiters wird ökonomisch sinnvoll ab einer Erntefläche von 10 ha, die einem erhöhten Wetterrisiko ausgesetzt ist. Für einen zukünftigen Familienbetrieb mit einem Kuhbestand von 40-60 Tieren und einer Futterfläche von 20-40 ha steht der Aufbereiter zur Qualitätssicherung des Grundfutters im süddeutschen Raum damit außer Frage.

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TRENDS IN AGRICULTURAL ENGINEERING
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VISCOELASTIC PROPERTIES OF BERRY FRUITS

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Viscoelastic flow of gooseberries, red and black currants was studied by loading whole fruit. Deformation as the function of time was analysed within the Hertz and Burgers models. The parameters of Burgers model, i.e. mean values of elastic and retarded Young modules and relaxation time are determined.

mechanical properties of berries ; viscoelastic flow ; deformation

1. INTRODUCTION

Mechanical and viscoelastic behaviour of fruits is important for an estimation of their resistivity against a damage during their storing or transport. Biological material of which fruits are composed behaves as a viscoelastic body /1/ . Therefore rheological measurements giving viscoelastic characteristics are necessary. In recent years viscoelastic investigations were done on different fruits and vegetables like apples, cherries or potatoes /1/ .

In this paper the viscoelastic characteristics of gooseberries, red and black currants will be presented. Fruits were submitted to load and its deformation was measured as the function of time. The obtained data were analysed on the basis of the three parameters Burgers model of a viscoelastic body /2/ as outlined in the following section.

2. METHOD AND RESULTS OF VISCOELASTIC CREEP MEASUREMENT

Viscoelastic measurements of berries were done in the apparatus already used for the creep deformation of apples /3/ cherries /4/ or potatoes /5/ . Similarly as in the case of cherries the whole fruit was introduced into the apparatus because it is nearly impossible to obtain well defined samples of those fruits. Also a part of stem was left with a fruit to assure the skin of fruit was intact (Fig.1). Before measurement the diameter 2R of a fruit was determined by a micrometer and then the piston of apparatus was displaced to touch the fruit surface without deforming it. Then the piston was loaded by a chosen constant load. The deformation (i.e. the displacement of the loaded piston divided by 2R) as a function of the time was registered by numerical micrometers. About

20 fruits of each sort freshly gathered was deformed in the time scale 5 - 7200 s. Measured dry matter of those fruits was found in the range 12.3 - 19.6 %.

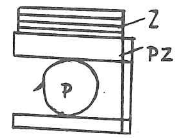

Fig. 1: Berry fruit under the deformation load (schematically)
P - berry fruit
PZ - piston
Z - load

The measured dependence of deformation $\varepsilon(t)$ as the function of time was analysed by the three parameters Burgers model of a viscoelastic body modified to the case of a sample with spherical shape. Our modification of Burgers model is shown in Appendix. The least squares fit of the theoretical dependence $\varepsilon(t)$ given by the equation (A7) to measured values gives the parameters E_o , E_r and T_r. Parameter E_o is the elastic deformation of fruit at the beginning of measurement. E_r and T_r are retarded Young modulus and relaxation time of a viscoelastic body, respectively. Using the Hertz model of an elastic deformation of a spherical body the Young modulus E_o which characterizes the elastic deformation of a fruit when creep started can be determided from the equation (A4). Relaxation time T_r is connected with the fruit viscosity η as $T_r = \eta/E_r$. The mean value of parameters E_o , E_r , T_r and η is shown in the Table 1.

Very important condition in measurements is the proper choice of load especially in the case of relatively fragile fruits like berries generally are. If during a measurement we obtain $\varepsilon(t) \sim \varepsilon_o$ = const., therefore the load deformates a fruit in elastic range only. In our measurements we have analysed only such data where $\varepsilon_\infty > \varepsilon_o$. Upper limit of the load value is determined by the condition $\varepsilon'(t) \sim 0$ for $t > T_r$ when $\varepsilon(t) \sim \varepsilon_\infty$. Such a measurement can be analysed by the three parameters Burgers model in our approximation. If the load overcomes the fruit strength, $\varepsilon(t)$ increases up to therupture of fruit skin and fruit is smashed. In the case of red and black currants the applied total load had the mass in the range 0.045-0.055 kg. The load applied on gooseberries had the mass in the range 1.045-1.545 kg.

The comparison of values E_o of red and black currants with E_o of gooseberries shows immediatelly that gooseberries are more rigid than currants. The elastic Young modulus of gooseberries is comparable with that one of cherries /4/ . On the other hand, the parameter E_o of currants is of the order of elastic Young modulus of sour cherries /4/ . In our measurements we have found that the ratio $(100\,\varepsilon_o/\varepsilon_\infty)$ was generally situated at the range 60 -75 %. This finding permits the use of our approximation (A6). It also explaines why in our measurements E_r is generally greater than E_o. The comparison of expressions (A4) and (A8) gives

$$E_r/E_o \sim 0.6\ (2 - \varepsilon_\infty/\varepsilon_o)\ /\ (\sqrt{\varepsilon_o}\left[(\varepsilon_\infty/\varepsilon_o) - 1\right]),$$

what situates the ratio E_r/E_o to the range $0.3/\sqrt{\varepsilon_o} - 1.2/\sqrt{\varepsilon_o}$.

As $\varepsilon_o = h/R$ is always much smaller then 1 it could be $E_r / E_o > 1$.

The differences in viscosities of currants and gooseberries express the different structure of pulp of these types of fruit. Nevertheless, the load which we have used is still lower then the load leading to the fruit destruction because it was chosen in a way to create the fruit viscoelastic deformation only.

3. CONCLUSION

In this paper the viscoelastic deformation of gooseberries and red and black currants was studied. The interpretation of our results was done on the base of modified Burgers model. Modifications of the model take in account the change of the surface on which the applied force acts. The measured creep dependence of the deformation $\mathcal{E}(t)$ as the function of time was used to determine E_o and the parameters of Burgers model like retarded Young modulus E_r and relaxation time T_r. The effective elastic Young modulus E_o was determined using the Hertz model from the elastic deformation E_o at the beginning of measurement because whole fruits were deformed.

APPENDIX : THE BURGERS MODEL ADAPTED TO THE VISCOELASTIC BODY OF THE SPHERICAL SHAPE

The three parameters Burgers model (Fig.2) describes a viscoelastic body characterized by parameters E_o, E_r and η.

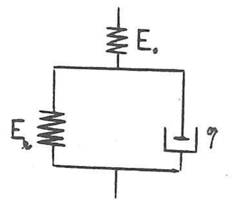

Fig.2: Schematic drawing of the rheological three parameters Burgers model
E_o - Young modulus characterizing the body deformation at the beginning of a measurement
E_r - retarded Young modulus
η - body viscosity

The parameter E_o is the Young modulus of the elastic deformation of a body at the beginning of a measurement, i.e. at the time t = 0. For t > 0 and for a constant load the deformation of a body continues as the consequence of a simultaneous compresion of a body described by the retarded Young modulus E_r and the viscous flow with the viscosity η. Stationary viscoelastic deformation E(t) within the three parameters Burgers model is therefore described by the relation /2/ .

$$\mathcal{E}(t) = (\sigma_o/E_o) + (\sigma_o/E_r)\left[1 - \exp(-t/T_r)\right] \qquad (A1)$$

with $T_r = \eta/E_r$. The relation (A1) is valid for a constant cross section of the sample S when $\sigma_o = F/S$ with F a constant force applied on the sample. However, for a sample of a spherical shape the cross section changes with time t in the same way as the function of displacement u(t) :

$$S(t) = \pi R^2 - (R - h - u)^2 \sim 2\pi R\,(h + u)$$

because it should be always $u < R$; R is the radius of a spherical sample and h is the displacement at t = 0 .

The deformation $\mathcal{E}(t)$ is defined as

$$\mathcal{E}(t) = (h + u(t))/R = \mathcal{E}_o + e(t)$$

and therefore

$$S(t) \sim 2\pi R^2\,\mathcal{E}(t) \qquad (A2)$$

The relation (A1) is the stationary solution of a phenomenological equation describing Burgers model /2/

$$\sigma(t) = E_r\,e(t) + \eta\,e'(t) \quad , \quad e' = de/dt \qquad (A3)$$

because for the stationary solution it is $\sigma' = 0$.
In (A3) the deformation e(t) is the time dependent part of total deformation. When $\sigma(t) = F / S(t)$ where F is again constant the equation (A3) will be now solved with the relation (A2) and the initial condition $\mathcal{E}_o = \mathcal{E}(t=0)$. Supposing that the most of the elastic deformation was done at the beginning of the measurement the initial deformation E_o can be connected with the parameter E_o using the Hertz model of deformable spherical body. The effective Young modulus E_o (up to the factor $1/(1-\nu^2)$ where ν is the Poisson constant) is related in the Hertz model with an applied force F, initial displacement u_o of a body and its radius R through the formula /6/

$$\frac{3\,F}{8\,h\sqrt{(2Rh)}} = E_o \qquad (A4)$$

The initial deformation $_o$ is $\mathcal{E}_o = 2h/2R = h/R$. Denoting the effective stress $\sigma_{ef} = F / \pi R^2$ related to the initial body radius we have

$$E_o = 3\pi\,\sigma_{ef} / (8\sqrt{2}\,\mathcal{E}_o\sqrt{\mathcal{E}_o}\,). \qquad (A5)$$

By using σ_{ef} it is $\sigma(t) = \sigma_{ef} / 2\mathcal{E}(t)$. Experimental measurements show that $e(t) < \mathcal{E}_o < \mathcal{E}_\infty$. Therefore e(t) can be assumed as a small value with respect to $\mathcal{E}_o$ and we have approximately

$$\sigma(t) = \sigma_{ef} / 2\mathcal{E}(t) \sim (\sigma_{ef} / 2\mathcal{E}_o) - \sigma_{ef}\,e(t)/(2\mathcal{E}_o^2) \qquad (A6)$$

In this approximation the equation (A3) can be solved with the condition $\mathcal{E}(t=0) = \mathcal{E}_o$ in form

$$\mathcal{E}(t) - \mathcal{E}_o = (\sigma_{ef} / 2E_r\,\mathcal{E}_o\,Q)\,(1 - \exp(-tQ/T_r)) \qquad (A7)$$

with $Q = 1 + (\sigma_{ef} / 2E_r\,\mathcal{E}_o^2)$

It is seen from (A7) that for $t \to \infty$ we have $\mathcal{E}(t) \to \mathcal{E}_\infty$ and

$$E_r = \sigma_{ef}\,(2 - (\mathcal{E}_\infty / \mathcal{E}_o)) / 2\,\mathcal{E}_o\,(\mathcal{E}_\infty - \mathcal{E}_o) \qquad (A8)$$

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Table 1. Mean values of Burgers model parameters determined by the creep of whole fruits of currants and gooseberries (Coefficient of variation corresponding to the parameters values is situated in the range 4 - 9 %).

variety	E_o	E_r	T_r	η	dry matter
currants:	MPa	MPa	s	MPa.s	%
Tatran	0.483	0.499	297.70	143.87	15.60
Jonkheer van Tets	0.255	0.416	248.56	103.54	15.14
Heineman. pozdní	0.728	1.247	428.35	534.32	19.38
Alfa	0.271	0.642	536.22	344.21	13.00
Primus	0.259	0.348	450.01	156.65	15.76
Red Lake	0.576	0.815	265.33	216.27	14.51
Slovakia	0.861	1.473	567.40	835.75	15.08
Bohemia	0.422	0.554	224.71	124.29	16.08
Hatton Black	0.331	0.982	672.23	659.86	16.63
Amos Black	0.378	0.646	313.08	202.14	19.62
Otelo	0.215	0.342	572.20	196.01	17.86
Eva	0.281	0.433	823.11	356.69	19.23
gooseberries:					
Britania	1.558	2.746	693.66	1905.22	12.36
Red Orleans	1.792	2.678	426.60	1142.89	15.85
Whinhans	1.749	3.466	324.37	1124.47	15.56
Primrose	1.585	2.412	514.21	1240.19	14.88
Welcome	1.186	1.654	698.14	1155.13	15.73

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

Study of the evolution of chemical and mechanical properties of Perennial Ryegrass for Different Harvesting Methods

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Keywords

conditioning, chemical crop properties, mechanical crop properties, silage quality

Summary

For a good feeding and conservation quality of silage the chemical and mechanical crop properties of the grass are important. The evolution of these parameters was studied during field wilting for conditioned and unconditioned material. Initial crop pH was found to increase with increasing dry matter content during field wilting. Next to it the pH was 1 % higher for the conditioned crop in 1990 ; but in 1991 the pH for the conditioned crop was 0.08 % lower. The buffering capacity decreased with an increasing dry matter content and there were no differences found for the different harvesting methods. The sugar content was for both years 3 % to 8.4 % higher in the unconditioned crop. The protein content in the conditioned crop was found to be 13 % higher in 1990 and was in 1991 10.8 % higher for the unconditioned crop. For the fiber content, the hemicellulose content was 8.5 % higher for the conditioned crop. For the mechanical properties a linear relation was found between the porosity and the fiber content indicating that a higher fiber content resulted in a less consolidated crop.

Study of the evolution of chemical and mechanical properties of Perennial Ryegrass for different Harvesting Methods

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1. Introduction

Chemical and physical properties of the crops for ensiling are important parameters that affect the succes of the silage making. The most important chemical characteristics are : the pH, the buffering capacity, the water soluble carbohydrates (WSC), the proteins and the fiber content /1/. The physiological (dry matter) and mechanical properties are important because they influence the compression behaviour of the material and also the consolidation which is needed to evacuate the air and to obtain a dense silage /2/ /3/ /4/.
All these properties are influenced by the harvesting method (conditioning or not) and by the conditions of the field wilting.

This work aims at establishing the influence of conditioning and of field wilting on the evolution of the chemical parameters (sugar, protein, fiber, pH and buffering capacity), the resulting physiological parameters (dry matter) and the resulting mechanical properties (porosity or density).

2. Methods and materials

1. Wilting experiment

During a three day field wilting period (first cut of Perennial Ryegrass in May 1990 and in May 1991) samples of conditioned and unconditioned grass were taken three times a day. All chemical analyses were performed as described below.
The climatic data were registrated on a weather station situated at the field site.

2. Chemical analyses

The dry matter content was determined by the classic oven method (76 hr, 65°C). The pH and the buffering capacity were measured in water extracts. On water extracts the water soluble sugar content was determined by an enzymatic method (Boehringer /5/): the glucose , the fructose and the sucrose directly ; the fructans (levans) were determined after acid hydrolysis.
The protein content was analysed by the Lowry method after comparing this method with the classical Kjeldahl procedure.
The fiber content was analysed according to a Van Soest procedure so that the different fiber fractions could be calculated (the NDF-, the ADF- and the ADL-fraction).

3. Mechanical analyses

The mechanical properties were determined in uniaxial cyclic compression experiments up to a maximum pressure of 120 kPa in a cilindrical chamber and the porosity was calculated after 5 and 10 compression cycles /6/ .

3. Results

1. Compression behaviour

A linear relation was found between the measured porosity and the fiber content. For the unconditioned crop the porosity after 5 compression cycles was most affected by the acid detergent lignin ; for the conditioned crop by the hemicellulose content. More fibrous (mature) materials could be compressed less dense and had a higher final porosity /6/.

2. The initial pH and the buffering capacity

In the 1990 experiments the pH for the conditioned crop was 1 % higher ; in 1991 the differences in pH between the conditioned and unconditioned crop were smaller but the pH was 0.08 % higher for the unconditioned crop.
A rise of the pH with an increasing dry matter content is shown in Figure 1. The remaining variation was caused by the difference in the crop maturity.

The regression analysis between the dry matter and the pH for the samples of 1991 gave the following results. For the conditioned crop :

$$pH = 5.942 + 0.1508\, dm + 1.1849\, (dm)^2 \quad \text{with } R^2 = 0.38 \qquad (1)$$

For the unconditioned crop :

$$pH = 5.159 + 4.6905\, dm - 5.5569\, (dm)^2 \quad \text{with } R^2 = 0.50 \qquad (2)$$

with R^2 = determination coefficient
dm = dry matter content (g dry matter/g fresh weight)

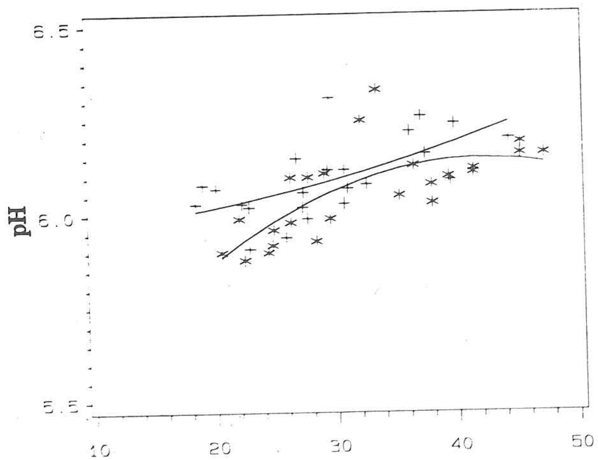

Figure 1 : Relation between the pH and the dry matter content for the conditioned (*) and unconditioned (+) crop

The buffering capacity is a measure of the resistance of the plant juice against a pH change. For a higher resistance a higher amount of lactic acid should be produced to obtain the optimum pH value in the silage. For the different harvesting methods no significant differences in buffering capacity were found. The relation between the dry matter content resulting from a difference in wilting time and the buffering capacity showed a negative relationship : a higher dry matter content resulted in a lower buffering capacity.
This relationship is illustrated in Figure 2.

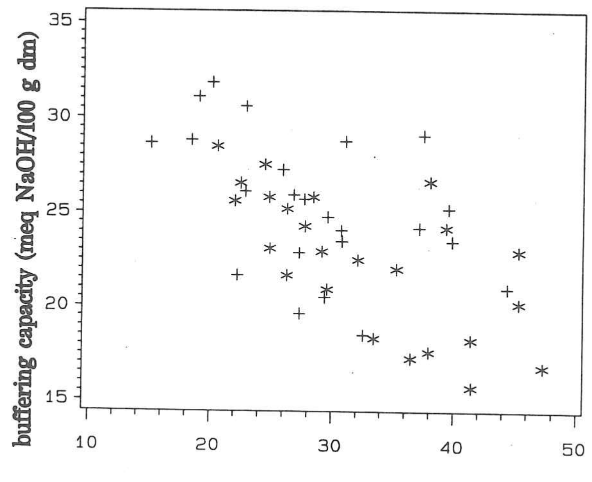

Figure 2 : Relation between the buffering capacity and the dry matter content for the conditioned (*) and unconditioned (+) crop

3. Sugar content

The water soluble sugar (WSC) content is an important characteristic since it is the substrate for the lactic acid bacteria. The amount of WSC is the result of different processes :

- the photosynthesis
- the respiration
- the hydrolysis of hemicellulose.

These processes are influenced by the harvesting method and the wilting time. In the literature the effect of photosynthesis was mentioned as a phenomena of some importance although in our experiments no important influence of this process was observed.
Conditioning resulted in a higher respiratory activity ; the respiration rate was 50 to 75 % higher for the conditioned than for the unconditioned crop.

In Figure 3 and Figure 4 the evolution of the different sugar fractions during the field wilting are shown for a conditioned and an unconditioned crop.

Conditioning resulted in a total WSC-content that was 3 % (1990) and 8.5 % (1991) lower. The monosaccharides were 2 % (1990) and 18 % (1991) and the sucrose 20 % (1990) and 1.5 % (1991) higher for the unconditioned crop while the fructans content was 9 % (1990) and 7.4 % (1991) higher for the conditioned crop.

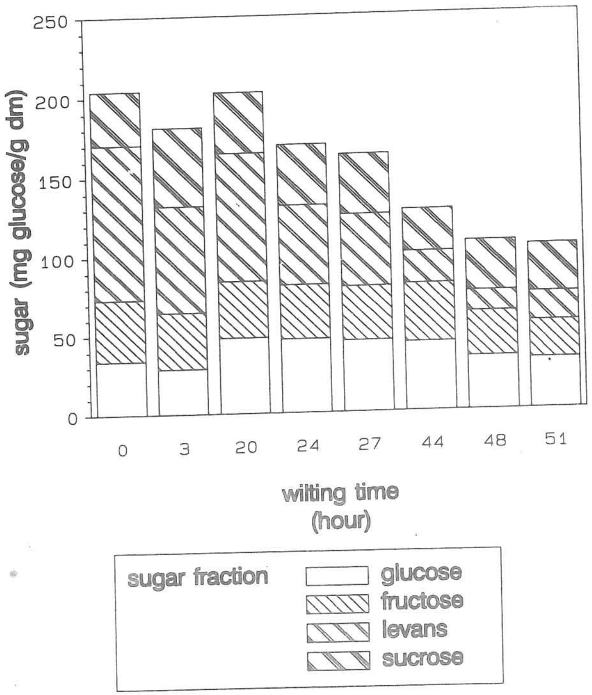

Figure 3 : Evolution of the sugar fractions during field wilting for a conditioned crop

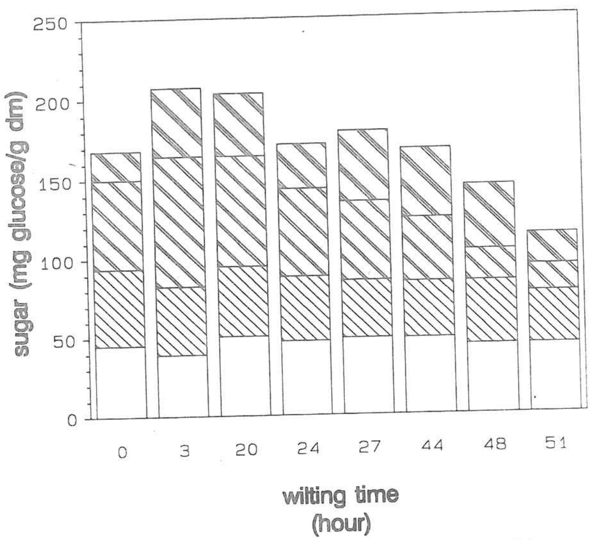

Figure 4 : Evolution of the sugar fractions during field wilting for an unconditioned crop

4. Protein content

In Figure 5 and Figure 6 the evolution of the protein content is shown during field wilting in 1990 and 1991 for the conditioned and unconditioned crop.

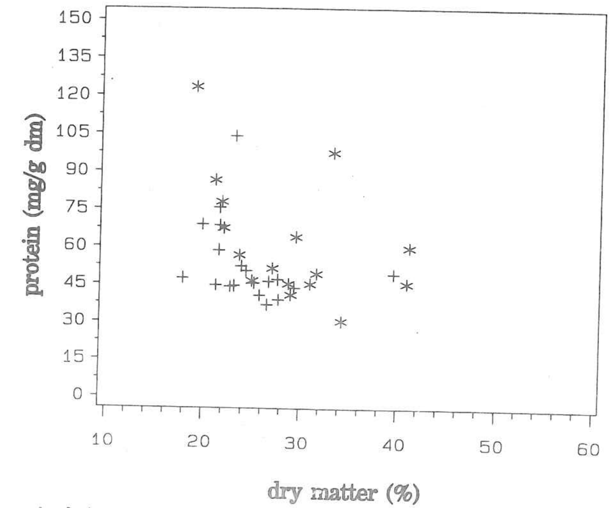

Figure 5 : Evolution of the protein content during field wilting in 1990 for the conditioned (*) and unconditioned (+) crop

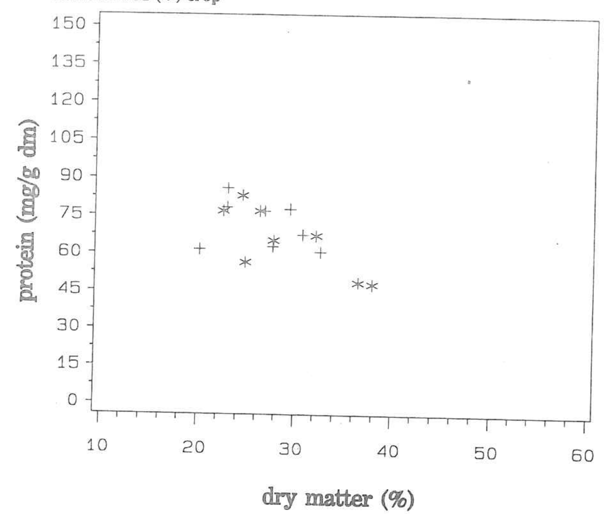

Figure 6 : Evolution of the protein content during field wilting in 1991 for the conditioned (*) and unconditioned (+) crop

A decrease of the protein content with an increasing dry matter content can be seen. Conditioning resulted in a 13 % higher water soluble protein content in 1990. On the other hand in 1991 the protein content was 10.8 % higher for the unconditioned crop.

5. Fiber content

For the hemicellulose content there was a significant influence of the harvesting method in both years : for the conditioned crop the hemicellulose content was 8.5 % higher. Neither the cellulose content nor the lignin content were sigificantly influenced by the harvesting method.
In 1991 the hemicellulose content of both crops was 13.5 % higher than in 1990. This agreed with a generally less mature crop in 1991 ; in 1990 the leaf stem ratio had a mean value of 0.70, while in 1991 this value was 1.19. This indicates that during crop maturation the hemicellulose content decreased in favour of the cellulose and lignin content. In 1990 the cellulose content was 28.78 % higher than in 1991 and the lignin content was even 34.74 % higher than in 1991.

6. Discussion

From the results given here it seems that conditioning influences the chemical crop parameters. Probably due to the interaction with climatical circumstances this influence worked one year in a positive sense and the other year in a negative sense. In 1990 during field wilting 6 mm of rain was registrated during field wilting while there was no rain in 1991.
In adverse climatic circumstances the pH and the protein content were higher for the conditioned crop ; these two parameters in combination with a lower WSC content (resulting in a low sugar/protein ratio) adversely influence the silage conservation quality.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

MAT-4, INNOVATED TESTER OF MASTITIS AND ANOMALOUS MILK

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Mat-4 is a pocket device supplied from a built-in source. It is used together with a special pallet to which milk samples from all teats of an udder is milked.The device Mat-4 analogly evaluates momentary electric conductivity of milked milk samples,it compares their values mutually and towards defined limits as well,and it alarms suspicition of mastitis or other anomalies of a milch cow and milk through LED lights.

relative conductivity;mastitis of the udder;milk anomaly; milk of the quarters;correlation with the milk and milch cow examination

1. INTRODUCTION

Industrialization of cattle-breeding eliminated heavy work in original production and increased productivity of work at the cost of increased expenses and the row of negative influences to a milch cow and milk.High percentage of illnesses and depreciation decreased both quality and quantity of milk.In comparison with developed European states the losses of more than 1000 litres of milk per milch cow yearly with frequent worse quality of milk and high costs force us to search the way of prompt and cheap information directly in original production with the possibility of separation of unfit milk and an "anomalous"milch cow.

The comparison of the results of milk conductivity during milking with the examination of the milch cows and the bacteriological and cytological examination of taked milk in a laboratory speaks to the benefit of the conductivity from the view of diagnosis promptitude,momentary result before milking,simplicity, application directly at a stall or at a milking shed,objectivity with excluding of other influences,but otherwise the possibility of momentary reaction of personnel.

One measuring of each values is always saddled with high inaccuracy with the possibility of accidental error.For these reasons it is necessary to repeat measuring with next milking which is not possible to do with other examinations due to exacting character of takings,sample transport and the claims to the specialist personnel and the laboratory.

Our and foreign measurings of milk conductivity proved during one-shot testing the coincidence only with 62,8% of taked samples before milking starting and with 92,2% during completing milking,i.e.from last sprinklings,which is complicated by unequal moment of ending milking of all quarters of an udder. The coincidence is understood as both positive and negative evaluation in the tests given above,where the coincidence in positive finding can be named as mastitis and the signalization of only some test-"false"mastitis.During repeated measuring and taking during next milking the coincidence was reached with 85 % of samples and during next triple taking it was reached even with 96% of measured milk samples.

The use of conductivity makes possible to observe the samples one after the other three times in a easy way and define the samples three times verified as positive or otherwise as negative with the efficiency of 95%:the evaluation is various with 5% of samples which can be caused by accidental influences of mechanical character,injury,stress and others.

This automatic control can be loaded into the program of regular continuous evaluation of milk and milch cow with tipping the "negative"or"positive"milch cows at the larger or computerized breedings and milking sheds with identification of milch cows and at the places where computera are used /1/.

2. ABSOLUTE AND RELATIVE CONDUCTIVITY

The composition of milk is changed with a milch cow as a subject with physiological,technical and pathological conditions of observed milch cow and with zoohygienic care,i.e.with the given milch cow with human and technical factors.These influences can be registred by the conductivity of reservoir milk because the differences in the conductivity among farms are 20% and more. They correspond to a number of somatic cells and microorganisms in milk /2,3/.The differences in the herd at the given farm will become evident in the differences of the conductivity of milch cow mixed milk,i.e.absolute values of the conductivity of the whole milking volume.

Expressed ability of mixed milk is not sufficiently sensitive for arised anomalies and for explicit indication of the udder inflammation illness sample because the anomalies (not only inflammations)arise in one quarter of an upper and later stages are very good registered palpably and visually as well.Thus the main cause of lower expressed ability of mixed milk conductivity changes is "dilution"of defective milk where the afflicted quarter has mostly reduced milk yield/2/.For these reasons it is necessary to observe milk of the quarters separately from the view of quick intervention which requires fourfold number of measuring.If we have the milking shed or computerized system including computer,the absolute value of the conductivity for planary screening could be the method very well realized but very exacting /3/.In common practice this method is very difficult and on wider canvas it is hardly applicable for large number of samples;therefore it is used only spasmodically.

For these reasons in world literature the conductivity ratio or differencial conductivity,which is based on comparison of the milk conductivity of all four quarters of an udder,is observed. The non-dimensional relative conductivity calculated from quotients

or differences of milk conductivities of individual quarters follows from the terms.Some authors related measured values of milk conductivity of 4 quarters to the blood conductivity,others to the average value of the conductivity of a farm or the conductivity of a reservoir milk sample,alternatively to the conductivity of each milch cow,etc.

We devised 16 relations for evaluation of relative conductivity on the basis of 4 measured milk samples of quarters /4, 5/ and we chose optimum version for construction of

a--portable relative conductometer for evaluation of quarter milk samples directly with a milch cow /6,7,8/

b--optimum program for automatic processing by computer /1/.

3. RELATIVE CONDUCTOMETER

The device MAT-4 is the relative conductometer produced in small series,constructed on the basis of experiences with the indicator of mastitis EVM-4 from 1983 which was verified at the Research Institute of Animal Production at Uhříněves in 1984-89 in the framework of research target /8/.

The operation of the device is based on errorless function of electronic circuits evaluating analogly momentary conductivity values of milk milked to pallet for quarter milk.It evaluates not only differences in milk conductivity of 4 quarters,it compares and evaluates if they are in permited range.It indicates larger differences,i.e.exceeding the permited interval,by the LEDs.

Simultaneously it evaluates minimum and maximum milk conductivity values of 4 quarters,compares them with set values and alarms the values which are lower or higher by the relevant LEDs.

This signalization makes possible to tip the milch cows not only with healthy or anomalous udder where it is possible to cover udder inflammations in beginning and advanced stage as well, irritation or injury of some quarter,impurities in a teat,and a row of others,but simultaneously any metabolic disorders,complaint of digestion,defective feed-stuffs,stress states,rutting cycles, advanced stage of being in calf and a row of physiological,technical and pathological stages as well as otherwise mineral stoppage,etc.

The system of the diods makes possible to differentiate individual situations on the condition that milk of 4 teats will be milked into taking pallet under the same conditions,purity,temperature,etc.

4. SIGNIFICANCE OF PROMPT INFORMATION

In spite of high intensity of cure in the Czech Republik in the last period,there was accrual of positive clinical mastitis, veterinary treatments and from here growing increasingly expences for cure and remedies.During evaluation of amount of veterinary treatments,each milch cow was clinically examined 3,6 times in 1979,even 5,18 times in 1981,and this number of examinations increased even when a number of milch cows fell down.It means that in spite of gradated prevention and therapeutical cure,the increase of a number of milk gland disorders,injuries and disorders of physiological character as well occurs in consequence of a row of technical imperfections and human factor as well /2/.

From 89,530 examined reservoir milk samples it was found out on the basis of the whole number of cellular elements following classification of examined samples by veterinary workmen in the Czech Republic:

to 0.5 million in 1 ml of milk	aprox.49%	of samples
0.5 to 1 million	" 40%	"
1 million and more	" 11%	" .

This outline appears high percentage of the milch cows which was found with some of mastitis possibilities which we found only during either spasmodical examinations carried out maximum 3-4 times per yera or the cases when mastitis is showed in advanced stage as apparent,ascertainable by current milch cow examination.The treatment in showed cases is lengthy and exacting irrespective of consequences which appear in milked milk and thus in processing industry.Simultaneously milk production falls down substantially with growing occurrence of cellular elements in milk,i.e.

0.25 to 0.5 mil.in 1 ml of milk	cut the production by	3.9% ,
0.5 to 0.75 "	"	6.8% ,
0.75 to 1.0 "	"	15.5% ,
1 and more "	"	18.0% .

The standard allows up to 0.5 mil.in 1 ml of milk and overlimit number indicates possibly illness of mastitis and difficulties for a supplier.One clinical inflammation of milk gland falls to 14 recognized ones which lead to increased fatness,untinely utility of individuals,decrease of milk biological value,milk processing and danger for health of calves in the subclinig's period, and in some cases the exposure to danger of tending personnel's health.

These facts demonstrate the significance of prompt indication of inception of any direct or undirect anomaly leading to given negative changes.

The question is 8 million samples daily with 1 mil.milch cows,which is ungovernable number where it is important to choose the algorithm of chosen method and parameter.If according to this standard the sprinklings are made daily with 8 mil.samples then with the exception of the first sprinklings this milk is possible to take into pallets and it is clear within 30 seconds:

a--which teat is anomalous compared with the others with each milch cow

b--if the milk conductivity of all quarters is "over the standard"

c--if the milk conductivity of some quarter is "under the standard".

For minimum delay during milking it is possible to do it during each milking and evaluate the milch cows with positive and negative finding after 3 milkings.With 14 milkings per week this examination is possible to do twice with each milch cow and cover 600 milch cows by one device:i.e.with two examinations with 3 takings with approximately 200 cows at 3 farms.

5. EXPERIENCES AND EVALUATION

The possibility of both planary screening and increased frequency of milch cow checking through the relative conductometer with threefold quarter milk taking into pallets twice per week folows

from above showed.Thus,high correlation with the bacteriological or cytological examination of milk and a milch cow as well can be reached.

There are a row of conductometers and corresponding procedures described in the methodology/9/ at various levels according to the farm equipment.The relative conductometer can be used to advantage for smaller farms and private persons,for less demanding plants with smaller technology and equipment.

We did the repeated checking with 101 milch cows at a farm where 5 milk cows did not milk for disorders or dry standing by. Fourteen milch cows with all 52 quarters with high conductivity and 32 milch cows with 67 "anomalous" quarters were tipped from 384 measured quarter milk samples.

pos.milch cows	14 and	52 q.pos.	0 norm.	4 q.does not milk
"	32 and	67 "	50 norm.	11 "
neg.milch cows	50 and	0 "	199 norm.	1 "
"	5 did not milk for disorders or dry standing.			
	96	119	249	16

total 384

In the course of next week 2 milch cows were taken to a slaughterhouse(was known),6 milk cows were in advanced stage of disorders(was known)and 6 ones was standing by for disorders during the week (was not known).Injured teats was found and inception of mastitis was verified additionally from 32 milch cows with some anomalous quarter.

From the whole number of 96 heads of milk cows 31% of quarters were found with positive findings,64.8% with negative findings, and 4.2% of quarters were not milked.

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PRAGUE 15-18 SEPTEMBER 1992

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COMPARING TWO DIFFERENT METHODS FOR MEASURING THE FIRMNESS OF CHAMPIGNONS

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This contribution informs you of the comparion between two methods for measuring the firmness of champignons. The Shear-press and the Compression test were compared. For this the Instron Test Machine was used. Futher the influence of the geometrical size of the samples upon the measuring values were observed and conclusions were made. The measuring of the fresh champignons and the samples of champignons stored for definite time at the temperature of 8 °C and 18 °C was carrying out.

Champignons; Shear-press test; Compression test; The Measuring of The Firmness

1. INTRODUCTION

Firmness of biological food materials can be defined as the modulus elasticity of the tissue under small deformation forces before the point of tissue failure (bioyield point - YP).

For firmness and toughness measurements of champignons after harvest the Instron Universal Testing Machine control by microcomputer was used. The Instron software was used. The texture profile (force/deformation (F/D)) curves for through analysis, was drawn on display, because Bourne et al. (1978) cautioned that serious errors can arise if data from texture profile curves are extracted by computer without interpretation of the curves by an experience operator.

Two measuring methods were used, shear-press method and compression method,the results were compared and are discussed in this report.

2. MATERIAL AND METHODS

For the comparing of results firmness characteristic of champignons the two methods shear-press test and compression test were used.

2.1. Shear-press test

The texture measurements were made using an Allo-Kramer Shear-Press standard test cell (dimension 67x67x63 mm with ten shear-press elements - blades).

Six champignons were cut by longitudinal cut. Six the half of champignons (each with the weight cca 50.0 g) was placed in the test cell with cut surface vertical.

The resistance offered by the champignons to the down-coming blade of the shear-press was measured in Newtons [N] force (F) and the mechanical energy was calculated to top point (TP) on F/D curve. Division of this figure by the weight of the six of the half champignons gave the shear-press reading per gram initial weight of champignons. This measure was executed three times after harvest and was repeated three times every day at four day storage time at the temperature 8 °C.

The 5 kN measure head was used for this test.

2.2. Compression test

The cylinder sample with diameter (d) from pulp of cap or stem of champignon was weighed and placed between compression elements of Instron. The hight of sample (l), the force and the deformation at bioyield point (F_{YP}, l_{YP}), at top point (F_{TP}, l_{TP}) and at maximum deformation of sample (F_{max}, l_{max}) were measured automaticaly. These point on F/D curve defined and described Abbot /1/. By computer these points were determined by the slope-treshold resp. zero-slope method /5/.

The press stress, the press strain and the press modulus at bioyield poit (σ_{YP}, ϵ_{YP}, M_{YP}) resp. at top point (σ_{TP}, ϵ_{TP}, M_{TP}) were calculated. The mechanical energy necessary for destruction to bioyield point (E_{YP}) resp. to top point (E_{TP}) was defined by integration method automaticaly. The energy was recalculated per gram of material (e_{TP}, e_{YP}).

2.2.1. The Optimalization of Units of Sample

For fresh champignons the influence of different unit of samples was followed (the combination of diameter of sample 17.5 mm; 15.0 mm; 11.0 mm; 8.5 mm and hight of sample 10.5 mm; 7.5 mm; 4.5 mm). The influence different unit of samples on observer values was expressed at unit ratio (r).

$$r = \frac{l}{d} \qquad [mm/mm] \qquad (1)$$

Also two samples from one cap of champignon were made (both samples at vertical direction of cut) and (first sample at vertical direction and second sample at horizontal direction of cut) and results was compared.

Six or ten the samples war made for one file of measure.

Two measure heads - 1 kN (for bigger samples) and 100 N (for smaller samples were used.

The results were compared.

3. RESULTS and DISCUSION

3.1. Shear-press Test

The shear-press curve of force profile is shown in fig.1. On the curve exist two phases of work of force:

1st phase of work of force

is from touch point till break point (BP). At this phase two manners of combination exert work on the champignons in pressure cell
- pressure exert
- flexure exert

2nd phase of work of force

is from break point, where macrostructura of material is broken, till total shear-press destruction of material. At this phase also two manners of combination exert work on the champignons in the shear-press cell, they are different than at 1st phase
- pressure exert
- cut exert

At break point all three manners of combination exert work on the champignons in shear-press cell at one moment.

Therefore, it is not possible to define characteristics of firmness at this point, not even at other point on F/D profile curve.

The dependention of energy to break point on time of storage is shown on tab.2. We can see that changes of firmness characteristics of champignons are very difficult to define, because the progress and values of these changes are very different for caps and stems of champignons.

Therefore, the compression test was used for next experiments.

3.2. Compression Test

The influence of unit of samples on stress and modulus on bioyield and top point exist in extreme ratios (r) of unit of samples only. If is ($0.7<r<1.3$) then the influence of unit of sample of material on firmness characteristics of material was not proved. See fig.3. For next experiments the samples with diameter 11.0 mm were used and hight cca 11.0 mm, because in this case unit ratio r=1.0 and samples of these units are normaly possible to make from caps and stems of champignons. In this case the maximal forces are smaller than 100 N for caps and stems of champignons. Therefore, is possible to use 100 N head. The influence of places on caps where the samples on firmness characteristic of material were cut was not proved.

The measure of firmness was executed three times after harvest of champignons and was repeated three times every day at seven day storage time at temperature 8 °C and 18 °c. The dependention of energy and modulus in bio-yield point of caps and stems is on fig. 4, 5, 6, 7.

4. CONCLUSION

The optimal units of samples for firmness quality measurement of champignons were defined and the method for measuring firmness values of champignons was worked up. The pressure stress, the pressure modulus at bioyield point and the pressure energy to bioyield point were defined as the firmness quality indicators of champignons at time after harvest. These parameters were used for observations of firmness changes during time of storage of champignons.

Is acceptable to carry out these esperiments for other materials and with helping uper suggested firmness quality indicators to define the maximum of storage time of these materials.

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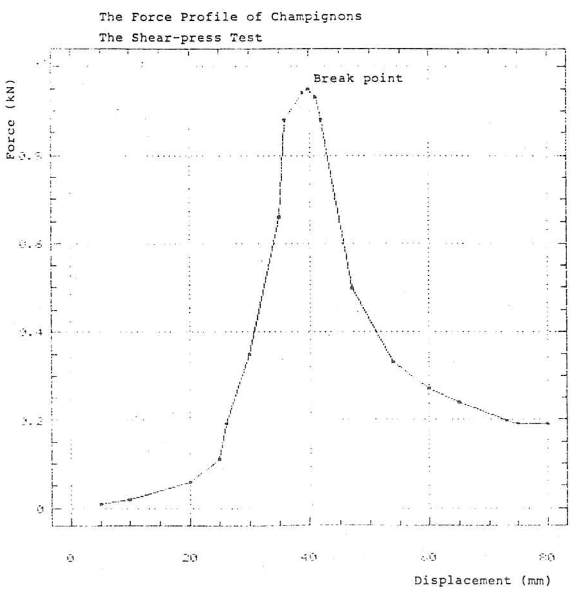


Fig. 1

Table 2 - CHAMPIGNONS Shear-press test

Time (day)	Value							
	Weight [g]		Energy to break point [mJ]		Energy/Weight [mJ/g]		Force at break point [N]	
	AVG	STD	AVG	STD	AVG	STD	AVG	STD
0	305.00	0.86	18962	944	62.17	0.76	882	47
1	303.67	0.65	22591	823	74.39	1.49	1008	40
2	305.79	0.86	23184	900	75.82	0.55	1044	43
3	302.81	0.52	23497	1062	77.59	0.36	1110	43
4	302.67	0.84	22327	1063	73.77	0.69	1066	34

AVG - average
STD - standard deviation

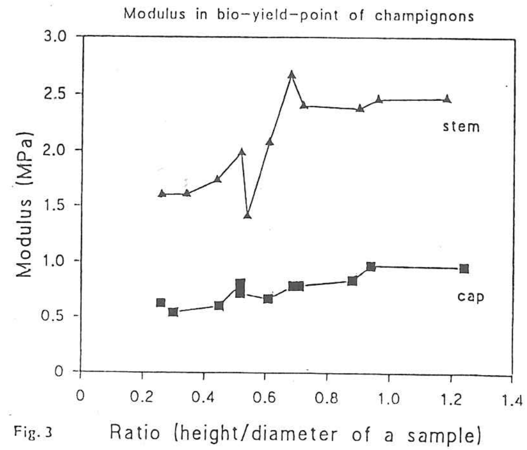


Fig. 3

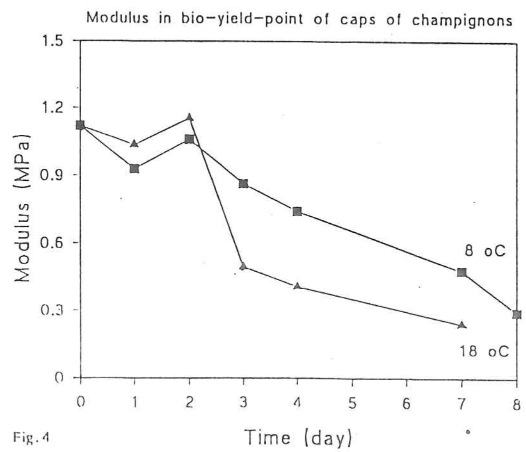
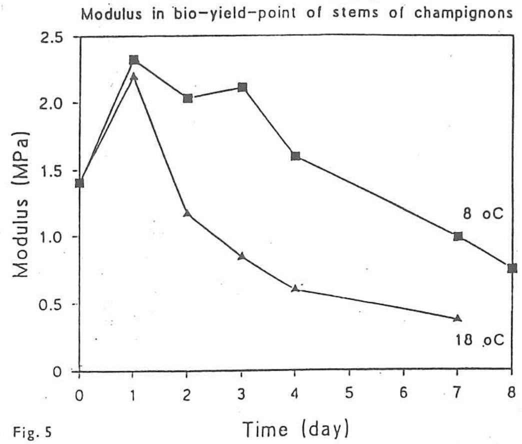


Fig. 4



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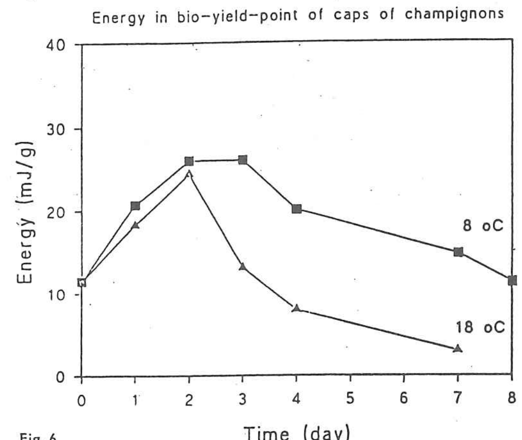

Fig. 6

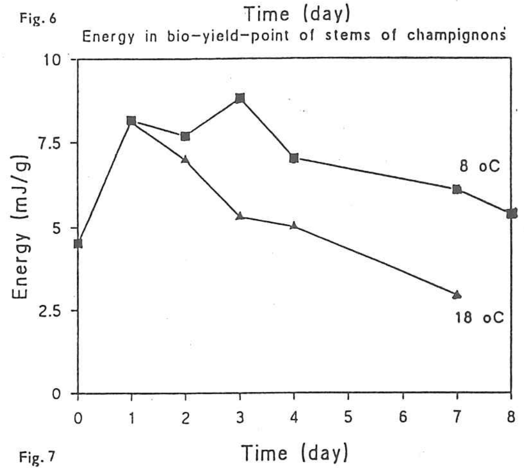

Fig. 7

TRENDS IN AGRICULTURAL ENGINEERING

PRAGUE 15 - 18 SEPTEMBER 1992

ÖKONOMISCHE BEURTEILUNG EINES SOLAREN GEWÄCHSHAUSTROCKNERS FÜR ARZNEIPFLANZEN IM VERGLEICH ZUR KONVENTIONELLEN TROCKNUNG

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The costs of drying are a fundamental burden for the production of medicinal plants. To lower the high energy costs, a solar heated dryer was developed on the base of a plastic film greenhouse. In simultaneous drying tests, the economic feasibility of the solar greenhouse dryer was assessed in comparative analysis of the fixed and variable costs of the novel design versus a conventional oil heated batch dryer. The results showed that the solar dryer needs more than double the size of the conventional dryer to attain the same capacity, therefore causing higher initial cost. Nevertheless the total costs per kg of dried crude drug have been in the same range due to lower variable costs. If the greenhouse dryer is fitted with a back-up heating system to overcome bottlenecks in capacity, the total costs of drying are generally lower compared to the conventional dryer.

solar energy; drying; medicinal plants; economic feasibility

1. EINLEITUNG

Bei der Herstellung von Phytopharmaka wird die traditionelle Wildsammlung von Arzneipflanzen zunehmend durch den feldmäßigen Anbau abgelöst, um die mengenmäßige Versorgung mit den unterschiedlichen Drogen sicherzustellen und um den Anforderungen an Identität und Reinheit, sowie den gesetzlichen Bestimmungen zum Schutz der Wildbestände gerecht zu werden /1/. Durch die nunmehr räumliche und zeitliche Konzentration der Ernte ist eine hohe Trocknungskapazität erforderlich, da das Erntegut zur Vermeidung von Qualitätsverlusten, verursacht durch rasch einsetzende fermentative Abbauprozesse, unverzüglich nach der Ernte getrocknet werden muß /2/. Bereits ab einer Anbaufläche von 1 ha wird eine Trocknungsanlage benötigt, womit die Wirtschaftlichkeit des Arzneipflanzenanbaus maßgeblich von den Trocknungskosten bestimmt wird. Sowohl zur Senkung der Energie- als auch der Investitionskosten wurde am Institut für Agrartechnik in den Tropen und Subtropen der Universität Hohenheim in Zusammenarbeit mit dem Institut für Mechanisierung der Universität Novi Sad ein solarer Gewächshaustrockner für Arzneipflanzen entwickelt und im vierjährigen Praxiseinsatz in Jugoslawien optimiert /3,4,5/. Die ökonomische Beurteilung der Anlage erfolgte in Form einer vergleichenden Betrachtung mit der am Standort anzutreffenden konventionellen Warmlufttrocknung. Als Vergleichsmaßstab dienten die Stückkosten der Trocknung, d.h. die Kosten, die bei der Trocknung von 1 kg lagertrockener Droge entstehen. Darin sind die variablen Kosten für elektrische Energie, Heizöl und Arbeit enthalten, sowie die anteiligen Abschreibungs-, Zins- und Reparaturkosten der Trocknungsanlagen.

2. MATERIAL

2.1 Solarer Gewächshaustrockner

Der solare Gewächshaustrockner entstand durch Modifikation eines Standard-Foliengewächshauses, wobei die gesamte Dachfläche als Kollektor genutzt wird. Dazu sind auf der Stahlunterkonstruktion zusätzliche Halteprofile montiert, in welche unter der serienmäßigen Eindeckung aus UV-stabilisierter Luftpolsterfolie ein schwarzes Absorbergewebe eingezogen ist. Um das Strahlungsangebot optimal zu nutzen, wurde der First in Ost-West Richtung ausgerichtet und die nach Süden orientierte Dachfläche bis zum Boden verlängert, **Bild 1**.

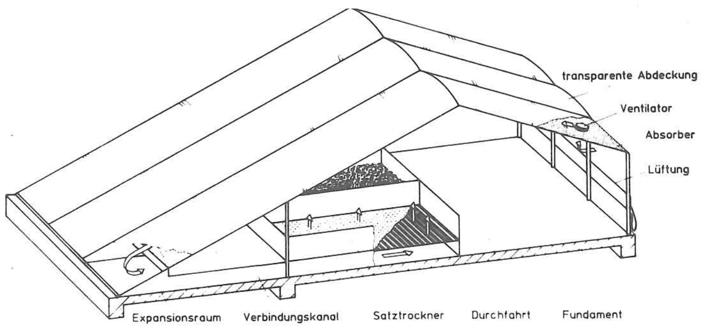

Bild 1: Solarer Gewächshaustrockner.

Das Foliengewächshaus hat ein Satteldach mit einer Dachneigung von 22°, eine Firsthöhe von 4,4 m und eine Stehwandhöhe von 2,4 m. Durch die südseitige Dachverlängerung wird die serienmäßige Hausbreite von 10 m auf 15 m vergrößert. Die Länge der Anlage ist aufgrund des modularen Konstruktionsprinzips im Raster des Binderabstandes von 2 m variabel. Jedes Binderfeld bildet ein eigenständiges Modul, welches aus Kollektor, Verbindungskanal und Trocknerbox besteht und von einem Radialventilator mit einer Nennleistung von 520 W belüftet wird. Bei einem Druckabfall von 50 Pa wird je Modul ein Luftdurchsatz von 3 900 m³/h erreicht, was einer Luftgeschwindigkeit von 0,1 m/s im Gutstapel entspricht. Die Luft wird im Bereich der nördlichen Traufe von unten angesaugt und zwischen Folieneindeckung und Absorber über das Dach geblasen, an der Südtraufe umgelenkt und durch den Luftkanal in den Satztrockner geführt, welcher durch Sperrholzwandungen in Boxen von jeweils 6 m Länge und 2 m Breite unterteilt ist. Mit Hilfe einer Stehwandlüftung an der Nordseite kann der Trockner sowohl mit Frisch- als auch mit Umluft betrieben werden.

Zur Überbrückung von Regentagen und zur zeitweiligen Steigerung der Trocknungskapazität bei Engpässen, kann der solare Gewächshaustrockner mit einer Zusatzheizung ausgestattet werden. Hierbei kommen mobile, ölbefeuerte Warmlufterzeuger mit Wärmetauscher zum Einsatz, die je nach Anzahl der Trocknermodule in einer entsprechenden Heizleistung ausgewählt werden.

2.2 Konventioneller Satztrockner

Zur Trocknung von Arzneipflanzen wurde am Versuchsstandort seither eine modifizierte Getreideflachbelüftungsanlage eingesetzt, **Bild 2**. Ein Radialventilator saugt die Trocknungsluft über einen Warmlufterzeuger an, der aus einem Ölbrenner und einem Trommelwärmetauscher besteht. Die erwärmte Luft wird durch zwei U-förmig angeordnete Hauptkanäle in die Trocknungshalle geleitet und mit Hilfe von Querkanälen auf die umschlossene Fläche verteilt.

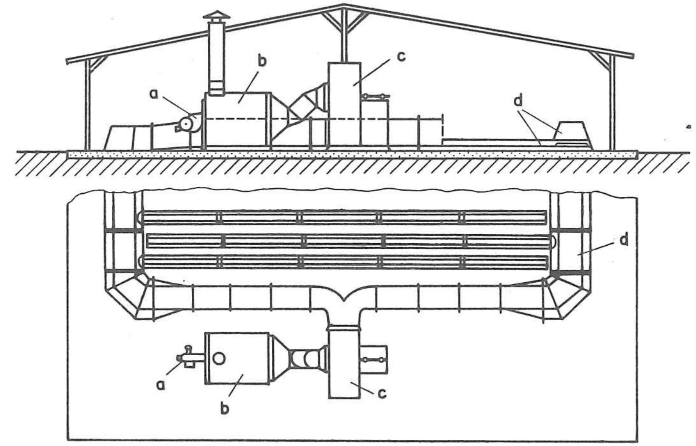

Bild 2: Konventioneller Satztrockner.

Das Trocknungsgut wird auf den Querkanälen aufgeschichtet, wobei die beiden Hauptkanäle als seitliche Begrenzung dienen. Die Anlage ist 10 m breit, die Länge richtet sich nach der installierten Ventilator- und Brennerleistung. Der Ventilator hat in seiner kleinsten Ausführung eine Leistung von 7,5 kW und fördert bei einem Druck von 700 Pa einen Luftstrom von 25 000 m³/h. Der kleinste Brenner hat bei einem Heizölverbrauch von 20 l/h eine Leistung von 200 kW. Mit dieser Ausstattung wurde im untersuchten Trockner bei einer Länge von 7 m eine Luftgeschwindigkeit von 0,1 m/s im Gutstapel und eine Temperaturerhöhung von 25 K erreicht. Die Anlage muß in einer Halle untergebracht werden, die mindestens 2 m breiter und 5 m länger ist als die Trocknerfläche.

3. METHODE

Zum Vergleich der solaren und konventionellen Trocknung wurden beide Anlagen so dimensioniert, daß sich deren Gutdurchsatz mit dem maximalen Trocknungsanspruch ausgewählter Arzneipflanzen deckt. Der Trocknungsanspruch stellt dabei die täglich zu bewältigende Erntemenge dar und ergibt sich als Quotient des Flächenertrages und der für die Ernte zur Verfügung stehenden Zeit. Ist die erforderliche Trocknergröße auf diese Weise bestimmt, können aus dem Neuwert A_W die durchschnittlichen jährlichen Fixkosten nach der dynamischen, teilweisen Annuitätenmethode berechnet werden, welche die Abschreibungs-, Zins- und Reparaturkosten berücksichtigt /6/:

$$FK = (A_W - R_W \cdot q^{-N}) \cdot \frac{q^N \cdot (q - 1)}{q^N - 1} + A_W \cdot \frac{r}{100}$$

Dem Zinsfaktor q wurde ein Zinssatz von 10 % zugrunde gelegt. Für die Nutzungsdauer N wurde bei den Fundamenten, den Gebäuden und der Gewächshauskonstruktion eine Lebensdauer von 20 Jahren angenommen, bei Geräten 10 Jahre. Die Luftpolsterfolie hat eine Lebensdauer von 5 Jahren. Für den Reparaturkostenanteil r wurde bei Gebäuden 5 % und bei Geräten 10 % veranschlagt. Es wurde davon ausgegangen, daß der Schrottwert der Anlagen am Ende der Nutzungsdauer gerade die Abbruchkosten deckt, womit der Restwert R_W entfällt.

Durch die Umlegung der durchschnittlichen jährlichen Fixkosten FK auf die pro Jahr getrocknete Drogenmasse ergibt sich der Fixkostenanteil der Trocknung. Zusammen mit den variablen Betriebskosten, welche aus den Energie- und Arbeitskosten bestehen, ergeben sie die Stückkosten der Trocknung. Dabei liegen die Preise für April 1990 zugrunde, die für Heizöl 2,60 Din/l und für Strom 1,05 Din/kWh betrugen. Die Lohnkosten lagen für Fachkräfte bei 100 Din/h und für Hilfskräfte bei 30 Din/h. Der Wechselkurs stand im April 1990 bei 1 DM für 7 Din.

4. ERGEBNISSE

4.1 Trocknungsanspruch

Der Anspruch unterschiedlicher Arzneipflanzenarten an den Durchsatz einer Trocknungsanlage, ergibt sich als Quotient aus dem Flächenertrag und der zur Verfügung stehenden Erntezeitspanne. In **Bild 3** ist dazu die täglich zu trocknende Erntemenge für einen kombinierten Anbau von jeweils einem ha Salbei und Pfefferminze dargestellt. Der größte Trocknungsanspruch entsteht in der Zeit von Ende September bis Mitte Oktober durch den zweiten Schnitt von Pfefferminze. In dieser Zeitspanne sind täglich 480 kg Frischmasse pro ha Anbaufläche zu trocknen. Das bedeutet, daß die Trocknungsanlagen so groß dimensioniert werden müssen, daß deren Durchsatz auch unter den ungünstigen Witterungsbedingungen im Herbst noch ausreicht, um diese Trocknungsmenge zu bewältigen.

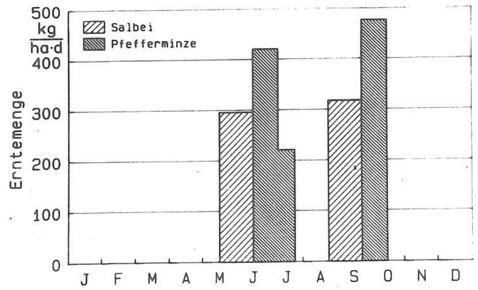

Bild 3: Trocknungsanspruch bei kombiniertem Anbau von je 1 ha Pfefferminze und Salbei.

4.2 Gutdurchsatz

Zur Dimensionierung der Trocknungsanlagen wurde deren Gutdurchsatz für Pfefferminze im Sommer und im Herbst in simultanen Trocknungsversuchen ermittelt, **Tabelle 1**. Der solare Gewächshaustrockner wurde dabei sowohl mit als auch ohne Zusatzheizung betrieben.

Tabelle 1: Kennwerte der solaren und konventionellen Trocknung für den ersten und zweiten Schnitt von Pfefferminze; (m_t = 65 kg/m², Juni/Juli und September/Oktober 1990).

	solar	solar mit Heizung	konventionell
Durchsatz [kg/m²d]			
Juni/Juli	15,3	30,5	31,6
September/Oktober	9,8	25,1	26,8
Heizölbedarf [l/kg]			
Juni/Juli	-	0,32	0,81
September/Oktober	-	0,38	0,90

Mit Zusatzheizung erreichte der solare Gewächshaustrockner mit 30,5 kg/m²d im Sommer und 25,1 kg/m²d im Herbst annähernd die gleiche Kapazität wie der ölbefeuerte Satztrockner,

allerdings mit einem um 60 % geringeren Heizölbedarf. Ohne Zusatzheizung ist die Kapazität des solaren Gewächshaustrockners im Sommer um 50 % und im Herbst um 60 % geringer.

4.3 Investitionskosten

Wird eine Gesamtanbaufläche von 5 ha zugrunde gelegt, die zu gleichen Teilen mit Pfefferminze und Salbei bebaut wird, so ergeben sich aus dem Trocknungsanspruch für den zweiten Schnitt von Pfefferminze für die drei Trocknervarianten unterschiedliche Mindestgrößen. Während für den solaren Gewächshaustrockner eine Rostfläche von 120 m² benötigt wird, reichen bei Einsatz der Zusatzheizung, wie auch beim konventionellen Satztrockner, 50 m² aus. In **Tabelle 2** sind die Investitionskosten der unterschiedlichen Trocknerversionen aufgeschlüsselt.

Tabelle 2: Investitionskosten der drei Trocknerversionen bei gleichem Durchsatz während der Zeit des maximalen Trocknungsanspruchs für eine Anbaufläche von 2,5 ha Pfefferminze und 2,5 ha Salbei, (Preise April 1990).

		solar	solar mit Heizung	konventionell
Fundament	Din	76 900	39 100	33 200
Gebäude	Din	339 900	200 900	89 100
Ausbau	Din	100 100	64 600	77 000
Ventilatoren	Din	45 700	20 800	50 000
Heizung	Din	0	57 800	80 000
Montage	Din	47 900	25 100	27 600
gesamt	Din	610 500	408 300	356 900

Wird beim solaren Gewächshaustrockner eine Zusatzheizung installiert, kann die Anlage entsprechend kleiner dimensioniert werden, wodurch die Investitionskosten von 610 500 Din um 30 % auf 408 300 Din reduziert werden. Der konventionelle Satztrockner verursacht mit 356 900 Din etwas geringere Investitionskosten als der Solartrockner mit Zusatzheizung, da das Gebäude zur Unterbringung eines Trockners in Jugoslawien mit ca. 90 000 Din sehr kostengünstig erstellt werden kann.

Mit zunehmender Anbaufläche steigt die erforderliche Größe der Trocknungsanlage und so auch die Investitionskosten, **Bild 4**. Da die Anlagenkomponenten nicht beliebig teilbar sind, erfolgt dieser Anstieg nicht proportional, sondern stufenförmig, ausgehend von einer bestimmten Mindestgröße. Die kleinste installierbare Heizleistung beträgt beim konventionellen Satztrockner 200 kW, die Erweiterung kann in Stufen zu je 100 kW erfolgen. Für den solaren Gewächshaustrockner beträgt dagegen die kleinste Heizleistung 20 kW und die nächst größeren Brenner haben Leistung von 30, 50 und 100 kW. Ähnliche Verhältnisse ergeben sich für die Ventilatoren und für die Bauhülle.

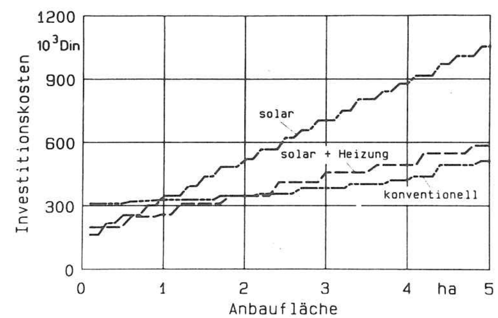

Bild 4: Investitionskosten unterschiedlicher Trocknerversionen bei zunehmender Anbaufläche von Pfefferminze.

Bis zu einer Anbaufläche von 1 ha verursacht der solare Gewächshaustrockner geringere Investitionskosten als der konventionelle Trockner. Aufgrund des größeren Kostenanstiegs entstehen jedoch bereits bei einer Anbaufläche von 4 ha etwa die doppelten Investitionskosten. Bei Einsatz einer Zusatzheizung sind die Kosten für den Gewächshaustrockner bis zu einer Anbaufläche von 2 ha geringer als die des konventionellen Trockners. Bei weiterer Flächenausdehnung ergeben sich dann wieder etwas höhere Investitionskosten.

4.4 Stückkosten der Trocknung

Da sich in den Trocknungsversuchen keine Unterschiede in der Drogenqualität ergaben, die sich auf den Erlös ausgewirkt hätten, kann die Wirtschaftlichkeit der drei Trocknervarianten allein anhand der Stückkosten der Trocknung beurteilt werden. Hierbei ergaben sich Unterschiede in der Zusammensetzung aus fixen und variablen Kosten. Bei schlechter Auslastung der Anlagen, wie das z. B. bei einem ausschließlichen Anbau von Pfefferminze der Fall wäre, überwiegt der Fixkostenanteil sehr stark. Durch eine Anbaukombination mit Salbei werden die variablen Kosten kaum verändert, der Fixkostenanteil sinkt jedoch durch die bessere Auslastung erheblich, **Bild 5**. Dieser Effekt macht sich besonders beim solaren Gewächshaustrockner bemerkbar. Hier sinken die Stückkosten durch die Kombination mit Salbei von 11,9 auf 6,6 Din/kg. Mit Zusatzheizung werden Stückkosten von 5,2 Din/kg erreicht, wogegen sie bei konventioneller Trocknung 6,0 Din/kg betragen.

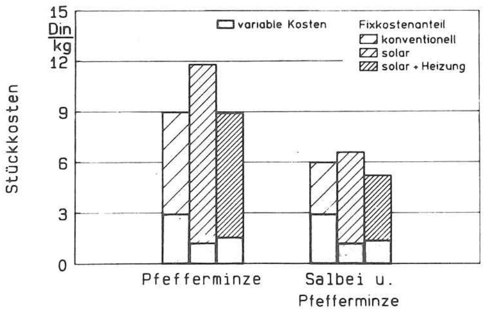

Bild 5: Stückkosten der Trocknung bei einem Anbau von 2,5 ha Pfefferminze, sowie bei einer Kombonation mit weiteren 2,5 ha Salbei.

In **Bild 6** ist die Auswirkung der Anbaukombination von Pfefferminze und Salbei auf die Stückkosten der Trocknung nochmals bei steigender Gesamtanbaufläche dargestellt. Bei einem kombinierten Anbau von Pfefferminze und Salbei sind die Stückkosten der solaren Trocknung mit Zusatzheizung durchweg geringer als die der konventionellen Trocknung. Falls keine Zusatzheizung installiert wird, ergeben sich dagegen bei einer Gesamtanbaufläche von mehr als 3 ha bis zu 15 % höhere Stückkosten als bei der konventionellen Trocknung. Falls die Stahlkonstruktion des solaren Gewächshaustrockners in Jugoslawien produziert wird, sinken die Stückkosten der solaren Trocknung um 13 %, so daß der solare Gewächshaustrockner bereits bei einer 10 %igen Preiserhöhung für Heizöl auch ohne Zusatzheizung ebenso wirtschaftlich arbeitet wie der konventionelle Satztrockner.

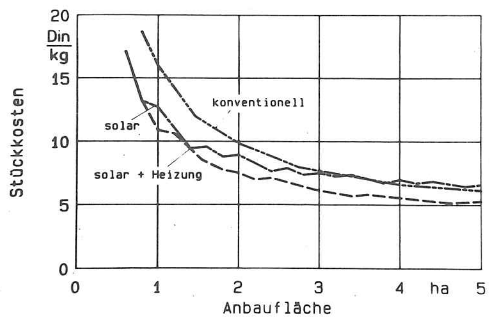

Bild 6: Stückkosten der Trocknung für einen kombinierten Anbau gleicher Flächenanteile von Pfefferminze und Salbei.

5. ZUSAMMENFASSUNG

Die Ergebnisse der ökonomischen Betrachtung zeigen, daß sich ein ausschließlicher Anbau von Pfefferminze ungünstig auf die Wirtschaftlichkeit der solaren Trocknung auswirkt, da hier im Herbst große Erntemengen in kurzer Zeit bei relativ geringer Globalstrahlung getrocknet werden müssen. Soll diese Trocknung allein mit Solarenergie erfolgen, muß der Trockner entsprechend groß dimensioniert werden, woraus sich neben den höheren Investitionskosten auch eine geringere jährliche Auslastung als bei der konventionellen Trocknung ergibt. Zur Verminderung des hohen Fixkostenanteils ist deshalb bei der solaren Trocknung eine gute Auslastung der Anlage besonders wichtig. Wird die Auslastung beispielsweise durch eine Anbaukombination mit Salbei erhöht, weist der solare Gewächshaustrockner bei kleinen Anbauflächen eine größere Wirtschaftlichkeit auf, als der konventionelle Trockner.

Zur Vermeidung von Engpässen, welche bei der solaren Trocknung im Herbst auftreten können, empfiehlt sich die Installation einer Zusatzheizung, mit deren Hilfe die Größe der Anlage und damit der Fixkostenanteil um mehr als die Hälfte reduziert werden kann. Mit einer solchen Zusatzheizung arbeitet der solare Gewächshaustrockner durchweg wirtschaftlicher als ein konventioneller Satztrockner.

Zur Senkung der Investitionskosten sollte die Stahlkonstruktion des Gewächshaustrockners in Jugoslawien gefertigt werden. Auf diese Weise kann selbst ohne Zusatzheizung annähernd die gleiche Wirtschaftlichkeit wie bei der konventionellen Trocknung erreicht werden. Wird davon ausgegangen, daß die Energiepreise in Zukunft stärker ansteigen als der Preis des solaren Gewächshaustrockners, so weist dieser klare ökonomische Vorteile gegenüber dem herkömmlichen Trocknungsverfahren auf. Noch günstigere Verhältnisse ergeben sich für den solaren Gewächshaustrockner, wenn berücksichtigt wird, daß das Gewächshaus außerhalb der Trocknungssaison zur Anzucht von Pflanzen genutzt werden kann, während sich das Gebäude eines konventionellen Trockners bestenfalls als Lagerraum verwenden läßt.

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TRENDS IN AGRICULTURAL ENGINEERING
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INCREASE ENERGY EFFICIENCY OF DRUM DRYER FOR DRYING OF SUGAR BEET NOODLES

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The paper presents some proposals for energy rationalization of drum performance which requires noadditional investment. The measured experimental data under industrial conditions of the sugar beet noodles drying are given, and the essencial parametars for quality performance as well. Effects of measures taken and the comparison with the previous performance are given.

Key words: drum dryer, sugar beet noodles, rationalization, specific heat consumption

1. INTRODUCTION

It is known that a big amount of thermal energy is using in drying process. Because of that it is well understood to provide the increase energy efficiency by different treatments, either by studing exchange process between heat and moisture and the way how does it occur, or by technical innovations and new constructive modes, and by improving conduction of process or by device verifications to be in line with the project demands. It is explicitly difficult in complex thermodiffusion processes like convective drying, to establish real indicators for facilitie's quality work and effect of using particular process and suggestions for rationalization. To evaluate and manipulate the dryer, it is necessarily to define the basic indicators for quality dryer work (specific heat consumption, capacity, quality of dried product) unambiguously and objectively. If it will achieve less value results than expected (projected)

all the lay blame wrongfully are on design or construction interventions, if real conditions of process are not include in analysis. Inversely, if reasonable process conditions are achieved, it has not to be the result of good construction or good intervention, but it can be the result of reasonable process conditions. On the other hand, finding out the real indicators of dryer's quality work, at the same time and avaliable practicabality (possibly remained unused) can be defined comparing with the maximum of effects which could be reached under same conditions.

2. MATERIAL AND PROCEDURE

After extensively observing the process of dehydrator for drying sugar beet noodles, under operating conditions, the source of aberrations from theoretical estimates are established and possibilities for process rationalization are observed. At this stage, it is requested for interventions, in campaign process of sugar beets, without any work imteruption and any investment intervention.

To solve this problem thermokinetic calculation for dehydrator was carried out; detailed measurement system was made; measurement for different dehydrator's regulations was done; the results are analyzed and sugestions for better process performances are given. Thermokinetic calculation enables determining all relevant parameters relating to input dehydrogenating agent condition depending on fuel flow, amount of preheated air for combustion and, state and amount of recycling waste gas. Depending on flow and input condition of moisten sugar beet noodles, the amount of "flooded" air, estimated losses and requested moistness from dehydrator, the conditions of dehydrogenating agent is established by iterative process depends on conditions of dried beet noodles and specific heat energy consumption (per volatile moisture unit based on 100 kg dried sugar beet noodles).

Studing the exchange heat and moisture process in dehydrator is very complex problem, first of all because of complexity process conditions. Thermodiffusion process of exchanging heat and moisture in drum dryer proceeds with phenomenous like: sticked particles of working substance, unequally agent's streaming around the particles at their droping from one to another small spade, at different particle's filled-up the ambient for exchange along the drum dryer, and at constantly drum rotation and producing new thermal and concentric stream circuits. After short contact with the dehydrogenating agent, particles remain the rest of the time at small spade and at the bottom of the drum dryer. During this period, so called "resting period", when sugar beet noodles are not falling down from the spades, volatile moisture from the surface of sugar beet noodles is not such intensively, but at those particles which are not in contact with dehydrogenating agent volatile is stoped. At the same time, relaxation and decrease thermal and concentric unevenness starts in the material. Therefore, thermokinetic calculation is done by appropriation that complex thermodiffusion problems of exchanging heat and moisture in dehydrator are approached like thermal problem.

3. MEASUREMENT SYSTEM

The measurement system is given, and includes:

1. measurement of air ambient conditions;
2. measurement of gas waste temperature, preheated primary air, drum dryer mask surface and recirculation tube;
3. primary air flow measurement
4. temperature measurement of dried and moisten thermometer wasted gas, which is recirculated in dehydrator
5. temperature measurement of input and output material
6. moisture level measurement of input and output material from dryer
7. measurement of flow wasted gas, recirculated in dehydrator
8. rotation number determining of drum dryer dehydrator
9. flow material measurement
10. structure measurement of combustion products longways and through the section of combustion chamber
11. temperature measurement of dehydrogenating agent and waste gas temperature for recirculation
12. temperature and flow gas measurement

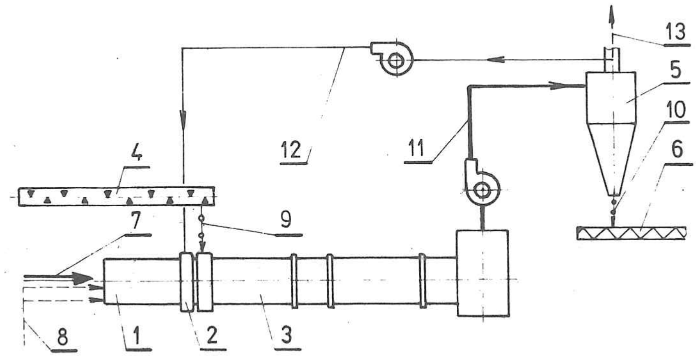

Figure 1 - Schematic of dehydrator with the plane of measuring spots

1. combustion chamber
2. mixing
3. dehydrator drum
4. raw sugar beet noodle
5. cyclone
6. dried material
7. fuel
8. ambient air
9. raw sugar beet noodles
10. dryed sugar beet noodles
11. gas and material
12. recirculation gas
13. waste gas

Measuring the above parameters enables detailed analyses for dehydrator and establishing current state. With the previous thermokinetic calculation it is possible to came up to first step realization of decreasing specific heat consumption.

The aberrations of dehydrator's working conditions from projected was find out under probation, and, hence, restraint for rationalization was considerable. This statement is related to incompatibile working conditions

between combustion chamber and dehydrator, inadequated primary air and fuel flow, undefined ratio of recirculated (wasted) gas from dehydrator and total input amount of dehydrogenating agent, unhomogeneity of temperature and circuit fields at the entry of dehydrator. All of this shows that the drying regimes are far away from optimum.

4. ENERGETIC RATIONALIZATION OF DEHYDRATOR PERFORMANCE

First step for decreasing specific heat consumption had include interventions on dehydrator device without any specific investment and standstill during the drying process of sugar beet noodles. The most important interventions are:

- intervention on combustion chamber (adjusting burner's performances observing composition of combustion products longways and through the section of combustion chamber, adjusting flame lenght, adjusting vaccum in the combustion chamber, and measuring and adjusting ratio fuel flow and fresh-preheated air in the combustion chamber);
- measuring and adjusting recirculated waste gas flow (comparing with total flow of dehydrogenating agent) from dehydrator;
- regulating acceptable drying regime (comparing with the previous state) for a defined input;
- adjusting combustion curve, namely the amount of fresh air depends on pressure in recurring masut tube (the amount of fuel);
- proposals for better process drive (adapting drying regime to content dried substance in raw sugar beet noodles, carefully process driving, namely sugar beet noodles drying till projected moisture, taking care that overdrying is not occur).

All of this (and other inteventions) results in specific heat consumption decreased for a maximum of 19% (comparing with the average specific heat consumption before intervention), and totaly taken on the average for a days after measurement, analysis and interventions for 11,4% in Sugar refinery I and for 14,9% in Sugar refinery II. Minimum specific heat consumption was 18.4 kg fuel/100 kg dried sugar beet noodles. An average specific heat consumption in tested dehydrator, before the intervention, was 21.0 kg fuel/100 kg dried sugar beet noodles. In further work the aberrations, subjectively and objectively, was occured, so important specific heat consumption exceedings happened some times even comparing with the conditions before interventions. Decreasing dehydrator's capacity (below nominal) results in increased specific heat consumption (figure 2-a) and partially overdried sugar beet noodles. Maximum specific heat consumption, after the intervention, was 24.5 kg fuel/100 kg dried sugar beet noodles, or 3194,5 KJ/kgW. Unstable entry and complexity process, and manipulator's habits resulted in occasionally overdried material, what caused decreased capacity and increasing specific heat consumption (figure 2-b), and deterioration of total rationalization results.

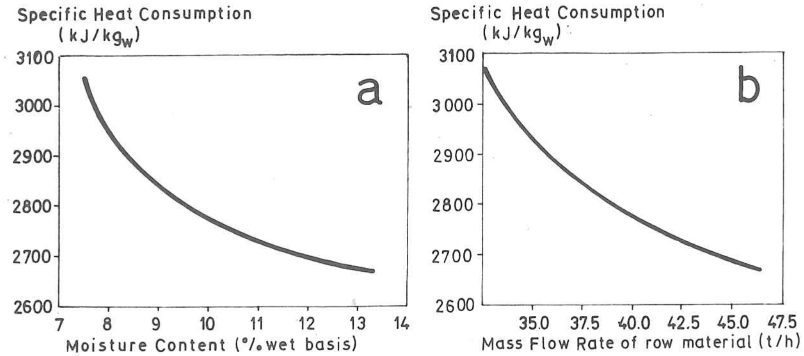

Figure 2 - Specific heat consumption dependence (per volatile moisture unit) upon:
a) dried sugar beet noodles moistness
b) input fresh material mass flow in dehydrator

Thanks to undertaken measures it is sure that the amount of dried sugar beet noodles increased (comparing with the conditions before the intervention), although it is hard to define the exact amount. Increased amount of dried sugar beet noodles is realized by reduced sugar beet noodles taken out from the drum dryer (by real ratio of amount of dehydrogenating agent and recirculated gas), and correctly adjusting combustion process in combustion chamber, namely by ragulating the enough amount of primary air for process realization in dehydrator and vaulting the coefficient of excess air within the regulated state.

The current conditions was far away from optimum, because the measured value of coefficient of excess air (1.8-2.2) was far above the most acceptable (1.3-1.6). And, the amount of dried sugar beet noodles is lower (tiny particles); this material, at such a dryer, burnt down, because of:

- rates are remarkably smaller, and less tiny particles are returning to dehydrtator,
- the total air amount is less, consequently the amount of oxygene at the dryer is remarkably lower,
- the coefficient of recirculation is remarkably increased, therefore the oxygen portion in dehydrator is less, and water vapour portion is increased.

5. CONCLUSION

Applied calculated thermokinetic model of dry process takes into consideration all relevant real conditions for dry process in dehydrator. Thus, the base for rationalization performances of dehydrator for drying sugar beet noodles is formed.

Based upon the previous results the sources of aberrations from the projected work devices was established. The measurements without any special investment or standstill are undertaken. The realized results show on important possibilities of decreased amount of dried sugar beet noodles and along with the maintance of good quality after pelletizing.

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TRENDS IN AGRICULTURAL ENGINEERING
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WET FRACTIONATION OF PHYTOMASS CONTAMINATED WITH HEAVY METALS AND RADIONUCLIDES FOR ISOLATION OF INNOCUOUS PROTEIN CONCENTRATES

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Distribution of heavy metals and radionuclides of foliage-caulescent biomass between fractionation products when protein concentrates being isolated has been studied. Scopes for additional to fractionation radiological decontamination of concentrates extracted have been explored. An opportunity to obtain edible for farm animal protein concentrates from foliage-caulescent biomass of green plants contaminated with radionuclides has been shown.

protein concentrates; heavy metals; radionuclides

1. INTRODUCTION

At present when biosphere is being contaminated continually technologies are becoming important by which migration of contaminants along biological chains and their accumulation in foodstuffs are restricted. Isolation of protein concentrates from foliage-caulescent biomass (FCB) of green plants is one of these technologies. This technology involves wet fractionation of phytomass when it being grinded and pressed press-cake and cell sap are separated /1/. Press-cake is usually fed to cattle and from cell sap protein concentrates are isolated. Content of herbicides, pesticides, mico- and microflora, toxins produced, other antialimentary and toxic substances decreases considerably by redistribution between fractionation products /2/. These features of the technology are of interest as a possible way to isolated ecologically pure protein preparations from plant biomass contaminated with heavy metals and radionuclides.

To find out this way distribution of mineral components and radioactive substances when protein concentrates being

isolated by fractionation of foliage-caulescent biomass of a number of fodder crops have been explored.

2. METHODS

Fractionation was carried out according to two patterns stimulating the most commonly used versions of protein concentrate isolation technique. In the first case cell sap was heated to 80° C when its proteins coagulate. Precipitate of the total plant protein fraction, that is leaf protein concentrate (LPC), was centrifuged. The given method is used in commercial production.

Fractionational protein isolation from cell sap is presumed by the most up-to-date techniques "Vepex", "Pro-Xan", "Polyprotein". In the second case cell sap is heated to 40...50°C when, so called "chloroplast" proteins fixed firmly with membrane structures coagulate. After separation of precipitate from supernatant at pH 4.0 soluble "cytoplasmic" proteins were percipitated. By its properties "chloroplast" protein fraction (CHPF) is close to LPC and is of similar application. Cytoplasmic protein fraction (CPF) concentrate, as to compare with LPC and CHPF contains more proteins and it is cellule and pigment free. It may be also used in human nutrition.

In some cases before precipitating of CPF proteins from cell sap at pH 11.0 organomineral complex (OMC) was isolated.

In initial biomass of alfalfa (IBA), in press-cake (PC), in protein concentrates, and in OMC contents of dry matter, protein, fats, chemical elements: Ca, Mg, Al, Na, K, Fe, P, Cd, Co, Sr, Mn, Pb, Cu were determined. Protein content was determined by "Kjeltec Auto" instrument (Sweden) by Kjeldahl method, fats were determined by Razumov's technique (1982). Element composition of samples was investigated by the PS-4 "BAJRD" instrument (Netherlands).

In phytomass of crops (clover, lupine, pea) contaminated with radionuclides and in its fractionation products radioisotope Cs-137, Cs-134, Sr-90 content was determined. Investigations of samples by gamma-rey spectrometry were carried out by AD CAM-100 "ORTEC" (USA) with detector GEM-40220. Sr-90 was determined by TENNELEC alpha-beta-gamma-spectrometer (USA).

3. BASIC INFORMATION

Results of biochemical and element composition of foliage-caulescent alfalfa biomass and its fractionation products are given in Table 1.

Experiments showed distribution of elements under study in fractionation to have a complex pattern. So, in mechanical biomass dewatering stage most of chemical elements moved into cell sap except Al and Fe which were accumulating in press-cake. While protein being isolated from cell sap some increase of phosphorus and heavy metal content in LPC and CHPF has been found, whereas in CPF concentration of these elements was below one in the initial biomass. Content of light Na and K metals in LPC and CHPF remained at the phytomass level and was rather higher in CPF preparation.

Table 1

Biochemical and chemical composition of foliage-caulescent biomass of alfalfa and products of its fractionation

Component content, % (ppm) in dry matter	Sample						Correlation coefficient	
	FCB	PC	LPC	CHPF	CPF	OMC	r_1	r_2
Protein	16,8	12,6	49,3	44,6	56,2	3,8		
Fat	3,1	3,3	12,9	10,8	0,6	0,5		
Na	0,03	0,02	0,02	0,04	0,04	2,20	-0,22	0,5
Mg	0,22	0,15	0,24	0,21	0,12	0,99	0,8	-0.1
Al	0,002	0,042	0,120	0,034	0,002	0,006	0,8	0,2
K	1,32	0,88	1,08	1,60	1,80	3,20	-0,2	0,7
Ca	2,21	1,92	2,74	3,10	1,88	16,11	0,9	0,4
Fe	0,032	0,162	0,292	0,100	0,022	0,034	0,7	0,1
(Mn)	34	38	94	80	30	186	1,0	0,4
(Sr)	82	88	80	80	34	394	0,9	0,6
(Zn)	22	26	112	60	34	60	0,5	-0,7

<u>Note</u>: Cu content in all samples was below 20 ppm, Pb below 5 ppm, Cd and Co below 10 ppm.

Values of correlation coefficient between concentration of elements under study and content of protein (r_2) and fats (r_1) in foliage-caulescent biomass and its fractionation products except of OMC are given in Table 1. As it is seen, content of most of metals in samples changed symbately with content of fats, and it was not correlated with protein concentration. In most cases r_1 values were closely spaced to 0,9 that indicated availability of a bond close to the functional one. Only for univalent metals an exception to the fule has been observed.

As a whole, distribution of elements in fractionation depended on their basic valency. So, changes in relationship of element concentrations in inicial and final product at each stage of fractionation closely correlated with each other within the groups of 3-, 2- and univalent ions (correlation coefficients accounted for values of the order of 0,9. There were no possitive correlation between metal groups.

It should be noted that almost all elements except of Al and Fe trivalent metals were accumulating in OMC wherein their content, as a rule, was by an order higher than in initial biomass. In this situation stage of preparative OMC separation can be considered as a method of demineralization of isolated further cytoplasmic protein concentrate and deproteinized sap.

Concentrations of some toxic metals (Pb,Co, Zn, Cu) under study in cytoplasmic fraction preparations comply with requirements regulating acceptable content of these elements in soybean protein concentrates applied in foodstuff industry.

It should be inderlined that distribution of elements is accompanied with concentration of proteins in LPC and CHPF preparations. As a result, specific content of heavy metals on a per-protein unit basis in this product decreases by several fold as to compare with initial phytomass. As protein is a basic component of fodder making up of protein ration for farm animals composed of LPC from contaminated green plants, as an alternative to its direct feeding offers more less heavy and toxic metal loading in food chain and their accumulation in foodstuffs.

Manner of distribution of elements under study, first of all, strontium in isolation of protein concentrates makes the given technology to consider as useful for processing of plant biomass contaminated with radionuclides.

In this connection we have run fractionation of foliage-caulescent biomass from a number of fodders (clover, lupine, pea) contaminated with radionuclides. Samples of foliage-caulescent biomass were taken within 10-km zone of Chernobyl AES. Lupine and pea biomass was fractionated according to LPC production procedure, and fractions of chloroplast, cytoplasmic proteins and OMC were isolated from foxtail clover.

Basic results of investigations are given in Table 2.

Table 2

Specific content of basic radionuclides (Bk/kg of dry matter) in foliage-caulescent biomass of crops and fractionation products under study.

Sample	Dry matter, %	Protein in dry matter, %	Cs-134 + Cs-137	Sr-90
		Lupine		
FCB	13,6	24,1	204092	27750
PC	21,3	17,0	63455	24420
LPC	15,0	40,6	20943	4107
		Pea		
FCB	20,6	19,6	52503	40700
PC	27,0	16,6	72472	33485
LPC	26,6	44,7	22422	10360
		Clover		
FCB	22,5	19,8	2720	23000
PC	26,0	18,4	1800	6500
LPC	26,0	37,8	1713	12000
CHPF	27,29	31,4	1770	5480
CPF	25,0	61,7	340	1810
OMC		-	2219	300000

Experiments showed distribution of radionuclides between the products of each fractionation stage. As a result, total press-cake activity on Cs and Sr of crops under study was below one of the initial phytomass with the exception of pea when activity of the product has been found to be at the level of initial raw material.

Total radioactivity of LPC preparations was one-third as high as one of foliage-caulescent biomass. Lupine activity decreased almost by one oder. As to take account of protein concentration in this product comparison of radionuclides with it is of a matter of interest. As for the data in Table 2 it is seen that specific content of radioisolopes in LPC on a per-protein unit decreased relative to initial biomass for clover 3-fold, and for pea-oats mixture and lupine 5 and 16-fold, respectively. At the same time specific activity of Sr-90 reffered to ptotein for clover decreases 4-fold, and for other crops 9 and 11-fold. Closely spaced effect in case of CHPF isolation has been found. In toto, disactivating effect of plant protein fractionation procedure was increasing in series PC, LPC, CHPF, CPF; total on Cs and Sr specific radioactivity of CPF was one of the tenth as high as one of the initial biomass. In view of protein concentration in this product specific activity of radioisotopes of Cs and Sr-90 per-protein unit decreases 25 and 40-fold, respectively.

Concentration of radioisotopes (mainly Sr-90) examined in OMC suggests necessity of separation stage for the product when phytomass contaminated with radionuclides is fractionated.

One of the properties of the technology of protein concentrate isolation from green plants is that its intermediate and final products are liquid or pastelike. This enables to use for their additional desactivation conventional methods of radionuclide removal from fodders and foods. As a method additional to the fractionation of protein concentrates by deactivation was used washing which has been found to be the most effective operation . Preparations isolated from clover were washed by water of pH 4,0 and water duty 4,0. In Fig.1 changes of product total activity-protein content relationship observed in washing of LPC preparation.

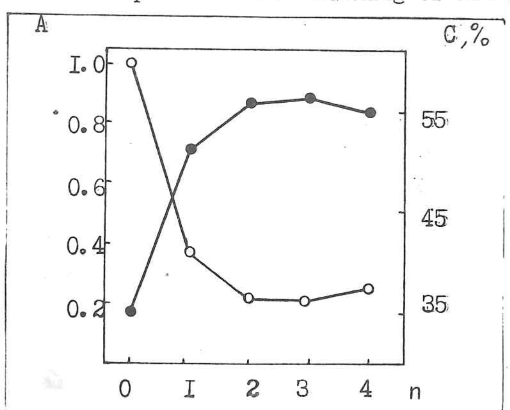

Fig.1 Changes of beta-activity (A○ , - relative units) and protein concentration (C●, in LPC preparation from clover), n - ratio of washing

As it is seen from the figure changes of the preparation radioactivity and protein concentration were of complex character. So, protein concentration at initial stages of washing was almost twice as high and after transfer throught a maximum it decreases;changes of -activity were followed by increase at the final stages of washing. As long as in two-times washing specific activity of Cs radioisotopes in the preparation is twice as low. It should be noted that nature of changes of LPC radioactivity (see Fig1) followed also dependence of specific activity changes of CHPF preparation in washing. Yet, in this case we have striven for a great effect. So, specific activities of Cs-137, Cs-134 and Sr-90 decreased 6 and 4-fold, respectively.

Nature of obtained dependences in washing of LPC and CHPF suggests fractional composition of radioactive impurities. In the first fraction are included Cs and Sr or fixed with them free compounds readily soluble but , mainly, non-protein origin which extractions into aqueous phase cause decrease preparation radioactivity and increase protein concentrations in them at initial stages of washing . In the second fraction are, probably, included radionuclides fixed firmly with insoluble in water matrix of the preparation; these radionuclides cause residual radioactivity. By of example fractional composition of radioactive impurities of LPC and CHPF suggest thorough investigation of the processes of interaction between radionuclides and all sap components to find out mexanism of contamination of extracted products. Yet, now from the results of CPF preparation washing one can have an idea, in particular: about nature of insoluble in water compounds which fix firmly radionuclides in LPC and CHPF. Unlike LPC and CHPF specific activity of Cs and Sr-90 radioisotopes decreases largely. As concentration of proteins in CPF is 1,5...2-fold higher than in LPC and CHPF, insoluble in water complexes giving rise to residual radioactivity of these products are of non-protein nature.

4. CONCLUSION

It is seen from the data that conventional technologies of plant protein fractionation modified with washing of isolated products by redistribution of radionuclides and their extractions make possible to isolate feed protein concentrations (LPC and CHPF with specific radioactivity 30...40-fold lower than in the initial biomass. As experiments on isolation and washing of concentrations of cytoplasmic proteins showed by these modified versions of the technology protein preparations can be isolated from plant material contaminated with radioactive substances. These preparations comply with maximum concentration limits of radionuclides in fodders and other products.

Meanwhile, because of press-cake isolated at wet fractionation stage as being the same on content of radionuclides as the initial phytomass, its conventional utilization is likely to be impossible. Methanol and biogas production can be an alternative variant pf press-cake utilization. Finally, at present are known methods and facilities for deep mechanical dewatering of phytomass by which yield of press-cake is decreased and 80-90% of plant protein are extracted into cell sap /1/.

It should be noted that mentioned above LPC technology "Vepex", "Pro-Xan" are technologies of the first generation. At present more up-to-date methods of plant protein fractionation have been developed and are still being developed. So, a technology of feed and food protein concentrate production has been developed. This technology depends on electromembrane methods of cell sap processing /3/ by which content of heavy and toxic metals, as well as, radionuclides in final protein products are greatly decreased at the expense of intensification of demineralization of protein systems. Voluable bioactivity substances such as trypsin inhibitor are extracted by this technology from plant material besides protein concentrates. Methods of preparative isolation of these substances ensure high level of purification from mineral components. By these methods useful bioactivity preparations are extracted from contaminated plant biomass. In general, application of up-to-date methods create preraquisites for realization of no-waste technology of phytomass processing. By this technology ecological pure protein concentrates and other products can be extracted in future from foliage-caulescent biomass contaminated, in particular with heavy and toxic metals, and also with radionuclides.

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TRENDS IN AGRICULTURAL ENGINEERING
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SOME ADVANTAGES OF CRAWLER TRACTOR WITH RUBBER TRACKS

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SUMMARY

In the paper the results of comparable testing of tractor with rubber tracks Challenger 65, wheeled tractor of joint construction (4x4)Z and of a standard tractor (4x4)S on an unploughed and ploughed stubble field, have been presented. We have measured the soil compaction parameters: depth of trace, width, soil compaction, cone resistance, sliding , power use (η_v) and weight use (φ_n).

Key words: rubber tracks, wheeled tractor, soil compaction, sliding, power use, traction coefficient, unploughed and ploughed stubble field.

INTRODUCTION

Numerous authors investigate the problems of the choice of the optimal characteristics of agricultural tractors and their influence to the soil and effects of agricultural production. The decrease of yield, the increase of power and seed, as well as numerous measures for the decrease of soil compaction /1/, /2/, /7/ have been established. Specific pressures in the central pneumatic zone up to 1000 kPa /18/, /19/ have been measured. In paper /8/ the cone pressure decrease for 25% at the depth of 5-10 cm of the crawler with rubber trucks has been established relating to joint construction tractor with double wheels 20,8 - 32. Nearly double smaller compacted surface has been measured and the double smaller depth of the compacted soil penetration with rubber tracks /9/, /10/, /21/. The detailed measurings of the traction parameters of a tractor with rubber tracks are given in papers /3/, /4/ and /5/ where the increase of the net traction coefficient for 20% is stated on a hard base and 58% on a ploughed base.

Having in mind the stated results of the authors the work aim has been defined: establishing the advantages of the crawlers with rubber tracks in relation to the wheeled tractors in the field of traction parameters and soil compaction.

MATERIAL AND METHODOLOGY

For the realization of the work set aim, three tractors have been tested on an unploughed and ploughed stubble field, on a soil with 80% of clay, with the soil moisture from 22 - 23 weight %. The soil compaction measuring was done by penetrometer "The Bush recording soil penetrometer". The traction parameters were measured by electronic devices of the Institute. The tractors, crawler with rubber tracks Caterpillar, Challenger 65, (CH-65) of 191 kW weight 5130 daN, joint construction tractor (4x4)Z of 194 kW, weight 12175 daN, front

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7270 daN, rear 4905 daN, double pneumatics 18,4-38 and standard tractor (4x4)S with all wheel drive of 132 kW, weight 7575 daN, front 3290 daN front pneumatics 16,9R28 and rear 20.8R38 were used.

RESULTS AND DISCUSSION

On the basis of measured and calculated parameters the analysis of the change was made: depth of trace, width depth, soil compaction, specific pressure Fig. 1 and Table 1. Cone penetration resistance is given on Fig. 2 & 3 and in Table 3. The equations of the cone resistance change with depth are given in Table 3. The traction parameters of the crawler with rubber trucks are given in the diagram Fig. 4. The dependence of the engine power use (η_v) (power at the draw bar : engine power) of the net coefficient traction (φ_n) (power at the draw bar : tractor weight) is given in the diagram Fig. 5 & 6.

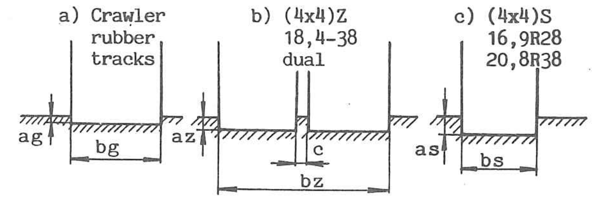
During the measuring of the trace depth of the rubber tracks the less values were measured for 33 - 83% in relation to the wheel tractor. The compacted surface as the ratio of trace and working width of the plough and disc harrow is smaller with the rubber tracks for 1,5 - 2,14 on the unploughed and 1,91-2,61 times on the ploughed stubble field, with the wheel tractor bigger specific pressures for 26-76% have been measured. The depth of the compacted soil with rubber tracks is approx. double smaller than with the wheel tractor on the unploughed stubble field Fig. 2. Mean cone resistance at the depth of 0-30 cm with the wheel tractor is bigger for 24 - 33% on the unploughed stubble field and for 21 - 32 % on the ploughed one, at the depth of 0-20 cm. On the ploughed stubble field at the depth of 0-10 cm cone resistance with wheel tractor is bigger for 32 - 42%.

The traction parameters are given in diagram Fig. 5 and 6. On the unploughed stubble field the use of power with tractor CH-65 is bigger for 16,4 % than tractor (4x4)Z and 17,1% than standard tractor (4x4)S on the ploughed stubble field 23,9 % and 27,6% respectively at the sliding of 3,8 % (CH-65), 10,43 % (4x4)Z and 15,38 % (4x4)S. The use of weight on the unploughed stubble field with tractor (CH-65) is bigger for 11,3-22,6 % and 13,1-24,2 % than with tractor (4x4)Z and (4x4)S on the ploughed for 21-32,6 % and 25,8-36,3 % respectively.

CONCLUSION

On the basis of performed research the following conclusions can be made:

- crawler tractor with rubber tracks during the agrotechnical operations compacts approx. two times smaller surface,
- the compaction intensity is smaller and penetrates to approx. double smaller depth,
- tractor power and weight is much better used specially on the soil of smaller carrying capacity,
- in accordance with the established advantages, it is indispensable to faster introduce crawler tractors with rubber tracks in the agriculture.



Conditions	Units	(a) bg	(a) ag	(b) bz	(b) az	(b) c	(c) bs	(c) as
Firm soil	mm Index	622 (100)	30 (100)	1040 (167)	45 (133)	200	490 (79)	55 (183)
Tilled soil	mm Index	622 (100)	50 (100)	1180 (190)	75 (150)	180	510 (82)	100 (200)

Fig. 1. A comparison of contact surface of rubber track and tyres

Tab. 1. Contact surface and nominal ground pressure

No.	Parameters	Units	Crawler (CH-65)		(4x4)Z		(4x4)S	
			Firm soil	Tilled soil	Firm soil	Tilled soil	Firm soil	Tilled soil
1.	Contakct surface -width-Total	cm Index	124,4 (100)	124,4 (100)	208,0 (167)	236,0 (190)	98 (49) (79)(39)	102 (82)
	front	cm	-	-	42	50	36	38
	rear	cm	-	-	42	50	49	51
	-Long	cm	298	319	-	-	-	-
	front	cm	-	--	50	53	46	51
	rear	cm	-	-	50	53	72	76
	-Surface	cm² Index	37.071 (10)	39.684 (100)	20.800 (56)	25.016 (63)	10.368 (28)	11.628 (29)
	front	cm²	-	-	10.400	12.508	3.312	3.876
	rear	cm²	-	-	10.400	12.508	7.056	7.752
2.	- Nominal ground pressure	kPa Index	41,5 (100)	38,8 (100)	58,5 (141)	48,7 (126)	73,1 (176)	65,1 (168)
	front	kPa	-	-	69,9	58,1	99,3	84,9
	rear	kPa	-	-	47,2	39,2	60,7	55,3
3.	-Width of plogh and harrow	cm	320	700	250	500	168	300
	-surface compaction	% Index	38,9 (100)	17,8 (100)	83,2 (214)	47,2 (265)	58,3 (29,2) (150) (75)	34,0 (191)

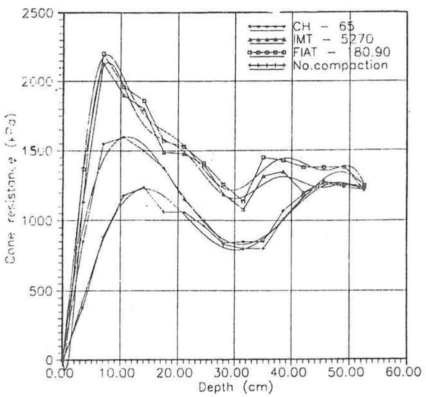


Fig.2. Soil cone resistance with depth
(Firm Soil - Average)

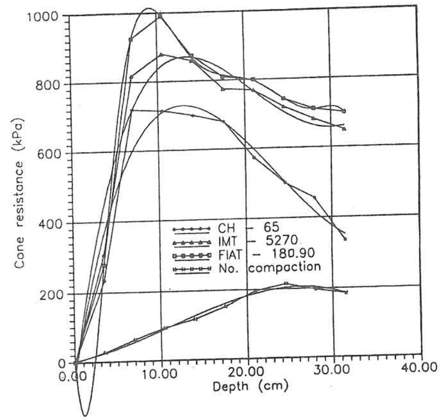


Fig.3. Soil cone resistance with depth
(Tilled soil - Average)

Tab.2. Average of cone penetration resistance

No.	Tractors	Firm soil		Tilled soil	
		0 - 15 cm	0 - 30 cm	0 - 10 cm	0 - 20 cm
1.	No compoction (Index)	783 (65)	883 (77)	60 (16)	80 (15)
2.	CH - 65 (Index)	1200 (100)	1150 (100)	380 (100)	540 (100)
3.	(4x4)Z (Index)	1467 (122)	1425 (124)	500 (132)	655 (121)
4.	(4x4)S (Index)	1600 (133)	1525 (133)	540 (142)	710 (132)

Tab. 3. EQUATIONS OF SOIL CONE PENETRATION RESISTANCE WITH DEPTH

No.	TRACTORS	EQUATIONS
	Firm soil (see Fig.2) x = depth CR = CI	
1.	No compoction	$CR_n = -14{,}7872 + 106{,}769x + 10{,}0758x^2 - 1{,}42845x^3 + 0{,}005404x^4 - 0{,}000883298x^5 + 5{,}05956.10^{-6}x^6$
2.	CH - 65	$CR_{CH} = -16{,}8743 + 354{,}839x - 25{,}292x^2 + 0{,}638943x^3 - 0{,}00528593\, x^4$
3.	(4x4)Z	$CR_z = -0{,}1672 - 329{,}658x + 405{,}803x^2 - 89{,}0876x^3 + 9{,}40143x^4 - 0{,}57444x^5 + 0{,}0217143x^6 - 0{,}000515673x^7 + 7{,}4936.10^{-6}x^8 - 6{,}09125.10^{-8}x^9 + 2{,}1224.10^{-10}x^{10}$
4	(4x4)S	$CR_s = -0{,}324826 + 1{,}77039x + 269{,}898x^2 - 65{,}425x^3 + 7{,}13795x^4 - 0{,}442588x^5 + 0{,}0168247x^6 - 0{,}000399424x^7 + 5{,}77603.10^{-6}x^8 - 4{,}65455.10^{-8}x^9 + 1{,}60249.10^{-10}x^{10}$
	Tilled soil (see Fig.3)	
1.	No compoction	$CR_n = 3{,}39161 + 4{,}488x + 0{,}5416x^2 - 0{,}0159x^3$
2.	CH - 65	$CR_{CH} = -40{,}542 + 143{,}946x - 8{,}6344x^2 + 0{,}1777x^3 - 0{,}001147x^4$
3.	(4x4)Z	$CR_Z = -42{,}8671 + 173{,}403x - 10{,}8851x^2 + 0{,}2512x^3 - 0{,}00184x^4$
4.	(4x4)S	$CR_s = -0{,}000638 + 17{,}6116x - 7{,}7574x^2 + 2{,}21618x^3 - 0{,}29328x^4 + 0{,}02037x^5 - 0{,}00077x^6 + 1{,}46805.10^{-5}x^7 - 1{,}12891.10^{-7}x^8$

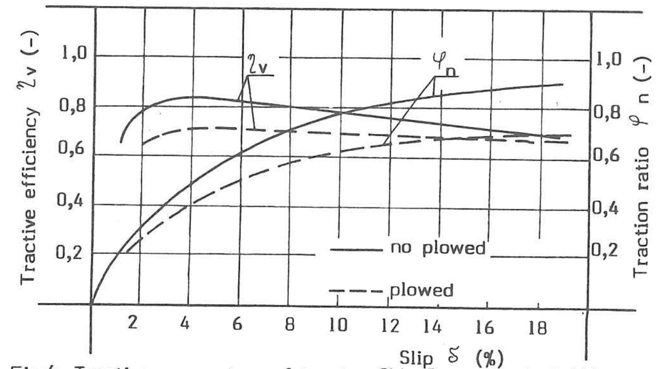


Fig.4. Tractive parameters of tractor CH-65 on wheat stubble

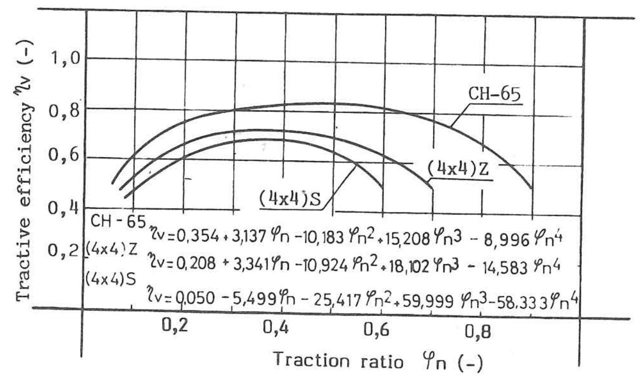


Fig.5. Tractive parameters of tractors on no plowed stubble

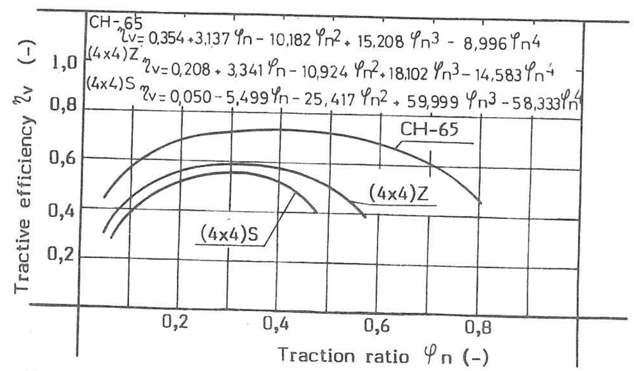


Fig.6. Tractive parameters of tractors on plowed stubble

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TRENDS IN AGRICULTURAL ENGINEERING
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REGRESSION MODELS FOR PREDICTING SOIL COMPACTION AND TILLAGE MACHINERY EFFECTS ON YAM CULTIVATION

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Four tillage systems were evaluated for yam cultivation in a sandy-clay-loam subjected to four levels of soil compaction, in the humid rainforest zone of Nigeria in 1984 and 1985. These tillage systems, minimum; traditional hoe-mounding; conventional and reduced tillage, were evaluated in terms of their effects on soil properties, crop performance and net income. The compaction levels were provided by different machinery weights and traffic. Regression models developed show linear relationships between soil properties and yam sprouting and yield.

soil compaction; minimum tillage; traditional tillage; conventional tillage; optimum tillage; regression model; yam

1. INTRODUCTION

Yam (Dioscorea rotundata) plays a major role in the economy of several countries in the West African sub-region as shown by Coursey /1/ and Onwueme /2/. Nigeria is the major producer, accounting for about 82.5% of the total world yam production as estimated by FAO /3/.

Traditionally, yam cultivation is by making mounds at times as high as 1m using the traditional hoe. This method does not encourage mechanization. Part of the multi-disciplinary work at the National Root Crops Research Institute, Umudike, Nigeria involves the mechanization of yam. This has resulted in improved varieties of yam and cultivation systems. Thus yams can now be planted on ridges and on the flat. This has enhanced the prospects for the mechanization of yam cultivation.

However, it is generally believed that the mechanization of crop production operations causes soil compaction which is the increase in density of a soil as a result of applied load or pressure. It was once thought that tillage operation before planting a crop would reduce soil compaction, but unfortunately this may not be the case with increased size of modern machinery and the increased number of vehicular traffics in the farm (Raghavan and Mckyes /4/; Pollard and Elliot /5/). This problem may be compounded by the fact that the area where yam is produced in Nigeria is characterized by soil of low structural stability and a very high erosive rainfall.

Due to the great concern for soil compaction, many scientists of various disciplines in developed countries have carried out studies on soil compaction. In the area under study, some soil compaction/tillage studies have been done for maize production (Onwualu and Anazodo /6/). However, no study on soil compaction and tillage effects on yam cultivation has been reported in the area. Yet such studies, would help in developing and selecting appropriate machinery and tillage systems that would minimize the risks of soil compaction.

It was against this background that the study reported here was started to monitore the effect of machinery traffic and tillage on Umudike sandy lay loam soil and yam cultivation (Nwokedi /7/). Data generated were used to develop regression models that could be used to predict soil compaction, yam sprouting and yield as functions of soil properties.

2. MATERIALS AND METHODS.

2.1 The Experimental Site.

The experiment was carried out at the National Root Crops Research Institute (NRCRI) Experimental Farm, in Umudike, Umuahia, Nigeria. Umudike lies at 29°N latitude, 32°E longitude and is 122 m above sea level and is under the tropical humid zone of Nigeria. The climate varies according to two major seasons - rainy and dry seasons. Annual rainfall in the project area is between 2,500 mm to 3,000 mm per year. The dry season is characterized by little or no rainfall, dusty winds and low relative humidity. The soil is sandy-clay-loam (Table 1). The farm has gentle slopes of about five percent and is well drained.

Table 1. Textural Composition of the Soil.

Sand (%)	58 ± 2.1
Clay (%)	32 ± 2.0
Silt (%)	11 ± 2.2
Textural Class	Sandy Clay Loam

2.2 Tillage and Compaction Treatments.

A Split Plot in Randomized Complete Block Design (RCBD) was established in the field for two cropping seasons, 1984 and 1985. In 1984, there were three levels of compaction and four tillage treatments with four blocks. The main plots were assigned to compaction and subplots assigned to tillage treatments. The compaction levels were heavy, medium/heavy, medium and low. These were provided by different machinery weights, implements and a number of farm tractor traffic runs. Tillage systems evaluated were; minimum, traditional,

conventional and reduced tillage. These systems were evaluated in terms of their effects on soil properties, yam sprouting, yam tuber yield, production costs, income, net income and financial efficiency of the total operations. An optimum tillage system was selected based on the evaluation. These were reported in detail by Nwokedi /7/. In this paper regression models developed using the data are presented.

Yam (Dioscorea Rotundata) was planted for two years (1984 and 1985) after mechanical operations. The tuber weight planted was 150 g. The planting spacing in each case was 1 m apart with 2 m discard around the field.

2.3 Measured Parameters.

Soil samples were collected before and after compaction and tillage treatments. These samples were subjected to laboratory analysis. Soil properties determined were moisture content (by the gravimetric method); bulk density (by the core technique) and soil resistance to penetrometer pressure (by the use of a hand held soil penetrometer equiped with a conical probe). Other soil properties derived from the above included porosity and particle density.

Crop performance measurements obtained were sprouting count, and tuber yield. Yam sprouting was determined by counting the number of plants that sprouted after three weeks of planting and after six weeks of planting. This was chosen so as to make sure most planted tubers have sprouted. Besides this, it had to be done at a time when the plants have produced long vines to be counted.

When the crop matured (all the vines completely dried and leaves fall out) the two centre lines in each sub-plot were harvested manually using a digger and knife. They were grouped according to compaction levels and tillage practices. The yams were weighed and converted to tonnes per hectare.

2.4 Statistical Analysis.

Stepwise regression analysis was used to establish relationships between each of the performance parameters and the soil properties. These were carried out using a computer statistical package. The models were selected based on the value of the coefficient of determination (R^2) and whether the equations are statistically significant or not. The performance parameters included yam tuber sprouting (SPC), yam tuber yield (PTY) and contact pressure (CP) and the soil properties were moisture content (MC), bulk density (BD), porosity (Por), particle density (PD) and soil resistance to penetrometer pressure (PR).

3. RESULTS AND DISCUSSION.

3.1 Sprouting.

The relationship between sprouting (SPC) and soil properties was linear and can be represented by:

$$SPC = a + bx_1 + cx_2$$

where a, b, c are regression coefficients which varied with the soil properties and x is the soil property concerned.

Tables 2 and 3 show regression equations developed for sprouting as a function of the soil properties for 1984 and 1985 respectively. The tables show that all the equations had very high R^2 values (72.3 - 74%). The coefficients were also statistically significant at the 1% level of probability.

3.2 Yam Tuber Yield.

Tables 2 and 3 show the equations developed for yield as a function of the soil properties. The relationships were linear. However, the R^2 values were very low and some of the coefficients were not statistically significant at 5% level of probability. Part of the reason for the poor relationship is that there may be other factors that affect yield other than the soil properties.

3.2 Contact Pressure.

Contact pressure was also related to the soil properties as presented in Table 3. The table shows that the relationships were linear. The R^2 values were also high (59%, 33%, 72%) and the coefficients were all significant. Thus, the effect of the contact pressure of a wheel on soil compaction for this soil can be predicted using the equations.

4. CONCLUSIONS.

The relationship between sprouting and soil properties was linear with R^2 values in the range 72 - 74%. Linear relationships were also established between yam yield and soil properties but R^2 values were low in the range of 48%. The relationship between contact pressure and soil properties was also linear with R^2 values from 33 to 72%.

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Table 2. Regression models developed from 1984 data.

REGRESSION EQUATION	R^2	Std Error	F-cal	F-tab 5%	F-tab 1%	
SPC=276.44+133.62BD	72.3	4.1	123.5	3.2	5.3	**
SPC=216.06+94.99BD-2.62PR	74.0	3.9	4.7	3.2	3.2	**
SPC=284.98+115.12BD-2.66PR-0.92POR	74.0	3.9	4.5	2.8	3.2	**
SPC=368.60+3.33BD-2.38PR-1.03POR+6.45MC	73.7	4.0	6.3	4.0	6.2	**
SPC=383.98+16.6BD-2.39PR-1.46POR+8.24MC+14.75PD	73.4	4.0	4.4	2.6	3.6	**

** Significant at $P_{0.05}$; ns = not significant at $P_{0.05}$; Ftab = tabulated F-value; Fcal = calculated F-value; std = Standard; SPC = Sprouting count; BD = Bulk density; POR = Porosity; MC = Moisture content; PD = Particle density; PR = Penetrometer resistance; PTY = Yam yield, t/ha; CP = Contact Pressure

Table 3. Regression models developed from 1985 data.

REGRESSION EQUATION	R^2 %	Std Error	F-cal	F-tab 5%	F-tab 1%	
SPC=216.06+94.99BD-2.63PR	74.0	3.9	123.5	3.2	5.5	**
PTY=29.24-3.05PR+0.24BD-0.12MC	48.0	5.9	1.5	4.0	5.5	ns
CP=60.32+61.7PR+48.39PTY-0.31PD	99.0	0.8	9.3	4.0	5.5	**

** Significant at $P_{0.05}$; ns = not significant at $P_{0.05}$; Ftab = tabulated F-value; Fcal = calculated F-value; std = Standard; SPC = Sprouting count; BD = Bulk density; POR = Porosity; MC = Moisture content; PD = Particle density; PR = Penetrometer resistance; PTY = Yam yield, t/ha; CP = Contact Pressure.

TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

IMAGE PROCESSING IN FOOD TECHNOLOGY

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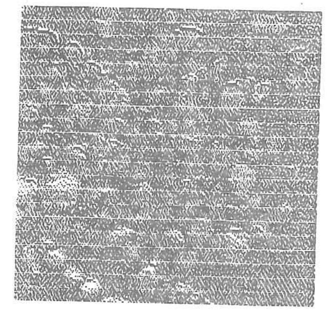
The communication presents an information about possibilities of implementing the progressive field of the computing technique in the food technology. Principles are presented of the concept of systems in proccessing the image information and in the basic field of application in food technology. The application fields chosen are demonstrated on particular possibilities. Procedures for solving the applications are analyzed and examples of existing systems are mentioned. Applications used in the FRIP are shown on examples. The use of methods of the image processing in food technology is shown to be particularly promising in connection with the quality control at all the stages of the food production.

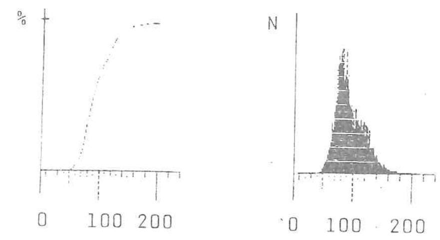
image analysis; image processing; food technology; process control; inspection; computer technique; quality of food

1. INTRODUCTION

Various methods are used in the field of the automatization of production processes and of their optimization. One of very progressive approaches is the processing of the image information. This method, connected with high requirements, is based on operations performed with a two-dimensional image obtained from the scene followed by means of a camera. Depending on the nature of the particular application, either one or several lines, the whole image format or (in the most complicated cases) the reconstruction of the third dimension are used. The last case is, however, already a matter of the computer vision and artificial intelligence.

The image analysis and processing found their applications particularly in military disciplines, in the cosmic research, metallurgy and medicine. Common industrial applications have found their applications only recently. Due to the refinement of the computing technique, the image processing becomes ever more feasible and thanks to the supporting software available, certain simple tasks can be solved almost at a level of PC. The food technology is a field, where the image analysis has only exceptionally found its applications. In spite of this, it is of interest to take advantage of this method in this field. The appearance of the product or also of semiproducts is frequently related to the quality of the final product. The hygienic standpoint is also of interest because of the contactless scanning of the controlling quantity.





Cumulative and distributive histogram of the gray values of all pixels in the image

Fig. 1 Original image of grains of cheese with histograms

2. IMAGE ANALYSIS AND IMAGE PROCESSING

These two groups are connected with each other, with their partial overlap. The image analysis is typically considered as operations resulting in searching for certain objects in the image. Depending on the type of the problem to be solved it is either necessary to quantify these objects, with possible measurements of their parameters, or to locate the position of a particular object in the image field. When we require, in addition to this, an answer to the question what is the extent of the agreement of the object followed with a certain preliminarily determined sample, we enter the field of ispection systems.

Otherwise, all the operations resulting in adjusting the matrix of image points are considered as image processing. This is the use of arithmetic and logic operations, of different operators or transformations. The result of this processing is for example the elimination of the noise in the image, improvement of the contrast and emphasizing of edges, recovery of the lost spatial information.

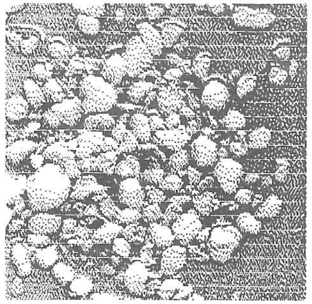
2.1. The hardware necessary for image processing

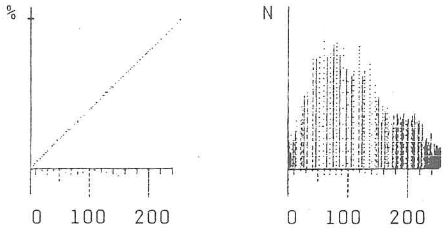
From the standpoint of the system configuration for the analysis of the image information, it is necessary to take into account the purpose of the system. Different approaches are used when forming on the one hand a universal system for the experimental work and, on the other hand, a system for specific applications. The system, however, always principally consists of the following components:

a) a camera - electrooptical transducer; source of electric analog signal modulated by the brightness of the scene scanned
b) a digitalization unit - a transducer producing a digital signal corresponding to the analog prototype
c) an image memory - a special buffer with a large capacity and short access time
d) the computer itself (including control inputs and program library)
e) a monitor - a display unit converting the signal from the image memory to its optical form
f) power outputs - in systems included into technology processes for implementing optimizing interventions into the process

2.2. Programming language and software

In addition to the hardware, it is necessary to provide the processing algorithm, to assemble the program for the computer. For the image processing, image recognition and image analysis, extensive libraries of subprograms were





Cumulative and distributive histogram of the gray values of all pixels in the image

Fig. 2 Enhanced contrast in fig. 1 (after linearisation)

established containing relevant algorithms. FORTRAN is being very frequently used. Its formerly almost exclusive position becomes of importance, again after a several-years retreat in favour of the other languages, as for example PASCAL. Attempts to introduce special higher programming languages (PIXAL) or interpretation languages (PICASSO) were not too successful. Their higher speed was achieved on account of very high requirements for the memory and of many further drawbacks. The language C occupied a special position. This language, which is not very extensive was widely used in the field of the image processing just thanks to its considerable speed of the calculation. However, it also possesses its disadvantages as for example a reduced readability of the program.

3. THEMATIC CIRCLES OF PROBLEMS IN FOOD TECHNOLOGY

The whole food technology is a very diverse combination of many special technologies and it presents a number of important chances for the implementation of the image processing. We will mention several examples for selected fields.

a) grading beef and pork carcasses

The problem of the classification and grading of meat has been solved by many producers of so called objective measurement devices. For this purpose they use different methods (ultrasound, infrared light, etc.) which are characterized by certain specific restrictions. Under defined conditions, they can however, exert better results than the subjective evaluation by the handling personnel. The image processing with the help of a computer can combine advantages of the visual evaluation and of the objectivity of instrumental techniques. Its role in the evaluation of the meat is in the identification and quantification of areas of the lean meat and fat tissue. The problems are given by bones, connective tissue and intramuscular fat (1). When using a black and white system, then also the color of the tissue. It is variable itself and it is changed with time (during drying in air). The intramuscular fat can be corrected with using a relevant factor, the identification of bones inside of the tissue will be made possible by a combination with an X-ray photo, the connective tissue can be more properly differentiated in the UV region of the spectrum.

b) grading poultry carcasses and fish

In the treatment of the other types of meat, it is also possible to find applications for the image processing for grading purposes. The qualitative evaluation of particular pieces at poultry slaughtering lines is still being performed subjectively in spite of the fact that this is the basic

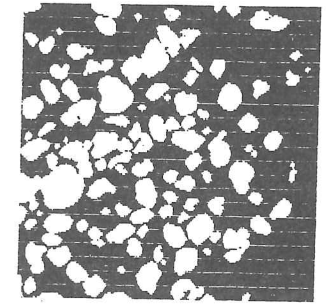


Fig. 3 Discriminated objects

parameter for managing the whole packaging plant. Attempts were made to carry out the automatic determination on the basis of a camera image (2), however, they have not been still completed to be used in operation.

An interesting, ever more urgent problem is grading of the fish according to the species and size, particularly for supplying the market with sea as well as fresh water fishes. The program for solving this task must safely identify particular species with measuring the size of individual specimens. The evaluation should also be independent of elastic deformations of the fish body (3). An automatized camera-controlled system is already available for the production of the fish fillet. This system named Lumetech identifies bones on the basis of the fluorescence in the UV light region.

c) processing of milk, production of cheeses

The course of processing the milk to cheeses calls for the application of the image processing already in the control of the semiproduct, so called curd (see Chapter 5). In the final cheese product, the analysis of its microstructure is of a particular interest (i.e. for example of the size and distribution of fat particles in the mass) together with changes of the structure on maturing and storaging.

d) the size and distribution of particles in powder materials

The determination of the amounts, size and distribution of particles in food materials of powderized nature is important for the laboratory analysis of the instantaneous condition (for example at a certain stage of the production) or of its changes depending on external conditions (temperature, moisture, storage time). This method can be, however, also used for checking the course of the technology process. For example the evaluation of particular fractions of the flour in the grain milling can be used for evaluating the course of the milling process (4) or possibly for comparison of the efficiency of different methods of milling.

Out of the other powderized materials, in the literature, it is particularly possible to find analyses of the starch, of different admixtures (e.g. stabilized vitamins) etc.

e) classification and grading of granular materials

On macroscopic scale, the determination of geometric parameters of grains of different types of cereals, pea, nuts, soya beans, etc., has a similar importance. The quantities ascertained in this way are particularly applicable in the classification, grading, however, also in the direct quality evaluation (5). The identification of anomalous morphology parameters of the given class of grains makes possible the detection not only of non-standard elements but also of different defects (fragments, cracks). For some species (as for example coffee, pistachio) it is more advantageous to performs the analysis beyond the visible region of the spectrum (in the UV band). By using X-rays it is possible to properly differentiate undesirable admixtures (for example small stones).

f) classification of lumped materials

In this field, apperance features are determined, usually the size, shape, color, spots signalizing a damage, etc. These features ascertained on the basis of the analysis of the image can serve for decisions in grading processes in potatoes, different species of fruits and vegetables (for example apples, tomatoes, cucumbers).

g) the control of the packaging and final products

As example, we will mention the industry of drinks, where the image processing can be used for checking the cleanness of or damage to bottles, or proper closure of tins, of the identification of the proper type of the label, of its intact condition and proper position after sticking on the packaging. In products wrapped in foils the perfectness of sealing can be checked.

From this brief listing, it is possible to see a wide variety of possible applications in the food technology. Since the analysis of the image information entering the system by means of the camera offers possibilities of a precise determination on the basis of the measurement, the subjective decision factor is avoided. This is the basic condition for the objective control in automatized processes.

It is to conclude that this spectrum of possible applications of the image processing in the food technology includes the following three directions:

1) the macroscopic classification of food materials
2) the analysis of food microstructures
3) the identification of technology parameters and their use in controlling technology processes

4. THE PROCEDURE IN APPLICATIONS

In each application, it is necessary to start with an unambiguous and precise specification of the problem, or of the function required, with a subsequent consultation with experienced specialists in the field of the image processing. On this basis, a proposal of the technology solution should be provided, not only from the standpoint of the work with the image information such as, but also with respect to the incorporation into the existing technology system, its affecting, etc. After elucidating these problems, it is possible to search for a suitable algorithm of the processing, to write a program for its accomplishing and, whenever possible, to check the function under laboratory conditions, for example on a model. Otherwise, the function should be implemented in situ with checking it directly under real conditions. This results in the target solution.

5. EXAMPLES FROM THE FIELD OF THE FOOD PRODUCTION

The Food Research Institute Prague is also interested in the use of the image analysis in the food industry within the work of the department of the process control. We will present two examples of laboratory applications.

The first one is the analysis of the microscopic image in the brewery production. It is performed for the identification and quantification of small objects dispersed in the liquid. During the beer fermentation, the amount of yeast cells in a certain volume serves as a parameter indicating the course of the fermentation process. After the filtration, the yeast cells are already undesirable and their presence signalizes an improper performance of the filtration process. Further undesirable microorganisms, as e.g. the Lactobacillus are a potential source of a reduced stability of the product. They can be searched for and differentiated on the basis of geometric parameters of objects in the segmented image. The yeast cells fall into the class of circular objects, whereas the above mentioned bacteria exert a distinctly elongate shape. Diatomaceous particles can possibly also be found in the filtrate. Their identification signalizes a failure of the filtration equipment.

The further case concerning the analysis of macroscopic images is from the field of the dairy production. The size of the cheese curd after the milk

processing is an interesting parameter of the quality of the cheese produced. The size and distribution of the curd size in the semiproduct is a governing factor for the product quality and a certain optimum range should be adhered to for a given type of the cheese. Fig. 1 shows a sample of the cheese curd without the whey. In the top part of the figure, in the form of histograms, the distribution is shown of particular levels of the grey shade for all the image points (image matrix 512x512 points, 256 levels of the grey shades). Fig. 2 offers the same view after an intervention improving the total contrast of the photo. The changes in the image matrix are very well obvious from histograms attached. A subjectively more easy differentiation of particular grains is obvious from a comparison of the two figures. The image segmentation by the thresholding will differentiate individual grains in Fig. 2, i.e. the objects searched for (Fig. 3). After their identification, it is possible to measure their area, which is a governing parameter for the evaluation of the sample. The grains can be classed on the basis of the observed size of the area of the grain projection onto the scanning plane or possibly on the basis of their equivalent circular diameter. From the standpoint of the sample preparation the matter disintegration is of importance, making possible the separation of particular grains. The further important circumstance is the illumination of samples with diffuse light preventing the origination of undesirable lustres. They would complicate the processing of the image with presenting requirements for further necessary filtrations. In contrast to this, the choice of a contrast bakground, in the given case most properly black and matte, will bring a simplification.

In both cases, photos obtained by the CCD camera SONY XC77E were used, from the microscope as well as with the help of the macroobjective. The photos were processed with the help of the VIDAS 21 (Kontron) analyzer.

6. CONCLUSION

The purpose of the contribution was to yield a brief information about the method of the image processing and possibilities of its implementation in the food production. Particular fields of the application of the method are outlined. A framework is described of the procedure in particular cases and the approach to solving the subjective determination of the information on interest is shown by way of examples. The method of the image processing is also very promising for the food industry, particularly from the standpoint of the production efficiency and quality. According to prognoses for the 1990´s, a great development of this method in the food industry is to be expected. More rapid development is assumed only in the automobile and electronic industry.

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TRENDS IN AGRICULTURAL ENGINEERING
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STATISTICAL PROCESSING OF FERRODENSIMETRICAL MEASUREMENTS OF RUNNING-IN REGIMES OF TRANSMISSION SYSTEMS OF SMALLTRACTORS FROM THE POINT OF VIEW OF PARTICLE ANALYSIS BY MEANS OF OBJECT ORIENTED PROGRAMMING IN THE SYSTEM SMALLTALK

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On the basis of measured ferrodensimetric values of the area concentration wear particles in the circuit lubrication system of engines it is possible to execute a trend analysis of the wear course and so exactly make a model course of the run-in regime. The specific statistical processing of values was executed using the system Smalltalk by means of object oriented programming.

run-in regime; course of wear; ferrodensimetrical measurement; method of the smallest squares; Taylor's expansion; object oriented programming; Smalltalk system

1. INTRODUCTION

The problems of studying run-in regimes of heat engines include a large spectrum of processes going on in the monitored engine and other factors which influence these processes. It is, therefore, obvious that during the analysis of wear mechanism it is necessary to look at these processes as a set of random events [1, 2], and then evaluate the monitored stochastic system by means of mathematical statistics.

The aim of this analysis is to determine the trend of wear, that is to monitor the wear course of the run-in regimes with the help of suitable diagnostic signals on the basis of a generally formulated mathematical model of run-in regime. As a diagnostic signal, the area concentration wear particles $\mathbf{WPC_d(t)}$ of the size of particles $\mathbf{d}$ dependent on time was chosen.

2. FERRODENSIMETRICAL MEASUREMENT EXECUTED BY MEANS OF IMAGE ANALYSIS

On the basis of the knowledge of a lot of authors [3, 4] a mathematical model of a diagnosed tribotechnical system was derived describing the dependence of area concentration wear particles dispersed in the circuit lubrication system and some other factors on time, in the form of a non-homogeneous linear differential equation of the second order

$$\frac{1}{\omega_d} \cdot \frac{d^2 WPC_d(t)}{dt^2} + \frac{2\xi}{\omega_d} \cdot \frac{dWPC_d(t)}{dt} + WPC_d(t) = \lambda \cdot \tau \cdot \frac{dP(t)}{dt} + \lambda \cdot P(t), \quad (1)$$

whose solution is the analytic notation of the dependence of explored quantitie. diagnosing the course of run-in.

Within the framework of experiments carried out, two types of gear systems of the smalltractors MT8-50 and MT8-157, the samples of lubricants obtained in precisely determined instants of time t_i were processed ferrographically and evaluated using the automatic system (Olympus CUE Image Analyzer) of image analysis.

The ferrographic trace on the ferrogram of the prepared sample was scaned with the microscope, the image was transfered by camera and then automaticaly evaluated using special software (Densitometry software, Planomorphometry software, Color image analysis software CUE-3 and Research level software CUE-4) of the computer system. In this way a wide set of data of area concentration wear particles $\mathbf{WPC_d(t)_i}$ correlated to the volume unit of the obtained sample of the exploited medium of lubrication dependent on time was obtained.

3. STATISTICAL EVALUATION OF RUNNING-IN TREND

Analytical dependence from the relation (1) is formulated with the function in the form

$$WPC_d(t) = \lambda \cdot \tau \cdot \frac{\omega_d}{\sqrt{1-\xi^2}} \cdot \exp\left[-\xi\omega_d t\right] \sin\left[\omega_d\sqrt{1-\xi^2}\, t\right] + $$
$$+ \lambda\left[1 - \frac{1}{\sqrt{1-\xi^2}} \exp\left[-\xi\omega_d t\right] \sin\left[\omega_d\sqrt{1-\xi^2}\, t + \varphi\right]\right], \quad (2)$$

where

$$\varphi = \mathrm{arctg}\left(\frac{\sqrt{1-\xi^2}}{\xi}\right).$$

In the presumption, that the brake horse power is constant, the coefficient of time change engine power τ is equal to zero and the equation (2) is very simplified. Consequently the first part of the above mentioned equation takes the zero value.

3.1. The nonlinear approximation with the help of the method of the smallest squares

The approximation function (2) is possible to express as a dependence $WPC_d(t)_i = f(t_i, c_j)$, where c_j are unknown parameters and $j = 0, 1, \dots, m$. For the purpose of clarity, we will further mark $\lambda = c_0$, $\tau = c_1$, $\xi = c_2$, $WPC_d(t)_i = y_i$ and the ideas of the process of deducing is described generally.

Presupposing on, that the parameters c_j are known, so for each t_i we can determine $f(t_i, c_0, \dots, c_m)$ as well as the residuum

$$r_i = f(t_i, c_0, \dots, c_m) - y_i, \qquad i = 0,1,\dots,n, \tag{3}$$

where y_i are measured values of the approximation function. The real residuum r_i however is not possible to execute, because we do not know the coefficients c_j in reality. The problem is then to determine the approximation coefficients and the residuum

$$R_i = f(t_i, {}^0c_0, \dots, {}^0c_m) - y_i, \qquad i = 0,1,\dots,n, \tag{4}$$

where ${}^0c_0, \dots, {}^0c_m$ are the starting estimates of coefficients c_j, and these can be determined with the graphical method or estimated from the knowledge of the solved problem.

Using Taylor's linear expansion, the approximation function then has the standard form

$$f(t, c_0, \dots, c_m) \cong f(t, {}^0c_0, \dots, {}^0c_m) + \frac{\partial f}{\partial c_0}(c_0 - {}^0c_0) + \frac{\partial f}{\partial c_1}(c_1 - {}^0c_1) + \dots + \frac{\partial f}{\partial c_m}(c_m - {}^0c_m). \tag{5}$$

If we calculate the mentioned expression for the values in each t_i and subtract y_i from both sides of the mentioned equation, we find the relation between r_i and R_i. We denote

$$\frac{\partial f_i}{\partial c_j} = \frac{\partial f}{\partial c_j}\Bigg|_{t = t_i;\ c_j = {}^0c_j}$$

then we can write the obtained result (5) in the form

$$\underbrace{f(t_i, c_0, \dots, c_m) - y_i}_{r_i} = \underbrace{f(t_i, {}^0c_0, \dots, {}^0c_m) - y_i}_{R_i} + \frac{\partial f_i}{\partial c}(c_0 - {}^0c_0) + \dots + \frac{\partial f_i}{\partial c_m}(c_m - {}^0c_m), \tag{6}$$

where $i = 0, 1, \dots, n$, then

$$Q = \sum_{i=0}^{n} r_i^2 = \sum_{i=0}^{n} \left[R_i + \frac{\partial f_i}{\partial c_0} \Delta c_0 + \dots + \frac{\partial f_i}{\partial c_m} \Delta c_m \right]^2 . \tag{7}$$

For the estimate of coefficients c_j with the method of the smallest squares it applies that $Q(\Delta c_0, \dots, \Delta c_m) = \min$.

$$\frac{\partial Q}{\partial \Delta c_j} = 2 \sum_{i=0}^{n} \left[R_i + \frac{\partial f_i}{\partial c_0} \Delta c_0 + \dots + \frac{\partial f_i}{\partial c_m} \Delta c_m \right] \cdot \frac{\partial F}{\partial \Delta c_j} = 0, \tag{8}$$

and $j = 0, 1, \dots, m$, where

$$F = \frac{\partial f_i}{\partial c_0} \Delta c_0 + \dots + \frac{\partial f_i}{\partial c_m} \Delta c_m$$

is a total differential of the approximation function (5). Substituting

$$\frac{\partial F}{\partial \Delta c_j} = \frac{\partial f}{\partial c_j}$$

into (8) and multiplying each term in the square brachet by the mentioned term we get equation (8) in the form

$$\frac{\partial Q}{\partial \Delta c_j} = 2 \sum_{i=0}^{n} \left[\frac{\partial f_i}{\partial c_j} \cdot R_i + \frac{\partial f_i}{\partial c_j} \frac{\partial f_i}{\partial c_0} \Delta c_0 + \frac{\partial f_i}{\partial c_m} \frac{\partial f_i}{\partial c_0} \Delta c_m \right], \tag{9}$$

where $j = 0, 1, \dots, m$, and after a conversion into the matrix form for $m = 2$ we obtain

$$\begin{bmatrix} \sum\limits_{i=0}^{n} \left(\frac{\partial f_i}{\partial c_0}\right)^2 & \sum\limits_{i=0}^{n} \frac{\partial f_i}{\partial c_0} \frac{\partial f_i}{\partial c_1} & \sum\limits_{i=0}^{n} \frac{\partial f_i}{\partial c_0} \frac{\partial f_i}{\partial c_2} \\ \sum\limits_{i=0}^{n} \frac{\partial f_i}{\partial c_1} \frac{\partial f_i}{\partial c_0} & \sum\limits_{i=0}^{n} \left(\frac{\partial f_i}{\partial c_1}\right)^2 & \sum\limits_{i=0}^{n} \frac{\partial f_i}{\partial c_1} \frac{\partial f_i}{\partial c_2} \\ \sum\limits_{i=0}^{n} \frac{\partial f_i}{\partial c_2} \frac{\partial f_i}{\partial c_0} & \sum\limits_{i=0}^{n} \frac{\partial f_i}{\partial c_2} \frac{\partial f_i}{\partial c_1} & \sum\limits_{i=0}^{n} \left(\frac{\partial f_i}{\partial c_2}\right)^2 \end{bmatrix} \cdot \begin{bmatrix} \Delta c_0 \\ \Delta c_1 \\ \Delta c_2 \end{bmatrix} = \begin{bmatrix} -\sum\limits_{i=0}^{n} \frac{\partial f_i}{\partial c_0} R_i \\ -\sum\limits_{i=0}^{n} \frac{\partial f_i}{\partial c_1} R_i \\ -\sum\limits_{i=0}^{n} \frac{\partial f_i}{\partial c_2} R_i \end{bmatrix}. \tag{10}$$

After solving this system of equations we obtain for the convenient chosen initial conditions ${}^0c_0, \dots, {}^0c_m$ the values Δc_j, where $j = 0, 1, \dots, m$. We repeat the solution for the new initial conditions ${}^1c_0 = {}^0c_0 + \Delta c_0$, ${}^1c_1 = {}^0c_1 + \Delta c_1, \dots, {}^1c_m = {}^0c_m + \Delta c_m$, if we don't get the precise enough $|\Delta c_j| < \varepsilon$, $j = 0,1,\dots,m$, where ε is the chosen exactness of the iteration solution.

3.2. The structure of calculation in the flexible system Smalltalk

Smalltalk is ideal for complex problems whose solutions require special features, which aren't contained in usual software environments like spreadsheets, classical programming languages etc. This complex of software tools is very available to the describing of statistical processing of measurements.

Our application is divided into three object parts: a model, a view and a controller. The model provides the storage and processing of data. The view corresponds to the output part of the graphical user interface and the controller manages the user input [7, 8].

We are using the standard views and controllers of the system. It means, we need not write the code for creating them. The model part is written as one object class named **WPC** with some methods (procedures) [9]. They are five methods:

1) class method **new** which contains instance creation,
2) instance method **windowOpen** which opens the application window,
3) instance method **readData** which prompts the data from user,
4) instance method **exec** which computes the data,
5) instance method **display** which displays output data into graph.

MT8-050

Parameters A: $lambda_A$ = 16.351, $omega_{dA}$ = 0.301, ksi_A = 0.129

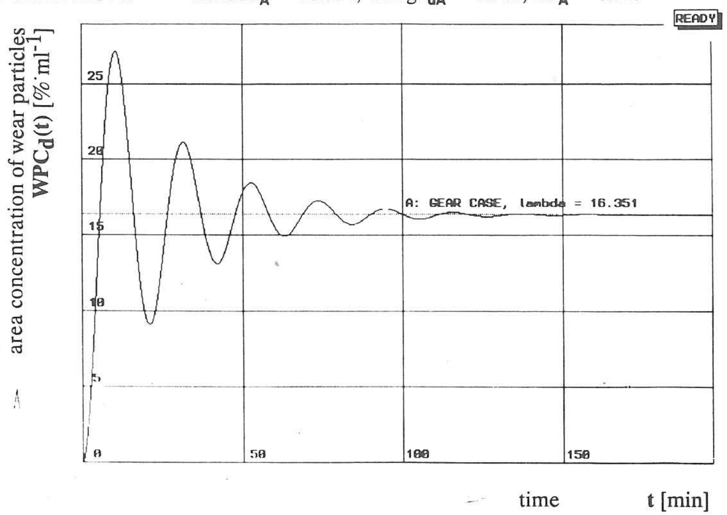

Fig.1 : Dependence of area concentration wear particles with the measurements **d ∈ <1, 15>** μm generated in the running-in regime on the time; smalltractor **MT8-050**.

MT8-157

Parameters A: $lambda_A$ = 14.794, $omega_{dA}$ = 0.215, ksi_A = 0.503
Parameters B: $lambda_B$ = 12.389, $omega_{dB}$ = 0.320, ksi_B = 0.389
Parameters C: $lambda_C$ = 9.622, $omega_{dC}$ = 0.265, ksi_C = 0.722
Parameters D: $lambda_D$ = 7.164, $omega_{dD}$ = 0.113, ksi_D = 0.932

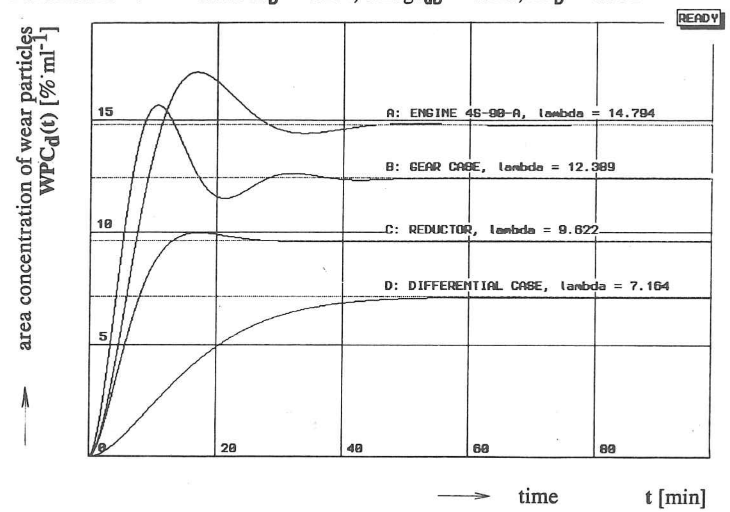

Fig.2 : Dependence of area concentration wear particles with the measurements **d ∈ <1, 15>** μm generated in the running-in regime on the time; smalltractor **MT8-157**.

4. DISCUSSION

The analytical course of the explored dependences are described by Fig.1 and Fig.2. As is evident from the course of the regression curves, the coefficient determines the level of concentration wear particles, to which the function values $\mathbf{WPC_d(t)_i}$ in the course of time converge. The generation of particles of a properly running-in regime in accordance with the theoretical assumptions [5, 6] is steadied on this level.

5. CONCLUSIONS

The tribological processes between two moving surfaces generally lead to losses of material from the system. Phenomenologically, the measured data of material losses, which are valid for conditions of hydrodynamic sliding, show that from the study of area concentration wear particles $\mathbf{WPC_d(t)}$, important information on the operating wear running-in mode and the actual condition of the structure of transmission systems of smalltractors can then be obtained.

Based on this fact, a statistical trend analysis of the imminent behaviour of machinery by means of object oriented programming in the system Smalltalk was undertaken.

The dynamical equilibrium of systems is represented by the convergence of the diagnosed value (see Fig. 1 and Fig. 2) and it is possible to claim that the running-in regimes come to the end from the point of view of the material balance of the systems.

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Appendix

Nomenclature:

Δc_j	differences between starting estimates and calculate value of parameters of approximation function ($j = 0, 1, 2$)
c_j	unknown parameters of approximation function ($j = 0, 1, 2$)
d	size of wear particles (µm)
F	total differential of the approximation function
P(t)	engine power dependent on time
Q	square of the residuum of the approximation function
r_i	residua of the approximation function ($i = 0, 1,..., n$)
R_i	residua of starting estimates of the approximation
t	time (min)
$WPC_d(t)$	area cocentration wear particles on time of the size of particles d dependent on time ($\%.ml^{-1}$)
$WPC_d(t)_i$	measured function values $WPC_d(t)$ ($\%\ ml^{-1}$)

Greek symbols:

ε	exactnees of the iteration solution
λ	coefficient of the wear level
ξ	coefficient of the separation
τ	coefficient of the time change engine power
ω_d	velocity of formation wear particles of the size of particles d (s^{-1})

TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

THE LONGITUDINAL SEED DISTRIBUTION OF SOME DELIVERY MECHANISMS IN TURKEY

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In this study, the longitudinal seed distribution patterns of some delivery mechanisms made in Turkey were determined by the new scaling-recording system aided by PC.

Finally, the internal double-run seed-delivery mechanism resulted in better distribution, especially at low seed rate according to the hoozier system fluted-wheel seed-delivery mechanism and the oblique fluted-wheel seed-delivery mechanism.

Keywords: Seed, longitudinal distribution, delivery mechanism, distribution pattern

1. INTRODUCTION

The purpose of the sowing proses is the distribution of a certain quantity of seeds over a given area and, finally for cereals, the placement at a certain depth in the seedbed. The description of the distribution in the horizontal plane can be based on the so called distances between nearest neighbour seeds (1).

With a given seed rate the land area per plant is also fixed. But, with including the negative effects of plants upon other neighbour plants, the shape of groving area is important from standpoint of yield (2).

With drilling technique, the seed distribution in the horizontal plane depends on the transverse and longitudinal distribution patterns are also generated by the delivery mechanism, firstly (3, 4).

Drilling machines had been used in the early 1900s, firstly. In the early years drilling machines had been got by

way of exporting. From the 1940s, home-made drills have been used widely in Turkey.

In this study, three home-made mechanical delivery mechanisms were researched and their longitudinal seed distribution patterns were determined by the new scaling-recording system and these mechanisms were compared.

2. MATERIALS

Seed delivery mechanisms researched in this study were:

1. The hoozier system fluted-wheel seed-delivery mechanism (DM1)
2. The oblique fluted-wheel seed-delivery mechanism (DM2)
3. The internal double-run seed delivery mechanism (DM3)

Delivery mechanisms were carried out using Kose 220/39 wheat variety (thousand kernel weight: 33 g).

3. METHODS

Tests were carried out on the test stand in which drilling machines can be operated at different forward speed by varying the rotation speed of its rools. During these tests forward speed were 1,5 m/s. The material flowed from seed delivery mechanism were continiously weighed cumulatively by the balance and the data were transmitted to personel computer in a continious stream by the RS-232 C interface circuit of the balance (5).

The balance is can automatically weigh in accuracy of 0,01 g and its transfers rates are selectible (from 300 to 4800 baud).

The time of scaling-recording was selected as 1/10 second in order to weigh the material flowing onto the row of 11,5 cm.

The data determined cumulatively for each replicate were saved by PC. After having been ordered by the programme written in accordance with FORTRAN 77, the material amounts flowed at each scaling interval were determined in weight.

The tests were carried out at the forward speed of 1,5 m/s for three seed rates (approximately 10 kg/da, 15 kg/da and 20 kg/da) with three replicates. The replicates were taken from the same delivery unit for each machine. For each replicate the scaling values of 200 number were taken from the balance at least.

Mean ($\bar{x}$), standart deviation (S), coefficient of variation (%CV) values and frecans tabulations were saperately determined with STATGRAF for each replicate. In addition, analyses of variance and LSD test at the 5% level of probability were used to analyse the coefficient data of variation and thus, compare delivery mechanisms. HARWARD GRAPHICS was used for draving of the column graphics.

During the tests the balance was just placed under delivery units, clean seed of wheat was used, seed boxes was filled half and pressures of tires were the same.

4. RESULTS AND DISCUSSION

According to analyses of variance (Table 1), all the factors were significantly different from satandpoint of varying of seeds flowed for each scaling interval (P< 0,01). In the other terms, the longitudinal distribution were influenced significantly by the types of seed delivery mechanisms and seed rates. But, the performances of seed delivery mechanisms were not affected from the interactions between mechanism and seed rate. Therefore, it can be explained that the individual effects of these factors don't depend on the other factor.

Table 1. Analyses of variance

Source of Variation	Degrees of Freedom	Sum of Squares	Mean Square	F-Value
Mechanism (M)	2	642,53	321,26	6,23**
Rate (R)	2	1095,96	547,98	10,63**
Interaction (MxR)	4	428,25	107,06	2,07
Error	18	927,14	51,51	
Total	26	3093,90		

** : Indicates significiance at the 1% level of probability

The seed delivery mechanism generated the best longitudinal distribution was the internal double-run mechanism (Table 2). With this mechanism, the mean value of variation coefficient (%CV) was 10,7. Whereas, with the hoozier system and the oblique fluted-wheel seed-delivery mechanisms, the mean values were 22,6 and 15,7 respectively.

With respect to seed-rates, the more increasing the seed-rate was, the better the longitudinal distribution was (Table 2). This was determined especially for fluted-wheel delivery mechanisms. The longitudinal distribution was quite bad for the hoozier system fluted-wheel delivery mechanism generally. Whereas, with the oblique fluted-wheel delivery mechanism, it was bad for the lowest seed rate only. This can be concluded from example column graphics (Figure 1).

Table 2. Comparison of variation sources

Source of Variation	% CV			
Delivery Mechanism 1 (DM1)	22,6	a		
Delivery Mechanism 2 (DM2)	15,7		ab	
Delivery Mechanism 3 (DM3)	10,7			b
Seed Rate 1 (10 kg/da)	25,3	a		
Seed Rate 2 (15 kg/da)	12,9		b	
Seed Rate 3 (20 kg/da)	10,9		b	

+ Means within each column not fallowed by the same letter are significantly different at the 5% level as judged by LSD test

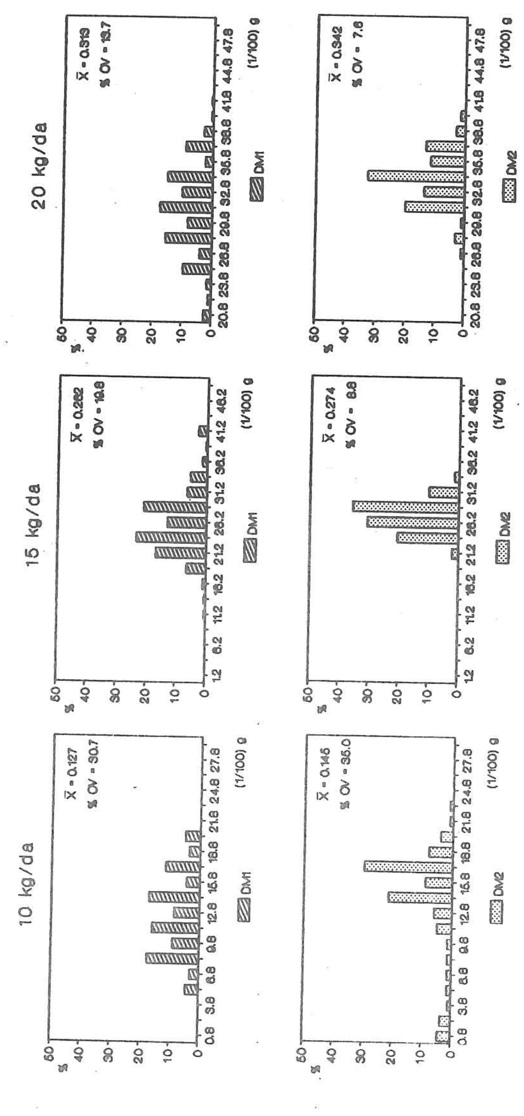

Figure 1. Example column graphics for different mechanisms and seed-rates

5. CONCLUSION

With the internal double-run delivery mechanism in which seed rate is adjusted by varying the rotation speed of shaft, the longitudinal distribution was better. In addition, oblique flutes improved the longitudinal distribution. But, some parameters such as wheel diameter, rotation speed, flute diameter must be determined suitably for fluted-wheel delivery mechanisms in order to generate the longitudinal distribution uniformly.

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TRENDS IN AGRICULTURAL ENGINEERING
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A CONTRIBUTION ON APPLE BRUISING

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Six Czechoslovak apple varieties assortment were thoroughly analysed in relation to their bruising-proneness. Mechanical properties of surface fruit layer were verified by help of penetration test, and cell flesh structure under the skin was examined by optical microscopy. The results show that the intervarietal differences in fruit bruising-proneness consist mainly in different course of changes of cell size from the skin up to the centre of fruits. Varieties in which extreme growth of the sizes of cells occurs, are characterized by high susceptibility to bruising.

apples; mechanical properties of surface layer of fruits; penetration; bruising-proneness; fruit skin and flesh; size of cells

One of the most important obstacles to mechanized picking of apples is the danger of their mechanical damage. Even a very small damage - bruising may decrease consumption quality of the fruits thus limiting their storage life. Nevertheless the bruising may be inflicted even by small forces experienced in manual picking. There are very important differences as to the susceptibility of fruits to the bruising and for this susceptibility a general concept of bruising-proneness is introduced; this concept comprises the whole set of properties like textural properties, kind and intensity of physiological reactions induced by pressure, ability of cell recovery after mechanical loading, etc.

In this paper we follow up with two previous papers /1,2/ describing the research of mechanical properties of skin and flesh of fruits of the nine varieties of Czechoslovak apple assortment. In this paper, we will concentrate ourselves to the relatively thin layer of flesh under the skin which, as found in both previous papers, determines the characteristic of fruits as to bruising-proneness.

1. MATERIALS AND METHODS

For the experiments the following varieties has been used: Jonagold, Florina, Starkrimson Delicious, Golden Delicious, Ontario, and Mc Intosh, all grown in experimental orchards of the Institute for Fruit Research and Improving in Holovousy. The fruits picked in the state of consume ripeness have been stored in cold store; the tests has been made in December 18 to 22,1989.

The testing has been made on several groups of fruits. The first group consisting of 3-5 fruis served for estimation of dry matter content in the skin c_{ss} and in the flesh c_{sd} (in the layer about 10 mm thick under the skin). The dry matter content has been estimated by gravimetrical method after the separation of the respective part from the fruits. The second group consisting of about 10 fruits has been used for testing of mechanical properties of fruit surface layer on insolated (OS) and uninsolated (NS) side of the fruit.

The method used for testing is described on Figure 1. By a longitudinal cut the fruit has been divided into insolated and uninsolated side and both these sides has been tested by indentation of flat faced steel cylinder according to Figure 1a. The indentation has been made with constant velocity 0,167 mm/sec using deformation instrument Instron,up to the moment of steep decrease of deformation force (see F_{p2} in Figure 1b). From the deformation curves (Figure 1b) the characteristics for the first damage of fruit has been derived: mean pressure on cylinder face σ_{p1} and relative indentation x_{p1}/d , and for fruit piercing σ_{p2} and x_{p2}/d. At the same time the so-called penetration or fictive modulus of elasticity E_f. After the deformation tested parts of fruits have been stored for 24 hours in room temperature and then cut through the centers of bruises with the aim to measure dimensions of the bruise d and z respectively, according to Figure 1c. During 24 hours after the deformation the bruise will turn brown and thus these dimensions may be easily measured. The dimensions of the bruise have been characterized by the values d/d , z/d , and V/d^3

The third and last goup of fruits served for the microscopic measurement of cell structures in the flesh below fruit skin. Using the microtome, several slices perpendicular to the fruit surface has been cut from each part of the fruit (OS and NS) (see Figure 2). The slices has been stained by safranine and about five slices analyzed under the microscope. The dimension of cells in the flesh in areas outside the veins is dependent on the distance x from fruit surface. This has been the reason for characterizing of this dependency by counting number of cells on the length of 1 mm on several places (6-8) with different distances from fruit surface. This measurement has been repeated for each distance from the surface on several slices 15 times in total.

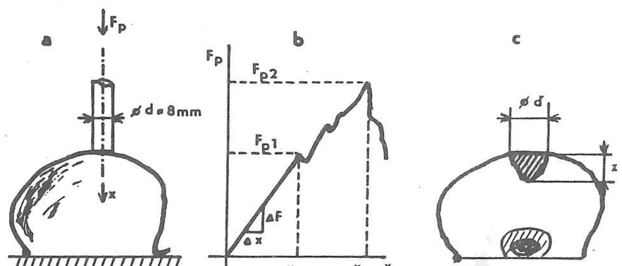

Fig.1. Schematic representation of penetration test; a- penetration test arrangement, b- deformation curve (definition of quantities) :

$\sigma_{p1} = \frac{4\,F_{p1}}{\pi\, d^2}$; $\sigma_{p2} = \frac{4\,F_{p2}}{\pi\, d^2}$; $E_f = \frac{F}{x\; d}$, c- cross-section of the with a bruise and estimation of bruise volume V (presuming that the bruise is of cone form):

$$V = \frac{\pi\, d^2}{12} \cdot z$$

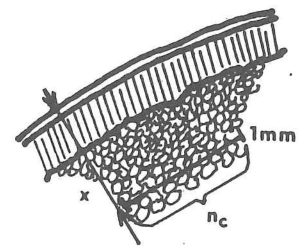

Fig.2. Schematic drawings of skin and flesh cuts - representation of subtraction of the n_c cell number on the line segment of 1 mm in the distance of x from the fruit surface.

2. RESULTS

The measured values are given on Table I and Table II. Table I contains the test results of mechanical characteristics of fruit surfaces, while Table II contains the data of dry matter content in the skin and flesh and basic data of the dimensions of bruises resulting from mechanical testing of fruits. The dependence of numbers of cells located within 1 mm (n_c) on the distance from fruit surface (x) is illustrated for two different varieties on Figure 3. From this figure it may be seen that the decrease of n_c with x is more slower in Starkrimson Delicious variety than in Ontario variety.

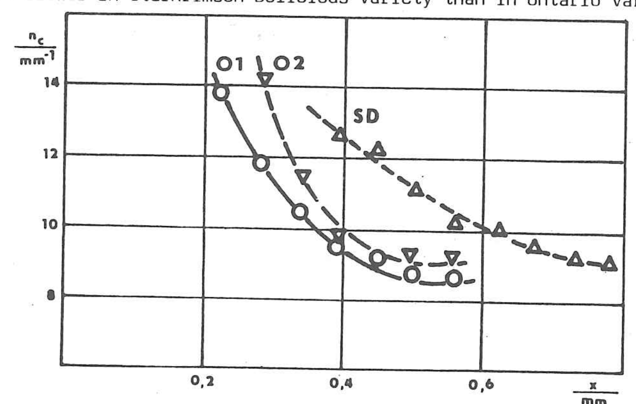

Fig.3. Examples of measured dependences of cell number per 1 mm (n_c) on the distance of measured place (x) from the insolated fruit surface. Mean values are plotted for two variants of the Ontario variety (O1 and O2) and the Starkrimson Delicious variety one (SD). Plotted dependences according to relation (1) are fully described in Table III.

3. DISCUSSION

The measured values n_c (see Figure 3) has been approximated by the equation

$$n_c = a + b\, c^{-kx}$$

where a,b and k are parameters and x is the distance of measured place from the fruit surface. The values of parametrs a, b, and k obtained from the respective measurements are given on Table III. Examples of these relations are in the graphs on Figure 3. It seems that for the majority of examined samples the number of cells on 1 mm of length in larger distances from

Tab.I. Mean values (s.h.) and coefficients of variation (v.k.-given in %) of the quantities measured within mechanical testing of the fruit surface

variety	den.[+]	x_1/d		x_2/d		$\frac{\sigma_1}{MPa}$		$\frac{\sigma_2}{MPa}$		E_f	
		s.h.	v.k.	s.h.	v.k.	s.h.	v.k.	s.h.	v.k.	s.h.	v.k.
JONAGOLD	OS	0,126	18,6	0,356	14,2	0,407	16,7	0,672	8,3	2,56	18,5
	NS	0,133	24,5	0,322	19,0	0,408	13,3	0,605	10,9	2,49	22,2
	C	0,130	21,5	0,339	16,9	0,407	14,7	0,638	10,8	2,53	19,8
FLORINA	OS	0,162	21,3	0,354	11,2	0,725	23,2	1,077	14,6	3,45	13,8
	NS	0,153	17,3	0,312	10,8	0,715	22,2	1,023	10,8	3,55	14,4
	C	0,158	19,2	0,333	12,6	0,720	22,1	1,050	12,8	3,50	13,8
STARKRIMSON DELICIOUS	OS	0,163	37,7	0,333	12,2	0,688	23,4	1,048	16,1	3,68	24,2
	NS	0,135	16,3	0,317	17,5	0,683	17,1	1,143	8,0	4,18	15,0
	C	0,149	31,6	0,325	14,8	0,685	20,0	1,096	12,8	3,93	20,2
GOLDEN DELICIOUS	OS	0,179	23,6	0,336	13,9	0,505	22,8	0,679	14,1	2,32	18,5
	NS	0,170	29,8	0,319	17,0	0,477	17,7	0,648	15,8	2,45	27,4
	C	0,174	26,2	0,327	15,3	0,491	20,3	0,672	15,0	2,38	23,2
ONTARIO	OS	0,113	23,5	0,379	16,1	0,364	48,8	0,837	18,5	2,53	36,2
	NS	0,104	16,4	0,424	14,1	0,297	34,9	0,729	16,1	2,33	25,6
	C	0,108	20,5	0,401	15,7	0,330	43,6	0,783	18,5	2,43	31,3
MC INTOSH	OS	0,146	32,1	0,422	9,5	0,398	27,2	0,770	10,5	2,26	20,6
	NS	0,149	38,5	0,414	9,8	0,337	30,1	0,693	7,6	1,95	15,9
	C	0,148	34,6	0,418	9,5	0,368	29,0	0,731	10,5	2,12	19,9

[+]denomination:OS-insolated side, NS- uninsolated side, C-both sides totally; E_f- fictive modulus of elasticity

Tab.II. Dry-matter content in skin (c_{ss}) and in flesh (c_{sd}) and mean values (s.h.) and the coefficient of variation (v.k.) of the values which characterize the sizes of bruises (see Fig. 1c)

variety bruising-proneness	den.[+]	$\frac{c_{ss}}{\%}$	$\frac{c_{sd}}{\%}$	d'/d		z/d		V/d^3	
				s.h.	v.k.	s.h.	v.k.	s.h.	v.k.
JONAGOLD	OS			1,30	5,1	0,678	11,9	0,303	20,0
more	NS			1,28	4,3	0,606	12,0	0,259	17,0
resistant	C	26,9	11,5	1,29	4,7	0,642	13,0	0,281	19,9
FLORINA	OS			1,14	4,1	0,612	11,4	0,203	15,5
more	NS			1,14	4,1	0,590	6,4	0,201	11,8
resistant	C	24,2	10,3	1,14	4,0	0,601	9,3	0,202	13,5
STARKRIMSON	OS			1,20	6,6	0,656	14,4	0,248	26,7
DELICIOUS	NS			1,15	5,1	0,625	9,4	0,222	13,6
more resistant	C	25,4	11,6	1,17	6,1	0,641	12,2	0,235	22,1
GOLDEN	OS			1,25	5,6	0,646	12,1	0,268	20,3
DELICIOUS	NS			1,27	7,6	0,675	12,9	0,290	27,4
susceptible	C	29,5	14,6	1,25	5,0	0,661	12,4	0,279	24,1
ONTARIO	OS			1,45	8,8	0,755	17,6	0,420	28,7
more	NS			1,63	11,4	0,898	17,9	0,641	32,4
susceptible	C	27,3	12,2	1,54	11,8	0,826	19,5	0,499	29,5
MC INTOSH	OS			1,54	7,5	0,775	10,9	0,486	20,7
susceptible	NS			1,53	7,3	0,719	9,4	0,442	21,5
	C	29,9	11,0	1,54	7,2	0,747	10,7	0,462	21,1

[+]denomination: OS- insolated side, NS- uninsolated side, C- both sides totally

fruit surface is about 8. The decrease of n_c with growing value of x is dependent mostly on the parametr k .

The relations between the measured values are described by correlation coefficients of mean values on Table III. It may be assumed from the data on this table that the volume of bruise V may be considered to be measure of bruising-proneness. This volume increases with the depth of penetration test x_2/d as witnessed by the value of corelation coefficient 0,92 . According to Table IV, bruising-proneness decreases with increasing values x_1/d, and particularly σ_1 which can thus be used as a measere of fruit bruising resistance in our tests. As to the structure of fruit, most important for bruising resistance is the thickness of cuticule t_c and the rate of decrease of n_c with increasing distance of measured place from fruit surface given by parametr k . The results prove that the fruits with slow rate of n_c decrease and small k have low volume of bruises and vice versa.

The results obtained up to the present has shown that the bruising-proneness of fruit may be tested by indentation of the cylinder to the side of fruit and measuring the stress σ_1, corresponding to the first cracking of the fruit. Nevertheless in real tests , the finding of this point on deformation curve may be very complicated. This point is characterized in various ways - from small non-linearity with inflex point up a distinct and characteristic peak.

The differences for various quantities between the insolated and uninsolated side of the fruit are always existing, but generally within the limits of statistical uncertainty. There are, however, some exceptions like fictive modulus of elasticity in the variety Starkrimson Delicious which is definitely lower on the uninsolated one. On the insolated side of the fruit the value n_c for the area close to the surface has been lower than on the uninsolated side. On Table V the regression relations between various quantities are given, selected according to their importance for bruise-proneness. It is clear from this table that the tighter and in most cases steeper relations exist on the uninsolated side of the fruit in comparison with the insolated one.

Tab.III. Regression of the n_o-x data by means of the relations $n_c = a + b\,e^{-bx}$ Nonlinear regression analysis was done numerically by help of the Minuit programme /3/.

variety	denomination	SFC %	a	b	k
JONAGOLD	OS	1,13	8,37	61,3	8,85
	NS	1,14	8,19	50,4	8,29
FLORINA	OS	3,03	5,90	17,5	2,54
	NS	0,81	8,26	22,9	4,83
STARKRIMSON DELICIOUS	OS	1,59	7,72	19,2	3,48
	NS	0,97	3,69	15,6	1,38
GOLDEN DELICIOUS	OS	0,88	8,06	36,7	6,47
	NS	1,33	8,12	36,1	6,63
ONTARIO 1	OS	3,35	8,16	41,9	8,91
	NS	0,73	8,24	35,6	8,69
ONTARIO 2	OS	2,22	8,94	300,0	14,55
	NS	0,89	8,47	108,8	11,27
MC INTOSH	OS	1,72	8,32	35,4	7,09
	NS	2,18	8,63	56,5	9,51

Tab.IV. Correlation coefficients of the relations between mean values of the measured quantities. Only correlation coefficients of statistically significant are given (at 5% level of significance)

	x_2/d	σ_1	σ_2	E_f	d'/d	z/d	V/d^3	c_{ss}	c_{sd}	a	b	k
x_1/d	-0,56	0,62			-0,64	-0,69	-0,69					-0,61
x_2/d		-0,71		-0,62	0,93	0,87	0,91					0,57
σ_1			0,81	0,80	-0,89	-0,76	-0,82	-0,68		-0,66	-0,72	-0,86
σ_2				0,91	-0,56			-0,76		-0,70	-0,61	-0,66
E_f					-0,74	-0,56	-0,64	-0,82		-0,77	-0,62	-0,77
d'/d						0,93	0,98	0,57		0,57	0,65	0,73
z/d							0,98				0,59	0,62
V/d^3											0,63	0,65
c_{ss}									0,56			
c_{sd}												
a											0,57	0,77
b												0,84

Tab.V. Parameters of linear regression relations of the $y=a'+b'x$ type between the most important quantities (the variable y is quality at respective line and an x quantity at respected column)

		σ_1 / MPa: a´	b´	r	k / mm^{-1}: a´	b´	r	x_2/d: a´	b´	r
V/d^3	OS	0,609	-0,550	-0,833			-	-0,781	3,005	0,888
	NS	0,802	-0,907	-0,836	0,068	0,044	0,756	-0,803	3,285	0,950
	C	0,720	-0,754	-0,815	0,154	0,028	0,655	-0,802	3,195	0,913
σ_1 / MPa	OS				0,750	-0,034	-0,840			-
	NS				0,810	-0,049	-0,908	1,405	-2,616	-0,822
	C				0,770	-0,040	-0,857	1,462	-2,704	-0,714
k / mm^{-1}	OS									-
	NS							-9,034	44,963	0,756
	C							-9,617	46,570	0,572

4. CONCLUSIONS

It has been proved that the mechanical qualities and bruising susceptibility of apple fruits are dependent on the rate of change of fruit flesh cell size close to the skin with relation to the depth below the fruit surface. The radial changes of flesh rigidity observed in apple flesh has been explained by the changes in cell sizes. It has been proved that the indicator of bruising-proneness of apple fruits is a force corresponding with the first appearance of damage in the indentation test.

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TRENDS IN AGRICULTURAL ENGINEERING

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ON THE NEED FOR STUDIES ON MECHANICAL DAMAGE TO WHEAT GRAIN

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The paper presents information on the major causes of mechanical damage and its identification in wheat grain. The authors present results of studies carried out so far, based on the X-ray and colorimetric methods, and indicate the need for undertaking comprehensive studies on the phenomenon of wheat grain damage and on the assessment of wheat grain susceptibility to damage of this type, in the aspect of the technological and breeding value of wheat.

wheat grain, damage, measurement methods, colorimetry, X-ray radiography

1. INTRODUCTION

In the world cereal economy wheat (*Triticum*) is considered as the most valuable cereal, due to its specific technological and nutritional properties /8/. Hence the interest of researchers is concentrated mainly on the physical phenomena that accompany the process of development of the grain and its utility value /1-4, 7, 9, 10, 12/.

One of the most intangible phenomena related to wheat grain ever since its ripening stage under field conditions, through harvesting and post-harvest processing (drying, cleaning, sorting etc.), until its processing, is the occurrence of mechanical damage /2, 3, 7, 8, 11/. The significance and extent of the problem is reflected in the abounding literature of the subject. So far, however, neither Polish nor foreign research provided sufficiently comprehensive theoretical knowledge of the problem, that would allow for the introduction of criteria of mechanical damage to grain into the quality requirements for cereals.

2. THE OCCURRENCE OF MECHANICAL DAMAGE

Mechanical damage can be defined as a state of disturbance of the natural continuity of particular tissues of the kernels, resulting from the destructive effect of external forces (harvest, transport) and/or internal stresses which may be caused by the gradient of moisture in the process of intensive wetting or drying of grain. Particular attention should be paid to the phenomenon, so far neglected by researchers, of the occurrence of internal cracks in grain during the pre-harvest period, which in consequence aggravates the effects of mechanical damage to grain in the course of harvest and in the post-harvest processing by lowering the technological or utility value of the material. The occurrence of mechanical damage to grain is closely related to its hardness determined by genetic as well as by environmental factors. Studies carried out to date indicate the necessity of including this feature in the evaluation of the technological value of wheat /2, 3, 7, 8, 10, 11/.

Hardness as a qualitative feature of wheat grain is not clearly defined. In cereal technology wheat hardness is taken as a variety or breeding effect in combination with environmental factors in the course of the plant growth and development. A hard wheat is understood as a wheat with mostly vitreous kernels, used to produce good bread flour, and a soft wheat is taken to mean a variety with mostly mealy kernels, used to produce sponge-cake flour and for bakery products. It should be stressed that such physical properties as hardness and glassiness, sometimes mistaken for synonymies, differ significantly from each other. Vitreous kernels are always hard, but not all hard kernels are necessarily vitreous. The glassiness of a kernel is usually assessed visually while hardness must be measured. Hence hardness is most often defined as the resistance presented by grain during its diminution or deformation, depending on the method of measurement. Occasionally grain hardness is defined as a function of the time of its diminution, of the granulation of grinding material obtained under standard conditions, of the amount of diminuted fraction of flour, of the extent of damage to starch, and of other indirect indexes. Each of these methods determined somewhat different properties of the grain and is based on the assessment of various anatomical parts of the grain. Hence the results of such determinations may differ from one another /7/.

3. METHODS FOR DAMAGE ASSESSMENT AND APPARATUS

With respect to the differentiation in the extent of the cracks or cavities, as well as their location, mechanical damage can be classified as external and internal damage. External damage to grain, in the form of cracks in the involucre, extending into the endosperm, can be identified by means of direct visual inspection or by means of other, indirect methods of measurement applicable to damage of this kind. Internal damage to grain, located within the endosperm and usually not extending into the aleurone layer, can be identified through X-ray detection. Therefore, methods applicable to grain damage assessment can be classified broadly in two basic categories: direct methods and indirect methods /1/.

Direct methods, most frequently based on visual assessment of the condition of the surface of the object under study, or of its picture or image, can be burdened with a considerable subjective error. In the case of the X-ray method, included in this group or category, the subjective character of the assessment can be largely limited. The X-ray method allows for an analysis of the level of endosperm damage and permits the study of the effect of destructive factors on the occurrence of damage of this type.

Indirect methods, more objective in character, allow the extent of damage to be assessed on the basis of the values of the parameters measured, and related to the extent of the damage. This group of methods includes methods based on biotests, as well as methods based on the absorption of water or staining solutions, making use of their optical or fluorescent properties. From the view point of applicability for the assessment of mechanical damage, methods based on biotests have limited uses due to their time and labour requirements. In this group of methods

the colorimetric methods deserves the closest attention. Its application for the assessment of mechanical damage to wheat grain permitted the discovery of the phenomenon, hitherto unknown, of different resistance to damage in the grain of winter and spring wheat with increasing content of proteins in particular growing environment.

The selection of a particular method depends primarily on the requirements of the researcher. For purposes of practical assessment of mechanical damage to grain the most useful are such methods which are rapid and easy to implement, and in which the effect of the subjective factor on the result of the evaluation is kept to the barest minimum.

2.1. X-ray method for the assessment of internal damage

The X-ray method, during the 1980's, found an extensive application in studies on damage to grain conducted at the Institutes of Agrophysics in Lublin and in St. Petersburg, and recently also at the Agricultural University in Prague. Grain damage is detected by means of a compact short-focus Russian apparatus, type Elektronika-25, which provides images of various magnification (x2 to x10) with good geometrical definition. Kernels for determinations are glued onto measurement cassettes of filter paper (usually 100 kernels per cassette) and subjected to X-ray detection. Soft X-ray radiation is absorbed to different extent by damaged and undamaged endosperm, giving a distinct image of endosperm crack lines and an outline of the germ against the background of the kernel image.

X-ray pictures obtained are analyzed visually using a microfilm projector with x40 magnification. Mechanical damage detected within the endosperm can be described by means of indexes based on an appropriate grinding of the image and on a digital system of denoting the distribution of the damage /6/.

Currently work is undertaken to computerize the analysis of X-ray pictures, according to an algorythm comprising a determined system of coordinates describing the location and extent of cracks recorded in the picture of the kernel.

2.2. Colorimetric method for the assessment of external damage

Since 1980, at the Institute of Agrophysics in Lublin, studies have been conducted on the application of the colorimetric method for the measurement of external mechanical damage to wheat grain /1/. The method consists in the determination of the optical density of a test solution which, in the original version of the method, was prepared by hand as follows: A 100-gram grain sample was subjected to the process of staining in a water solution of Fast Green of strictly determined concentration, following which the grain together with the solution was poured into a container with a screen bottom and washed with a jet of running water to remove excess dye from the involucre of the kernels. Then the grain sample was immersed in a container with NaOH of low concentration in order to discolour the sample and to obtain the test solution. The solution obtained in this way was used to determine, according to the photometric method, the level of extinction which constituted a measure of the extent of mechanical damage to the grain. Studies conducted according to this procedure reveal the general level of mechanical damage in a 100-gram sample of grain. The higher the level of damage of this kind the higher the level of extinction of the solution tested.

So far the colorimetric method has not found a practical application, possibly because of the need to prepare the test solutions by hand. The procedure of test solution preparation, in order to maintain replicability of measurements, requires a strict observance of a uniform and constant time (approx. 30 secs.) of the operations involved in the staining, washing and discolouring of the sample.

To increase the objectivity of the conditions of test solution preparation under laboratory conditions, a semi-automatic tester with photometer has been designed. In selected time intervals of the duration of particular operations, the photometric tester provides test results free of the subjective error of the operator. Also, a method has been developed for the determination of the susceptibility of grain to damage of this kind, and for the method - a laboratory simulator of grain damage has been designed. The measure of grain susceptibility to mechanical damage has been adopted as the difference in the levels of extinction of solutions tested, obtained for grain samples subjected to static loading within the range of up to 8 and up to 4 MPa. A complete measurement set called the Tester of Mechanical Damage to Grain (type TMDG-2), developed as a result of the studies, is designed for the assessment of the susceptibility of wheat grain to mechanical damage, and for the determination of the extent of this type of damage /5/.

3. RESULTS

3.1. X-ray studies

To verify the thesis of the effect of variety features on the level of mechanical damage to wheat grain, the following experiment was carried out /2/: At the stage of full technological ripeness, ears of 5 varieties of spring wheat were samples, after which the grains were removed from the ears by hand in order to avoid the kind of technological damage that occurs in machine threshing. X-ray analysis of the kernels (5 x 100 kernels) revealed very extensive differentiation in the number of grains with internal damage within the varieties under study (Table 1).

Within *Triticum durum*, the Miradur variety was characterized by the lowest level of damage to endosperm (7%), while the Cando variety showed a threefold increase in damage. Within *Triticum aestivum*, the strain LGR 36/11 and the Jara variety were characterized by a high (over 45%) percentage of damaged grains, while the Alfa variety settled at a damage rate of about 30% .

Studying the effect of the process of intensive wetting on the occurrence of internal damage, the following experiment was carried out /2/: For the experiment samples were taken of the grain of the Ulla spring wheat variety. The grain samples originated from combine harvest in Finland. The moisture content of the grain from combine harvest exceeded 30% . X-ray detection of the grain, prior to the wetting, did not reveal any internal damage, while in the case of grain subjected to intensive wetting (through immersion in water for three hours) about 60% of the kernels tested had cracks in their endosperm.

4.2. Colorimetric studies

The results of colorimetric studies carried out so far /1, 4, 5, 12/ show that an increase in the content of protein in the grain of winter wheat entails an increase in the susceptibility of the grain to mechanical damage, while in the case of spring wheat an equivalent reaction is a decrease in the susceptibility of the grain (Table 2). Moreover, it has been found that the technological properties of grain (baking value) are related to the susceptibility of the grain to mechanical damage. Table 3 presents examples of values of heredity indexes of two of the properties studied: the susceptibility of grain to mechanical damage (W_{sd}) and the protein content of the grain. The features of grain susceptibility to mechanical damage is genetically conditioned to a higher extent that is the

case with protein content. It seems that the method of colorimetric determination of the susceptibility of wheat grain to mechanical damage, as a qualitative feature, can have a practical application also in breeding programs.

5. CONCLUSIONS

- Internal damage, which may occur in wheat grain before combine harvesting, can considerably increase the extent of external damage after the harvest, irrespective of the settings of the working parameters of the combine, causing a deterioration in the technological as well as in the utility value of the grain material. Therefore, there is a need for further X-ray studies aimed at determining the susceptibility of grain to damage of this kind for the more important (technologically) varieties of winter and spring wheat.
- The results of colorimetric studies indicate significant utilitarian effects, as they suggest that winter wheat breeding aimed at increasing its protein content entails a decrease in the resistance of the grain to mechanical damage.
- Interesting from the viewpoint of breeding is the degree of hereditary character of the protein content in the grain, and of the susceptibility of the grain to mechanical damage. It seems, therefore, that the colorimetric method for the determination of wheat grain susceptibility to mechanical damage as a qualitative property can have a practical application in breeding studies.
- The results of studies encourage further research aimed at improving the existing methods, and developing new ones, for qualitative assessment of wheat grain. Proposals for the popularization and standardization of the assessment of mechanical damage to wheat grain and of the assessment of the susceptibility of the grain to damage of this kind within the system of grain purchasing and trade constitute the objective of the authors.

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Table 1. Percentage content of grains with lateral cracks of endosperm in selected spring wheat varieties /2/

	Miradur	Cando	LGR 36/11	Jara	Alfa
Internal damage (%)	7.0	21.0	45.6	29.6	45.8
Statistical anal.*	a	b	c	d	c

* - Means with the same letter are not significantly different at the 5 % risk level.

Table 2. Total protein content, index of grain susceptibility to mechanical damage, and assessment of the baking value of the flour /4/

Variety	Total protein content (%)	W_{sd} index (-)	Baking value
	W i n t e r	*w h e a t*	
Liwilla	10.2	21.1	poor
	12.3	23.2	
Grana	10.6	18.4	poor
	12.7	25.8	
Panda	11.6	7.3	good
	13.7	8.5	
	S p r i n g	*w h e a t*	
Alfa	13.4	10.0	medium good
	14.7	7.1	
Jara	13.4	9.1	medium good
	16.0	7.5	
LGR 36/11	16.1	6.7	very good
	17.4	5.9	

Table 3. Heredity indexes of selected characteristics - $h^2_{s.l.}$ /4/

Characteristics studied	Years	
	1982	1983
Total protein content (%)	0.768	0.747
W_{sd} index* (-)	0.968	0.953

* - W_{sd} index is marked in /4/ as GVI (Grain Vulnerability Index).

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TECHNISCHE DIAGNOSTIK UND KRAFTSTOFFVERBRAUCH VON DIESELMOTOREN

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In the paper there are conclusions of research which have been directed to application of technical diagnostics on diesel engines of farm tractors. Diagnostic measurements of power and specific consumption of fuel have been applied to engines as a basical procedure of diagnostics which further contains additional detailed measurements. The results of research proved that power and specific consumption of fuel are indispensable diagnostic signals for useful periodical maintenance and tuning of engines and their application gives multiple economical effect by savings of fuel.

technical diagnostic; combustion engine; power; consumption of fuel; economic

VORWORT

Die Betriebskosten der landwirtschaftlichen Traktoren, LKW, PKW, Bau- und anderer Maschinen mit Verbrennungsmotoren sind sehr stark vom Kraftstoffverbrauch abhängig. In der tschechischen Landwirtschaft sind die jährlichen Kraftstoffverbrauchskosten, beispielsweise bei den Traktoren, rund fünfmal grösser als der Abschreibungswert der Maschinen.

Der Grund liegt zweifellos auch im unverhaltnismaßig hohen Anstieg der Kraftstoffpreise in den letzten Jahren, aber das ist auch in Zukunft zu erwarten. Es ist im Interesse der menschlichen Gesellschaft der Verbrauch, vorwiegend an fossilen Kraftstoffen, zu verringern und zwar nicht nur aus ökonomischen, sondern auch aus ökologischen Gründen. Bei Verbrennungsmotoren gilt, daß ihr ökonomische Betrieb meistens auch ökologisch günstig wirkt.

LÖSUNGSERGEBNISSE

In Rahmen von Betriebsversuchen wurden in drei Jahren (von 1986 bis 1989) unter anderem 19 Stück der landwirtschaftliche Traktoren Z-8011 untersucht, bei denen die Leistung und der spezifische Kraftstoffverbrauch in Gramm pro Kilowattstunde alle 200 Motostunden gemessen wurden.

Der untersuchte Motorentyp Z-8011 hat die folgenden Grundparameter:

- Diesel, 4 Zylinder- Viertaktsaugmotor
- Bohrung/Hub- 110/120 mm
- Direkteinspritzung mit Reiheneinspritzpumpe
- Nenndrehzahl 2200 U/min
- effektive Leistung 52 kW bei 90% Nenndrehzahl
- indizierte Leistung 67 kW bei 90% Nenndrehzahl
- efektive spezifische Kraftstoffverbrauch 250 g/kWh bei 90% Nenndrehzahl
- indizierte spezifische Kraftstoffverbrauch 195 g/kWh bei 90% Nenndrehzahl.

Es wurden folgende Meßgeräte verwendet:

- Elektrische Bremse mit dem Anschluß an der Zapfwelle, eigene Konstruktion der TF VŠZ Praha, Messgenauigkeit der Leistung 1,5%, Messgenauigkeit des Kraftstoffverbrauchs 2%
- Leistungs- und Kraftstoffverbrauchsmeßgerätt MVS-86, ebenfalls eigene Konstruktion der TF VŠZ Praha, das nach dem Beschleunigungsprinzip arbeitet, gleiche Genauigkeit (Leistung 1,5%, Kraftstoffverbrauch 2%), /1/
- Andere übliche Diagnosegeräte, einschließlich des Einspritzwinkelmeßgerätes und des Kompressionsdruckmessers.

Das Ziel der genannten Versuche war folgendes:

1. Untersuchung der Beeinflussung der Kraftstoffverbrauchskosten durch die Zustandsänderung des Motors während des Betriebes.
2. Untersuchung der Diagnosemöglichkeiten zur Aufdeckung und Vermeidung eines ansteigenden Kraftstoffverbrauchs im Betriebsverlauf.
3. Vergleich und Auswertung der Möglichkeiten, die Leistung und den Kraftstoffverbrauch mit der Bremsmethode oder mit der Beschleunigungsmethode zu messen.
4. Vergleich und Auswertung der Möglichkeiten, die Werte der effektiven oder indizierten Leistung und des spezifischen Kraftstoffverbrauchs zu messen.

Der dritte und vierte Punkt der obengenannten Ziele sind in diesem Beitrag nicht enthalten. Aus der Auswertung der Versuche resultiert eindeutig, daß bei den diagnostischen Messungen die Leistungsbremse voll durch die Beschleunigungsmethode ersetzt werden kann und daß die Ausnutzung der Beschleunigungsmethode wesentlich billiger in Investitions- und Betriebskosten ist.

Ähnlich war es mit der Messmöglichkeit und mit bisher nicht üblichem Ausdrücken der Diagnoseparametern mittels der indizierten Leistung und des indizierten spezifischen Kraftstoffverbrauchs. Diese nicht übliche Möglichkeit zeigte sich als sehr günstig besonders in den Fällen, in denen die Motortemperatur im Lauf der Messungen nicht bequem gehalten werden kann. Die Lösung des dritten und vierten Punkt des obengenannten Ziels mündet also in die Entwicklung der neuen Beschleunigungsmethode, die an andere Stelle erwähnt wird/2/.

Im Rahmen der ersten zwei Punkte des obengenannten Zieles wird bei jedem untersuchten Traktor alle 200 Motostunden eine Komplexdiagnosemessung und, wenn nötig, auch eine Detaildiagnosemessung durchgeführt. Die Komplexdiagnosemessung bedeutet hier eine Messung der indizierten Leistung in kW und des spezifischen Kraftstoffverbrauch in Gramm pro Kilowattstunde indizierter Arbeit, alles bei 90% Nenndrehzahl des Motors.

Die Detaildiagnose wird nur in dem Fall durchgeführt, daß die Leistung um 5% gesunken ist, oder der spezifische Kraftstoffverbrauch um 5% gestiegen ist. Zu dieser Detaildiagnose werden obengenannte Messgeräte und andere übliche Werkstatausrüstung genutzt. Ein praktisches Beispiel der Meßergebnisse ist in der Tafel 1 dargestellt.

Tafel 1 - Auszug aus dem Meßprotokol

Nr. der Messung	Traktorentyp	Nr. des Traktors	Meßergebnisse in indizierten Werten bei 90% Nenndrehzahl			
			Am Anfang der Messung		Nach der Instandhaltungsmaßnahme	
			Leistung (kW)	Spezif. Kraftstoffverbrauch (g/kWh)	Leistung (kW)	Spezif. Kraftstoffverbrauch (g/kWh)
62	Z-80 11	BN-28 33	60	266	64	199
63	Z-80 11	BN-35 03	64	203	--	--
64	Z-80 11	BN-45 86	66	273	70	199
65	Z-80 11	BN-55-63	80	255	70	194
Toleranzwerte			min 64	max 205		

Im gezeigten Auszug aus dem Meßprotokol (Tafel 1) sind die typischen Beispiele der Messungen klar zu sehen. Bei Nr.63 blieben die Leistung und auch der spezifische Kraftstoffverbrauch innerhalb der Toleranzgrenzen. Deswegen reichte die Komplexdiagnosemessung am Anfang aus und die Detaildiagnose, einschließlich der Instandhaltungsmaßnahmen und der wiederholten Leistungs- und Verbrauchsmessung, war nicht mehr

nötig. Im Fall von Nr.63 hatte sich der Techniker mittels der Komplexmessung nur überzeugt, daß das Kraftstoff- und Verbrennungssystem des Motors in Ordnung ist und man könnte sagen, daß die Meßkosten in diesem Fall praktisch umsonst waren. Es handelt sich um die Kosten, die rund 20 Minuten der Komplexmessungszeit entsprechen.

Ganz anders ist es aber in anderen gezeigten Fällen. Beispielsweise waren bei Nr.62 am Anfang die Leistung unter und der Kraftstoffverbrauch über den Toleranzgrenzen. Im Laufe der Detaildiagnose wurden die Ursachen des genannten Zustandes aufgedeckt und der Normalzustand mit entsprechenden Maßnahmen wiederhergestellt. Die Instandhaltungskosten entsprechen in diesem Fall rund 240 Minuten der Meß- und Instandhaltungszeit. Auf der anderen Seite bedeuten die genannten Maßnahmen die Verminderung des Kraftstoffverbrauches bei gleichzeitiger Vegrößerung der Leistung.

Ohne entsprechende Informationen aus der Komplexdiagnose und den folgende Maßnahmen könnte der Traktor im Fall Nr.62 beispielsweise 1 Jahr ohne jedwede Beunruhigung des Besitzers arbeiten und dabei einen um 33,7% höheren Kraftstoffverbrauch als nötig haben.

Ähnliche Situationen wie bei Nr.62 sind bei Nr.64 und Nr.65 zu beobachten. Interessant ist das Beispiel Nr.65, bei dem die Anfangsleistung sehr hoch, konkret 80 kW, war. Diese Leistung wurde hier nur auf Grund der erhöhten Kraftstoffördermenge erreicht, weil der Traktorist die Eispritzpumpenplombe beschädigt und die Motorleistung kurzsichtig erhöht hat. Nach der nochmaligen richtigen Einstellung der Einspritzpumpe wurde zwar die Leistung auf den akzeptablen Wert von 70 kW gesenkt, aber auf der anderen Seite auch sehr wesentlich der spezifische Kraftstoffverbrauch von ursprünglichen 130% auf rund 100% des Nennwertes gesenkt.

Im Laufe der genannten Versuchsjahre waren die ökonomischen Erfolge nicht so günstig, wie im Beispiel in Tafel 1 gezeigt wird, zweifellos infolge des erhöhten Niveaus des gesammten Zustandes der untersuchten und mit Hilfe der Diagnostik instandgehalten Motoren.

Die statistische Bearbeitung der Versuchsergebnisse ergab, daß der jährliche Einsatz der technischen Diagnostik auf Dieselmotoren Z-8011 eine durchschnittliche Einsparung des Kraftstoffverbrauchs um 4,1% und bei Einsatz in jeder 200 Motostunde eine durchschnittliche Einsparung 8,7% bedeutet. Diese 8,7% Kraftstoffeinsparung entsprechen beim Traktor Z-8011 rund 700 Liter jährlich, was in heutigen Preisen 10500,-Kčs jährliche Kosteneinsparung ermöglicht.

Auf der anderen Seite der Rechnung stehen die Instandhaltungskosten, die direkt mit der Diagnose verbunden sind und die im üblichen Fall , d.h. ohne Diagnostik, sehr wahrscheinlich nicht auszugeben wären. Diese "zusätzlichen" Kosten, umgerechnet auf heutige Preise, entsprechen aus statistischen Ergebnissen im Durchschnitt nur 18% der ersparten Kraftstoffkosten. Es scheint also, daß man bei der konsequenten Anwendung der technischen Diagnostik bei den untersuchten Motoren jährlich 8.610,-Kčs einsparen könnte.

ZUSAMMENFASSUNG

Durch konsequente Anwendung der technischen Diagnostik unter den Betriebsbedingungen kann bei den untersuchten Dieselmotoren 8,7% des Kraftstoffverbrauches eingespart werden. Gute Erfahrungen wurden mit der Komplexdiagnosemessung gemacht, die die Werte der indizierten Leistung und des indizierten spezifischen Kraftstoffverbrauchs beinhaltet. Die Einsparung des Kraftstoffes hat einen direkten günstigen Einfluß auf den Umweltschutz.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

INFLUENCE OF DIFFERENT TRESHING MECHANISM ON DAMAGE OF MALT BARLEY

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A combine harvistter E 512 was compared with a laboratory model of threshing mechanism with a concave grate equiped with driven rotating cylinders. The lowest damage of grains was achieved by the combine harvester E 512 at 900 revolutions per minute (r.p.m.) of the thresling cylinder and at "leaving" gap hight 6.4 mm.The threshing cylinder circumferential velocity of 48.9 $m.s^{-1}$ and the concave cylinders circumferential velocity of 18 - 22 $m.s^{-1}$ were set up at the laboratory threshing mechanism. Olthough the damage of grains was higher, the consumption of energy was lower.

threshing mechanism; combine harvester; concave grate; damage; threshing;

1.EINLEITUNG

In dieser Arbeit beschäftigen wir uns mit den Vergleichsmessungen des klassischen Schlagleistendreschmechanismus beim Mädrescher E 512 und des Dreschmechanismus mit dem Rotationskorb bei dem Braugerstedrusch aus dem Standpunkt der Kornbechädigung nach ČSN 461011. Für die Messung wurde der Mähdrescher E 512 mit folgenden Grundparametern benutzt:

- Diameter des Dreschtrommels 0.6 m
- Drehzahl des Trommels 600 - 1200 /Min
- Anzahl der Schlagleisten im Dreschkorb 14
- Lücke zwischen dem Trommel und dem Korb
  beim Eintritt 13 - 25 mm
  beim Austritt 3 - 14 mm

Die Testalage des Dreschmechanismus mit dem Rotationskorb wurde an dem Lehrstuhl für Landmaschinen der Landwirtschaftlichen Hochschule in Prag im 1990 hergestellt.

2. Die Messungsmethodik

Die Methodik wurde an dem Lehrtuhl für die Landmaschinen in 1990 entwickelt und sie beträgt die Methode der Probenahmen und die Wahl der Dreschmechanismen.

2.1. Die Probenahme vom Mähdrescher E 512

Für die Probenahme haben wir den Mähdrescher E 512 vom Schulgut Lány ausgenützt. Die Proben wurden bei Hilfe einer Spezialsonde während des Maschinengangs bei der Abflußöffnung des Schneckenförderers in der Trichterrutsche des Mähdreschers abgenommen.

Die Gewichtsmenge der Proben betrug ungefähr 50 g (das entspricht der Masse von cca 1 Tausend Samen). Für die Probenahme erwählten wir die Trommeldrehzahl von 900, 1050, 1100 /Min. Die Einstellung des Dreschkorbs wurde in der Bedienungskabine an der Anlage für genaue Lückeneinstellung reguliert. Die Proben wurden an dem Grundstück des Schulguts Lány mit der Kornnässe von 10.13 - 11.10 % in stehen dem Bestand abgenommen.

2.2. Die Probenahme vom Dreschmechanismus mit dem Rotationskorb

Auf Grund der Ergebnisse der Messungen von den vergangenen Jahren haben wir folgende Zylinderdreh zahl des Dreschkorbs

gewählt: 2450, 2750, 3000 / Min.

Für die Einstellung des Trommel-Korb-Zwischenraums wählten wir zwei Werte Ein- und Austritt und zwar 12/5 und 6/4 mm. Für die Möglichkeit des Vergleichs der Kornbeschädigung beim Drescher mit Rotationskorb und dem Mähdrescher E 512 wählten wir Durchgangsleistung der Getreidemasse von 4 kg/s. Dieses Wert korrespondiert mit der Zwischenraumdurchgangsleistung, die bei der Messung an E 512 erreicht wurde. Für die Labormessung wurde das Material an dem Acker abgemäht und in die Garben gebunden. Die Nässe beim Drusch war 13.9 %.

3. Die Auswertungsmethode

Die abgenommene Probe wurde an die ganze Fläge der Auswertungsplatte ausgebreitet. Die Probe wurde stufenweise nach einzelnen Körnern ausgewertet. Das Korn wurde in 4 Grundgruppen gemäß der ČSN 461011 sortiert:
- erste Klasse - Korn unbeschädigt
- zwiete Klasse - Korn mit Keimbeschädigung
- dritte Klasse - Korn mit Beschädigung mehr als 1/4 der Spelzeoberfläche
- vierte Klasse - Kornbrüche (ohne Rücksicht an die Große)

Die Summe dieser vier Klassen hat die gesamte mechanische Beschädigung angegeben. Bei allen Probenahmen beobachteten wir die Verluste bei der Absonderrung des Korns vom Stroh. Diese Verluste haben bei empfohlener Dreschereinstellung die festgelegte Grenze nicht überschritten.

3.1. Analyse der Messungsresultate

Analyse der gesamten Beschädigung wurde aus dem Standpunkt des Zwischenraums zwischen dem Trommel und dem Korb und aus dem Standpunkt der Unfangsgeschwindigkeit des Dreschtrommels (d.h. Drehzahl) durchgeführt. Für den Betrieb des Mähderschers ist es nötig ein Kompromis zu bestimmen, bei denem bei relativ geringster Beschädigung zum relativ besten Drusch kommt. Diese Abhängigkeit wird an der Abb. Nummer 1 graphisch dargestellt. Aus dieses Abbildung folgt, daß es geeignet ist, die Drehzahleinstellung des Dreschtrommels an 900 ausnahmsweise an 1050 /Min und die Austrittlücke an 6.4 mm bis 9.0 mm einzustellen.

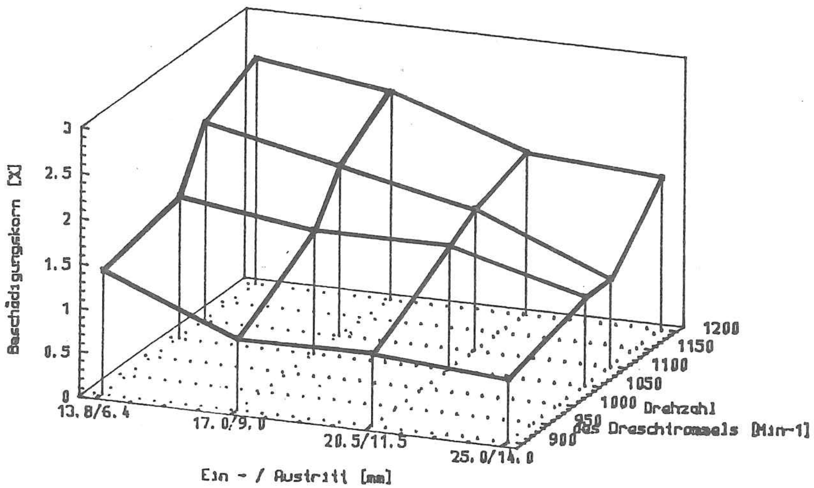

Abbildung 1: Gesammte Beschadigung des Mahdreschers im Abhangigkeit von der Ein-/Austritt und von der Drehzahl des Dreschtrommels

3.2. Analyse der Resultate der mechanischen Beschädigung beim Dreschmechanismus mit Rotationskorb

Der Dreschtrommel arbeitete bei der Umfangsgeschwindigkeit von 48.9 / Min. Die Umfangsgeschwindigkeit der Korbszylinder bewergte sich im Interval von 18 m.s.$^{-1}$ bei 2450 /Min bis 22 m.s.$^{-1}$ bei 3000 Umdrehungen / Min. Bei den angeführten Parametern wurde der volle Drusch des Korns aus der Ähre sicergestellen. Die Abb.Nummer 2 zeigt den Verlauf die gesamte Beschädigung.

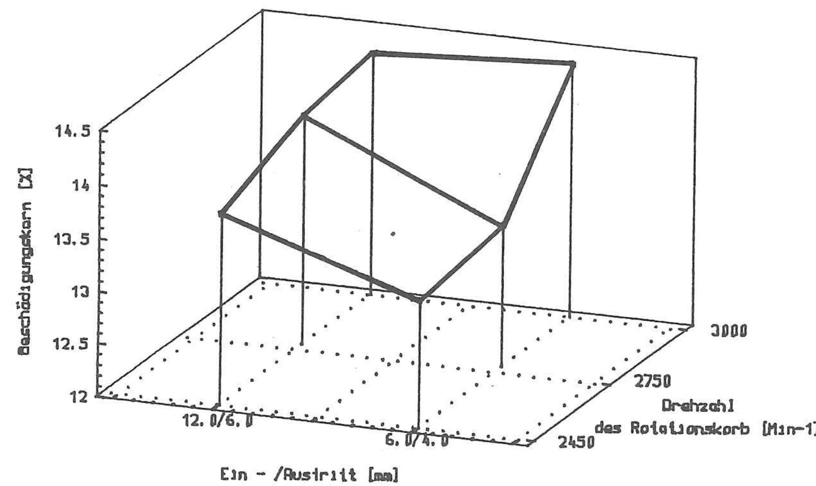

Abbildung 2 : Gesammte Beschadigung des Models in Abhangigkeit von der Ein-/Austritt und von der Drehzahl des Rotationskorb

Bei der Veränderung der Zylinderumdrehungen beim Dreschkorb wurde kein wesentlicher Unterschied bei den einzelnen Beschädigungsformen festgestellt. Die gesamte Beschädigung ist größer als bei den Derschmechanismus des Mähdreschers E 512. Der untersuchte Mechanismus erwies günstige Resultate beim Erbsendrusch, aber unter den oben angeführten Umständen und bei seiner jetzigen Einstellung ist er für den Braugerstedrusch nicht günstig.

4. Schlußfolgerung

Die beim Mähdrescher E 512 abgemessenen Resultate zeigen, daß die Dreschereinstellung einen erheblichen Einfluß an die Größe der mechanische Beschädigung hat (siehe Abbildungen).

Es ist Schade, daß die Ernte in vorigem Jahr unter sehr trockenen Bedigungen verlaufen ist. Bei dem Drescher mit dem Rotationskorb ist es nötig noch einige Konstruktionsverbesserungen durchzuführen, die die reduzierte mechanische Kornbeschädigung bringen könnten. Dieser Dreschmechanismus erweist sich als sehr hoffnungsvoll vom Standpunkt der Energieersparung, was auch einen finanziellen Effekt bringen kann. Der Drescher mit dem Rotationskorb kann auch höhere Durchgangsleistung als klassische Mähdrescher erreichen.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

Modellbildung zur Simulation von Traktorschwingungen

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Frühere Forschungsarbeiten auf dem Gebiet der fahrdynamischen Simulation von Traktoren wurden mit der Entwicklung erheblich verbesserter Fahrzeugmodelle fortgesetzt. Dieser Fortschritt wurde durch Einsatz des Mehrkörper-Simulationsprogramms SIMPACK erreicht.

Für komplexe fahrdynamische Simulationsberechnungen, die beispielsweise auch Lankmanöver einschließen, muß eine realistische, rauhe Fahrbahnoberfläche nachgebildet werden. Hierfür werden mathematische Methoden skizziert, die auf der ein- sowie auf der zwei-dimensionalen inversen Fouriertransformation beruhen.

Fahrdynamik; Fahrsicherheit; Fahrkomfort; Traktoren; Fahrbahnunebenheiten.

In continuation of previous research work on tractor ride vibration simulation more accurate tractor models could be generated applying a professional multi-body simulation program called SIMPACK.

For a complex simulation of ride dynamics including e.g. steering behaviour a realistic rough surface must be generated. For this mathematical methods are suggested applying the one- and two-dimensional inverse Fourier Transformation.

Ride dynamics; ride security; ride comfort; tractors; rough tracks.

1. Einleitung

Ackerschlepper gehören zu den universellsten und komplexesten Fahrzeugen überhaupt. Moderne Traktoren enthalten neueste Technologien aus allen Bereichen des Maschinenbaus und der Elektronik. Dennoch besteht im Vergleich mit dem PKW- und LKW-Sektor ein erheblicher Nachholbedarf in zwei Bereichen, und zwar bezüglich der Ergonomie und der Fahrdynamik. Diese beiden Aspekte sind eng miteinander verknüpft: Eine fahrdynamisch günstige Auslegung eines Traktors wird in der Regel nicht nur zu höherer Fahrsicherheit führen, sondern auch zu einer verminderten Schwingungsbelastung des Fahrers, also zu einem erhöhtem Fahrkomfort bzw. verbesserter Ergnomie.

Im Rahmen des sich ständig verändernden Anforderungsspektrums an Traktoren gewinnen Transportaufgaben heute immer mehr an Bedeutung. Hieraus resultiert zwangsläufig der Wunsch nach schnelleren Fahrzeugen, der jedoch mit dem Standard-Schlepperkonzept nicht oder zumindest nur eingeschränkt realisierbar ist. Bei höheren Geschwindigkeiten wird der Fahrer durch die anwachsenden, nahezu ungedämpften Fahrzeugschwingungen in zunehmendem Maße belastet. Gleichzeitig können diese Schwingungen zum zeitweiligen Abheben der gelenkten Vorderräder führen. Die Lenkbarkeit des Traktors ist dann nicht mehr sichergestellt. Ebenso kann das Bremsverhalten beeinträchtigt werden.

In den letzten Jahren sind verschiedene Möglichkeiten zur Verbesserung des fahrdynamischen Verhaltens von Ackerschleppern vorgeschlagen worden. So sind u.a. Vorderachs- oder Kabinenfederungen sowie dynamische Schwingungstilger in der Diskussion. Die Realisierung solcher Systeme ist mit beträchtlichen Entwicklungskosten verbunden. Aus diesem Grund ist ein wachsendes Interesse an der Simulationstechnik feststellbar, durch deren Einsatz kürzere Entwicklungszeiten bzw. niedrigere Kosten bei gleichzeitig steigender Qualität der Ergebnisse erreicht werden sollen.

2. Entwicklungsstand

Seit einigen Jahren werden fahrdynamische Simulationsrechnungen für Ackerschlepper durchgeführt /1, 2, 3, 4, 5, 6/. Die Fahrzeuge wurden bei diesen Arbeiten als Systeme gelenkig oder elastisch verbundener Starrkörper (Mehrkörpersysteme MKS) nachgebildet. Die Umsetzung der jeweiligen Modellvorstellungen in ein Computer-Programm erfolgte in der Regel durch eigenhändiges Aufstellen der Differentialgleichungssysteme und Programmierung in einer höheren Programmiersprache wie FORTRAN, Pascal oder C. Diese Vorgehensweise beinhaltet folgende Nachteile:

1. Hohe Fehlerwahrscheinlichkeit sowohl im Bereich der mathematischen Modellbeschreibung als auch bei der eigentlichen Programmentwicklung
2. Starke Vereinfachung des Modells (geringe Anzahl an Freiheitsgraden, Linearisierung der Fahrzeugbewegungen)
3. Geringe Flexibilität

Die Arbeit mit solchen 'selbstgeschriebenen' Programmen ist mühselig. Die Vielfalt der Modelle und Untersuchungsmöglichkeiten ist stark eingeengt. Im Bereich der Produktentwicklung ist diese Verfahrensweise nicht akzeptabel.

Ein am Institut für Landtechnik und Baumaschinen der TU Berlin entwickeltes Simulationsprogramm in FORTRAN wurde auf der AG ENG '90 in Berlin /7/ vorgestellt. Bei diesem Programm können zwar durch einen Preprozessor namens CSMP /8/ verschiedene Differentialgleichungslöser für das jeweilige Modell ausgewählt werden, außerdem sind diverse Fahrzeugmodelle implementiert, aber letztlich konnten die beschriebenen Probleme nicht eliminiert werden. Die Modellbeschreibung umfaßt lediglich die interessanten Freiheitsgrade, z.B. beim Standardtraktor Heben, Nicken und Wanken des Rumpfes sowie jeweils einen Freiheitsgrad für die Pendelachse und den Sitz. Die Bewegungen wurden linearisiert berechnet. Freiheitsgrade wie Gier- und Querbewegungen oder die Drehung der Räder wurden vernachlässigt. Die Beschränkung auf die wesentlichen Freiheitsgrade führt zum einen zu geringer Genauigkeit, zum anderen aber auch zu einem sehr kompakten Modell, so daß die Rechenzeiten extrem niedrig liegen.

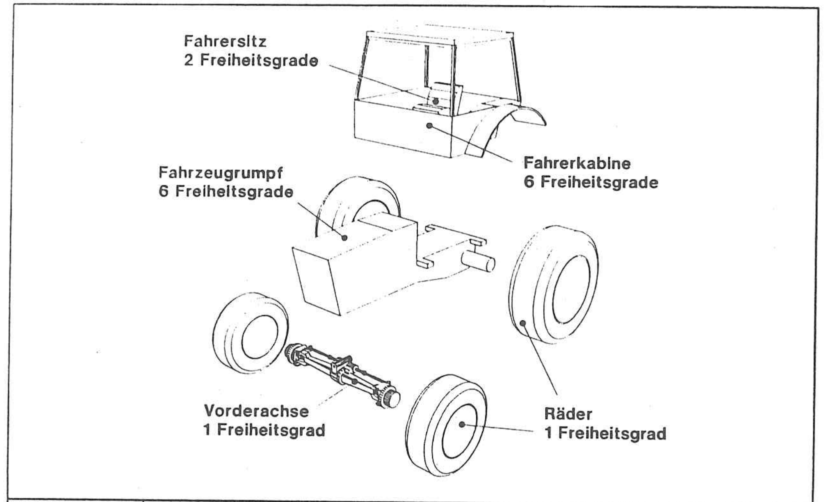
3. MKS-Programme

Mit Hilfe sogenannter Mehrkörper-System-Simulationsprogramme (MKS-Programme) konnten erheblich verbesserte Modelle entwickelt werden. Das wichtigste Merkmal von MKS-Programmen - wie beispielsweise ADAMS, NEWEUL, MEDYNA, ALASKA - ist die automatische Generierung des Differentialgleichungssystems für ein mechanisches Modell. Daher ist mit diesen Programmen eine vergleichsweise einfache und flexible Modellentwicklung möglich. Prinzipielle Probleme von MKS-Programmen sind einerseits der relativ hohe Rechenzeitbedarf und andererseits mögliche mathematische Beschränkungen bei der Modellierung: einige Programme lassen keine großen Bewegungen zu (linearisierte Berechnung); zum Teil ist die Modellierung kinematischer Schleifen nicht möglich.

Im Rahmen des Forschungsprojektes *Schwingungssimulation von Traktoren* wird am Institut für Landtechnik mit dem MKS-Programm SIMPACK (entwickelt bei MAN-Technologie) gearbeitet. Es handelt sich hierbei um ein im Vergleich zu ähnlichen Programmen kostengünstiges System. SIMPACK zeichnet

sich darüber hinaus durch ein äußerst effektives, numerisches Verfahren aus /9/, so daß der Rechenzeitbedarf relativ gering ist. Daher läßt sich SIMPACK auch auf PC's implementieren. Die Berechnungen erfolgen nicht-linear. Große Bewegungen sind also zulässig. Die Modelle können kinematische Schleifen und elastische Teilkörper enthalten. Die Ausstattung mit Pre- und Postprozessoren (Eingabe von Anregungsverläufen, graphische Ergebnisaufbereitung, Effektivwertberechnung, Spektralanalyse ...) ist jedoch schlecht, so daß hier immer noch ein erheblicher Arbeitsaufwand für den Anwender verbleibt, der das Programm an seine Anforderungen anzupassen hat.

Abb. 1 zeigt schematisch das mechanische Ersatzmodell eines Standardschleppers. Grundsätzlich lassen sich mit diesem Modell alle Fahrsituationen nachbilden. Für eine aussagekräftige Simulationsstudie ist die Kenntnis der Modellparameter eine unabdingbare Voraussetzung. Neben den Massen der Teilkörper müssen die Trägheitstensoren sowie alle Federungsparameter bekannt sein.



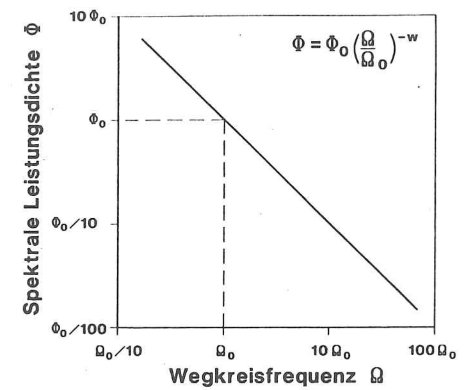
TU berlin ILT	Teilsysteme und Freiheitsgrade des Standardtraktors	KA 20225-01

Abb. 1

Bei Ackerschleppern sind die Reifen in der Regel das wichtigste Federelement. Während die Trägheiten auf der Grundlage von Konstruktionsentwürfen durch CAD-Programme berechnet werden können, müssen die Reifenparameter experimentell ermittelt werden. Die vertikalen dynamischen Reifenkenngrößen liegen aus zahlreichen Untersuchungen am Institut für Landtechnik vor /10, 11, 12/. Die horizontalen Parameter, zu denen auch Reib- und Schlupfbeiwerte zählen, sind jedoch bei Niederdruckreifen bis heute weitgehend unbekannt. Z.Z. kann nur mit geschätzten Werten gearbeitet werden (/3/).

4. Generierung unebener Fahrbahnoberflächen

Neben den eigentlichen Modellparametern kommt der Anregung durch die Unebenheit der Fahrbahn eine besondere Bedeutung zu. Fahrbahnoberflächen haben eine charakteristische spektrale Verteilung /13/, wie in Abb. 2 dargestellt. Dieses Diagramm zeigt, daß ein einfacher, weißer Rauschgenerator als Anregung bei der Simulation die Realität nicht korrekt nachbildet.



nach Braun

Typisches Leistungsdichtespektrum einer Fahrbahn | PL41002-2

ABB. 2

Die einseitige spektrale Leistungsdichte Φ des Unebenheitsverlaufes einer Fahrspur ergibt im doppelt-logarithmischen Maßstab eine Gerade. Daher lassen sich Fahrspuren durch zwei Parameter, nämlich Φ_0 und w, beschreiben. Diese Kenngrößen sind für unterschiedlichste Fahrbahntypen tabelliert. Mit diesen Werten können Fahrspuren generiert werden, indem aus dem Spektrum die Fouriertransformierte rekonstruiert und anschließend eine inverse Fouriertransformation durchgeführt wird. Die exakte Wiederherstellung der echten Transformierten und damit auch des zugrunde liegenden Unebenheitsverlaufs ist naturgemäß nicht möglich, da bei der Berechnung der spektralen Leistungsdichte die Phaseninformation verloren geht. Wenn die fehlenden Phasenlagen der Transformierten mit einem Zufallsgenerator erzeugt werden, ergibt die inverse Fouriertransformation einen gleichverteilten Unebenheitsverlauf mit denselben statistischen Eigenschaften wie die ursprüngliche Fahrbahn.

Für die Generierung einer statistisch gleichen Spur mit Hilfe der inversen Fouriertransformation müssen drei zusätzliche Randbedingungen bzw. Parameter berücksichtigt werden, die Einfluß auf die statistischen Eigenschaften, z.B. auf die Standardabweichung oder auf den Effektivwert des Unebenheitsverlaufes haben:

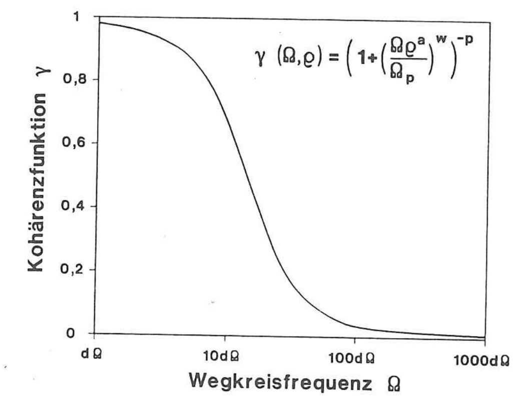
1. Die minimal zu berücksichtigende Frequenz Ω_{min}
2. Die maximal zu berücksichtigende Frequenz Ω_{max}
3. Die Frequenzbandbreite dΩ

Bei Frequenzen $\Omega < \Omega_{min}$ muß das Spektrum Φ zu null gesetzt werden, da die in Abb. 2 angegebene Gleichung für Φ bei $\Omega = 0\ m^{-1}$ einen Pol besitzt. Mit dieser Gleichung können die Fahrbahnunebenheiten im extrem niederfrequenten Bereich, also bei sehr großen Wellenlängen folglich nicht beschrieben werden. Die Grenze liegt bei einer Wellenlänge von ca. 80 m (entsprechend einer Wegkreisfrequenz $\Omega = 2\pi/80\ m^{-1}$).

Die höchste Frequenz Ω_{max} ist gleich der Nyquistfrequenz Ω_{Nyq} und hängt daher von der Länge ds des Meßintervalls ab ($\Omega_{Nyq} = \pi/ds$).

Die Frequenzbandbreite dΩ ergibt sich unmittelbar aus der Länge s der vermessenenen Fahrbahn nach der Gleichung $d\Omega = 2\pi/s$. Infolge der Diskretisierung des Spektrums hat eine Variation von dΩ Einfluß auf den Energieinhalt bzw. den Efektivwert des Spektrums. Dieser Einfluß verschwindet bei sehr kleinen dΩ.

Der oben vorgeschlagene Algorithmus, mit Hilfe der eindimensionalen inversen Fouriertransformation eine Fahrspur zu synthetisieren, muß für den allgemeinen Fall einer Fahrdynamik-Simulation erweitert werden, da in der Regel mehr als nur eine Spur benötigt wird. Dabei genügt es nicht, den Algorithmus mehrfach nacheinander anzuwenden, da bei dieser Methode unkorrelierte Unebenheitsverläufe entstehen würden. Bei realen Fahrbahnoberflächen existiert jedoch ein innerer Zusammenhang zwischen den einzelnen Spuren, der sich im Frequenzbereich über die Kohärenzfunktion ausdrücken läßt (Abb. 3). Die Kohärenzfunktion hängt vor allem von der Spurweite ab.



p, a, Ω_p: Fahrbahnabhängige Parameter
w : Welligkeit
dΩ : Bandbreite
ϱ : Spurweite

nach Ammon

Kohärenzfunktion mehrerer Fahrspuren | PL41302-1

ABB. 3

Unter Berücksichtigung der Kohärenz konnte die oben dargestellte Vorgehensweise zur Generierung von Unebenheitsverläufen so modifiziert werden, daß zwei korrelierte Spuren berechnet werden. Diese erweiterte Methode wird in Abb. 4 schematisch gezeigt. Sie ist jedoch nicht ohne weiteres auf mehr als zwei Spuren erweiterbar.

Aus diesem Grund mußte für fahrdynamische Simulationen auf ausgedehnten Oberflächen ein neues Verfahren entwickelt werden, das hier abschließend kurz skizziert wird:

Die Gleichung für die Leistungsdichte Φ nach Abb. 1 kann in eine Ω_1-Ω_2-Frequenzebene übertragen werden:

$$\Phi = \Phi_0 \left(\frac{\sqrt{\Omega_1^2+\Omega_2^2}}{\Omega_0} \right)^{-w}$$

Die modifizierte Gleichung beschreibt die spektrale Leistungsdichte einer isotropen, zweidimensional ausgedehnten Fahrbahnoberfläche. In Analogie zu den oben vorgeschlagenen Methoden für einzelne Fahrspuren läßt sich aus der Leistungsdichte die Fouriertransformierte mit Hilfe eines Zufallsgenerators synthetisieren. Mittels der inversen zwei-dimensionalen Fouriertransformation kann aus der Fouriertransformierten eine statistisch gleichverteilte, isotrope Fahrbahnoberfläche berechnet werden. Isotropie entspricht zwar nicht in allen Fällen der Realität, aber Ammon /14/ konnte nachweisen, daß sie bei vielen Fahrbahnen zumindest näherungsweise erreicht wird. Daher ergibt das neue Verfahren zur Synthetisierung rauher Fahrbahnoberflächen mit der zwei-dimensionalen inversen Fouriertrans sinnvolle Anregungsdaten für Simulationsrechnungen.

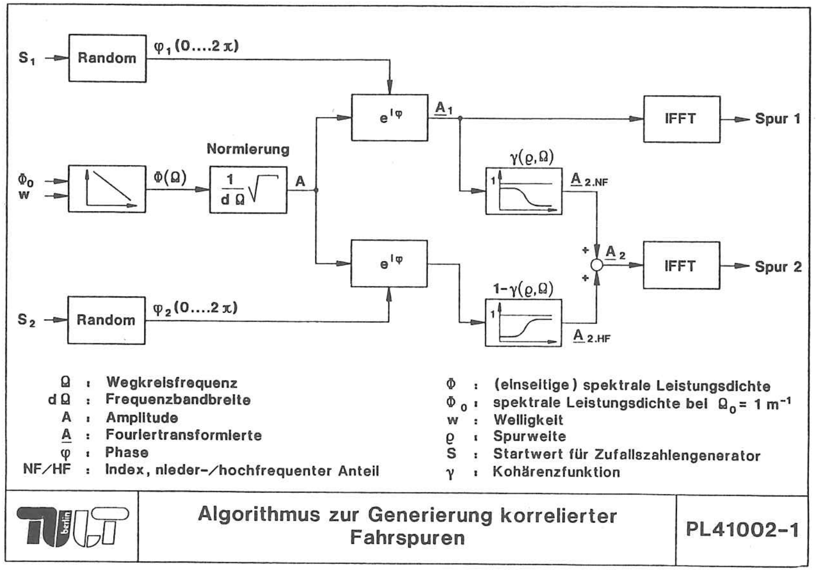


ABB. 4

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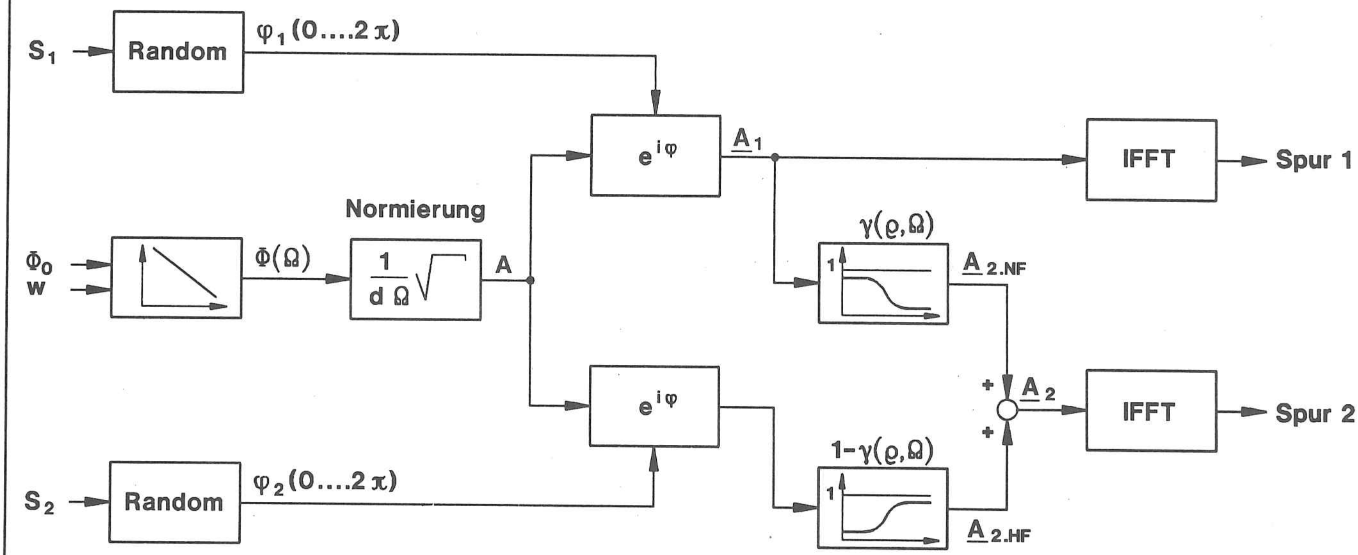
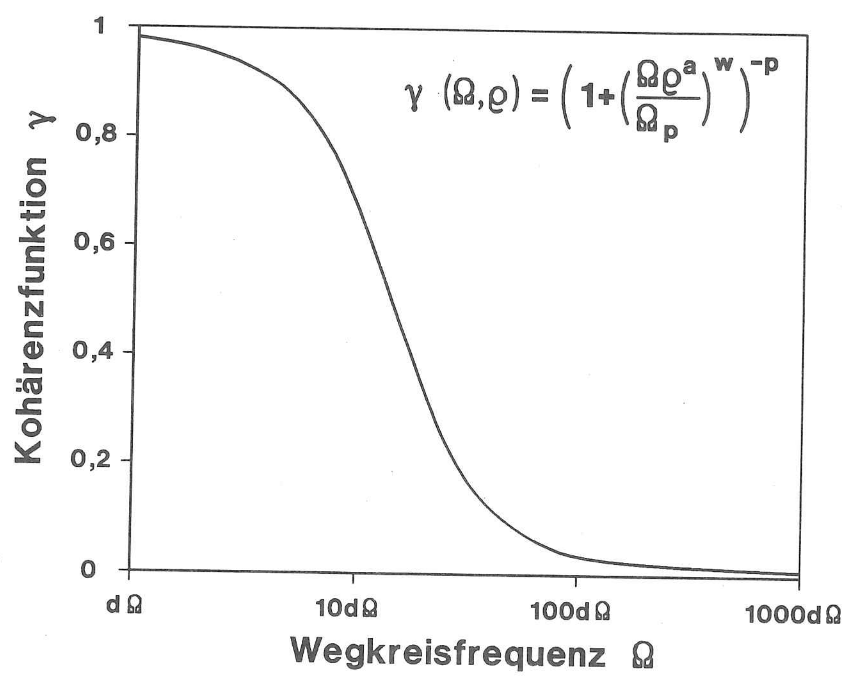


Ω : Wegkreisfrequenz
dΩ : Frequenzbandbreite
A : Amplitude
A : Fouriertransformierte
φ : Phase
NF/HF : Index, nieder-/hochfrequenter Anteil

Φ : (einseitige) spektrale Leistungsdichte
Φ_0 : spektrale Leistungsdichte bei $\Omega_0 = 1\ m^{-1}$
w : Welligkeit
ϱ : Spurweite
S : Startwert für Zufallszahlengenerator
γ : Kohärenzfunktion

Algorithmus zur Generierung korrelierter Fahrspuren

PL41002-1



$$\gamma(\Omega,\varrho) = \left(1+\left(\frac{\Omega\varrho^a}{\Omega_p}\right)^w\right)^{-p}$$

p, a, Ω_p: Fahrbahnabhängige Parameter
w : Welligkeit

dΩ : Bandbreite
ϱ : Spurweite

nach Ammon

Kohärenzfunktion mehrerer Fahrspuren

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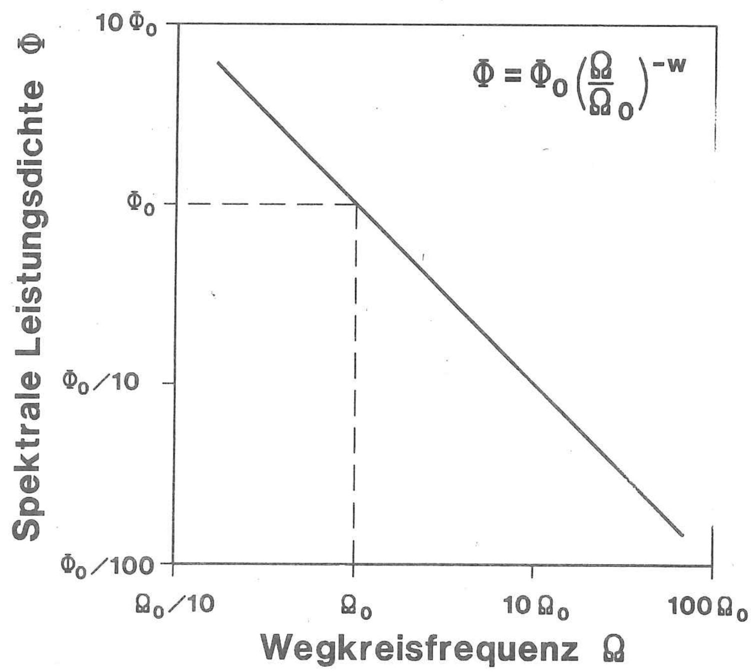
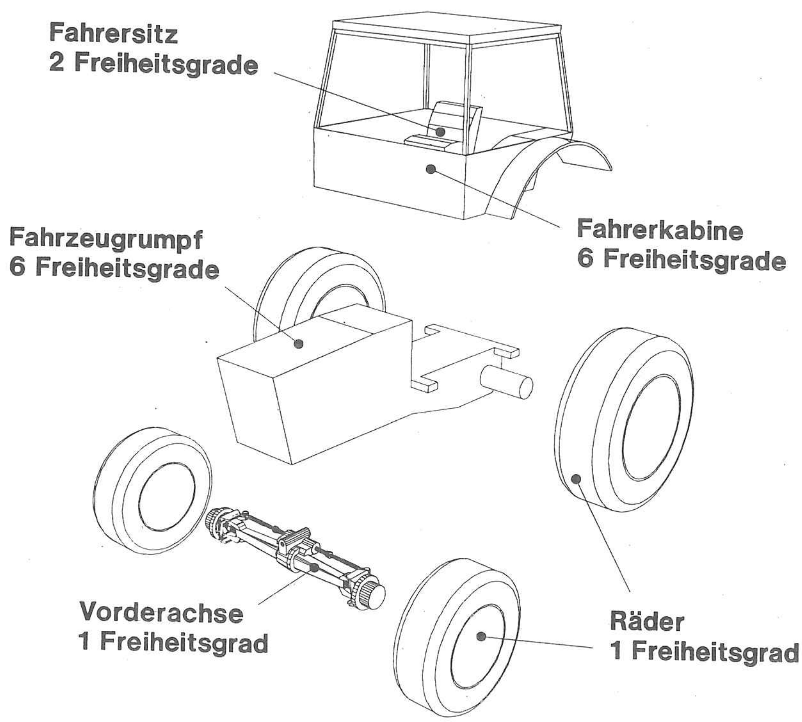


nach Braun

TU berlin	Typisches Leistungsdichtespektrum einer Fahrbahn	PL41002-2



TU berlin	Teilsysteme und Freiheitsgrade des Standardtraktors	KA 20225-01

TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

APPLICATION OF MEASURING RESULTS OF SOME PHYSICAL QUANTITIES IN MILK ORIGINAL PRODUCTION

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Measuring of physical quantities of milk,especially quarter milk portions in the course of milking is significant for further development process and the farm management. Practical applicability of the system in milking process and possibilities of using the device in various types of milking devices were proved.

quarter milk samples;milk conductivity; milk temperature.

1. INTRODUCTION

The world-wide trends of research and development of milking devices are increasingly aimed at automation of milking process (milking ending,milk gland stimulation,controlled nourishment,information on the course of milking and milk flow intensity).The attention is also paid to acquisition of information on milk physical properties which,with proper interpretation,can contribute to improvement of milk quality and milch cow health.Milk conductivity and milk temperature are the most important for present demands.

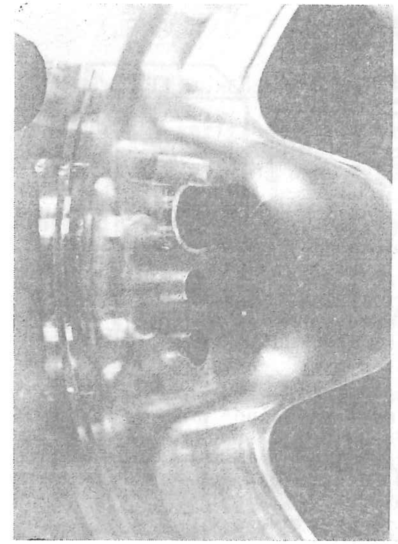
The condition is to obtain larger number of information in the course of one case of milking and process the data from individual udder quarters separately.

With regard to technical solution it is necessary to consider construction,execution and operational reliability of electrodes (sensors),capacitance of milk collector,self-cleaning ability of electrodes and their resistance to influence of desinfectants used with milking device sanitary.

System adaptibility to various milking devices of various producers is also significant for practical realization.

2. SENSORS OF MILK VALUES FROM INDIVIDUAL UDDER QUARTERS

With regards of evaluation of milk quarter portions it is possible to place electrodes in the teat cap or the milk tube



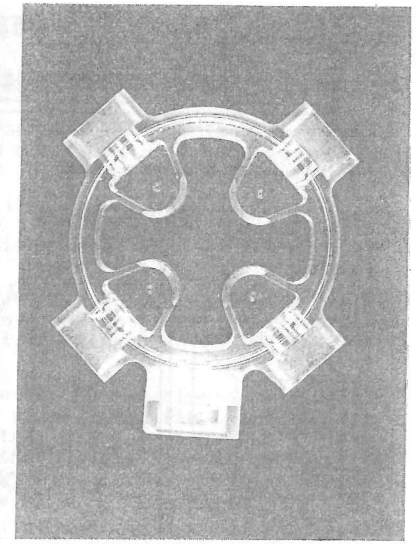


Fig.1.The milk chamber equipped with the conductivity electrodes and the thermosensor

Fig.2.The whole view of the main part of the inset/milk collector/

or the milk collector /Fig.1 and 2/.

Various types ,dimensions and materials as well with two and four-electrode sensors as well were tested as conductivity detective device.

The choice of four pairs of electrodes and four temperature sensors was made both absolutely and relatively.Setting to absolute value of conductivity with certain temperature was made in the calibration standard solution 0.1 N KCl with the tabulated values of the conductivity including corresponding temperature gradients γ(R). According to the needs of practice the sensors were set to corresponding values in the temperature ranges 15 to 39^{0}C.

Relative adjustment of four pairs of electrodes each to other (i.e.mutual difference of measured conductivity values) was made by extension of carbon electrode front end.Minimum mutual differences in obtained values of the conductivity of four sensors were reached by proper choice and modification maximum to 1 %.

For various reasons,proved by experiments,the teat cap and the milk tube do not comply with building the temperature sensors in them.The optimal place of mesuring is the milk collector(Fig.1,2).

The inset,which improved interior volume of the collector and thus the space for milk flow as well,was designed,constructed and tested.This modification makes possible to build in 4 conductivity sensors as well as 4 temperature sensors without decrease of milk running through the collector.

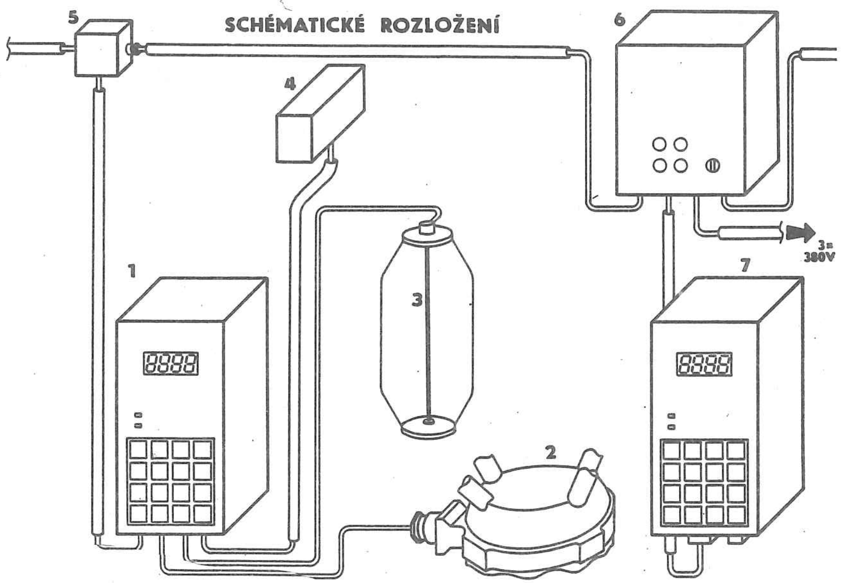


Fig.3.Schematic layout of the complete system

1-measuring unit in each milking box	5-distribution box
2-milk collector with an inset and sensors	6-central source
3-milked milk meter	7-data latch
4-receiver exciter to a responsor	

The advantage of this construction consists in mounting, adjustment and testing of the inset outside of milking device without breach of milking set operation.This proposal makes possible quick replacement also in the course of milking.

Schematic layout of the complete system in the milking shed includes following parts,described in the Fig.3.Futher the system is added by:
-PC-AT portable (control computer through the parallel interface Centronics)
-sine pulse generator (5 kHz,0.4V)of four circuits of probe impedance conversion
-linear rectifier
-8-bit converter A/D
-serializer
-control circuits
-power supply.

3. METHODOLOGY,MEASURING AND PROPER RESULTS

Proper verification of proposed model of last version with thus built-in sensors and measuring unit was passed off in the circular milking shed DZKD 15 (Czechoslovak production).

Repeated measuring after three hours with 12 to 15 milch cows eight times one after the other confirmed the reliability of the whole equipment in exacting conditions of the milking shed.

Check measuring in calibration solution confirmed the continuance of both sensor constants and obtained temperature dependences including conductivity compensation to the temperature of 20°C.

Proper measuring in the course of experiments was originally made during the whole time of milking with the temperature of milked volume with one quarter,then with 4 quarters simultaneously,in the course of time the compensation of measured values to the temperature of 20°C was included,and last measuring meant simultaneously the course of milk temperature of each quarter individually as well.

In the course of experiments the proper intervals of data taking from 0.7 to 3 seconds was tested and the value takings was optimalized with the regard to computer and program.

The takings of each minute give about 4000 values with one milch cow during one case of milking and the question is a necessary number of values from each quarter for further processing.

Measured values of the conductivity were processed grafically with 12 to 15 milch cows always eight times,i.e.with about 100 milch cows.

Samples of chosen dependences in the course of milking are showed in the Figures 4a and 4b.

4. EVALUATION AND CONCLUSION

Research and development were realized with regard of the possibility of application in modern milking sheds,systems,alternatively in milking robots.

The possibility of non-stop checking of milk and its properties in connection to health of an udder,milch cow and milk quality was proved.Further the possibilities of using the system for evaluation of technological discipline and milking technology level were proved.

Functional ability,operational reability,reproducibility of measured data as well as positive correlation of found results with other tests and control measurings were confirmed.

The obtained results were used for processing of expert-evidence system proposal.
The results are prospective not only for using by the producer of milking technology,but they are also interesting from the view of the sale of the complete device abroad.

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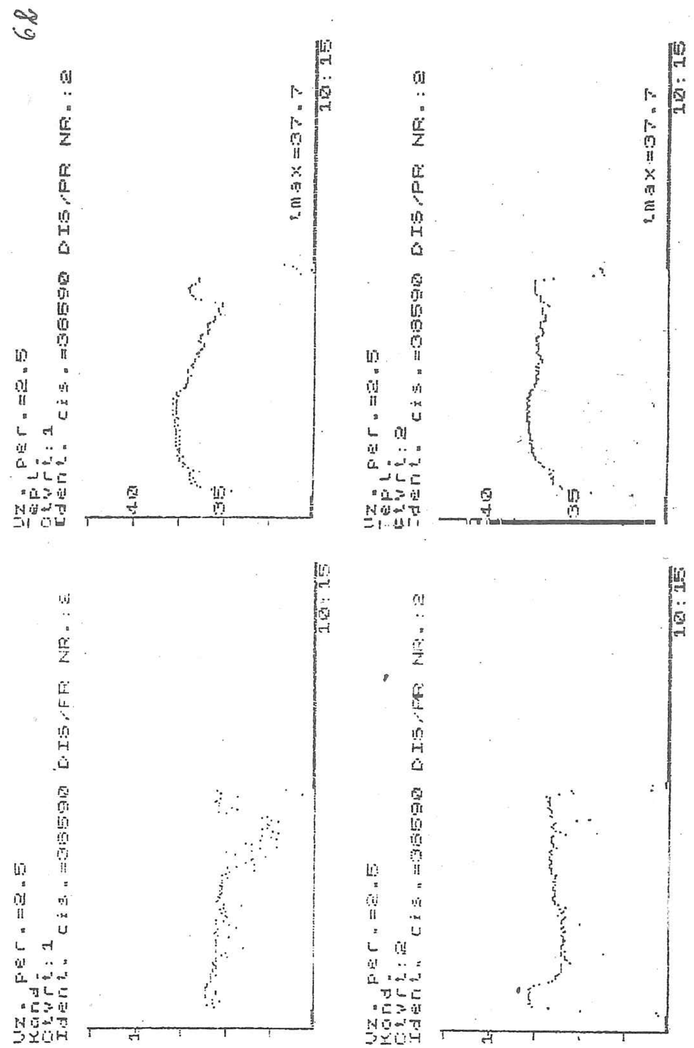

Fig.4a.The course of conductivity left and temperature right during milking of the milch cow 38590 in the front left and back quarters for the time of 10.15 minutes with taking after 2.5 seconds and with marking the maximum reached temperature.The whole milk yield for 5 minutes is 6 litres, i.e.the milk rate of flow in one quarter is approximately 5 g per second.

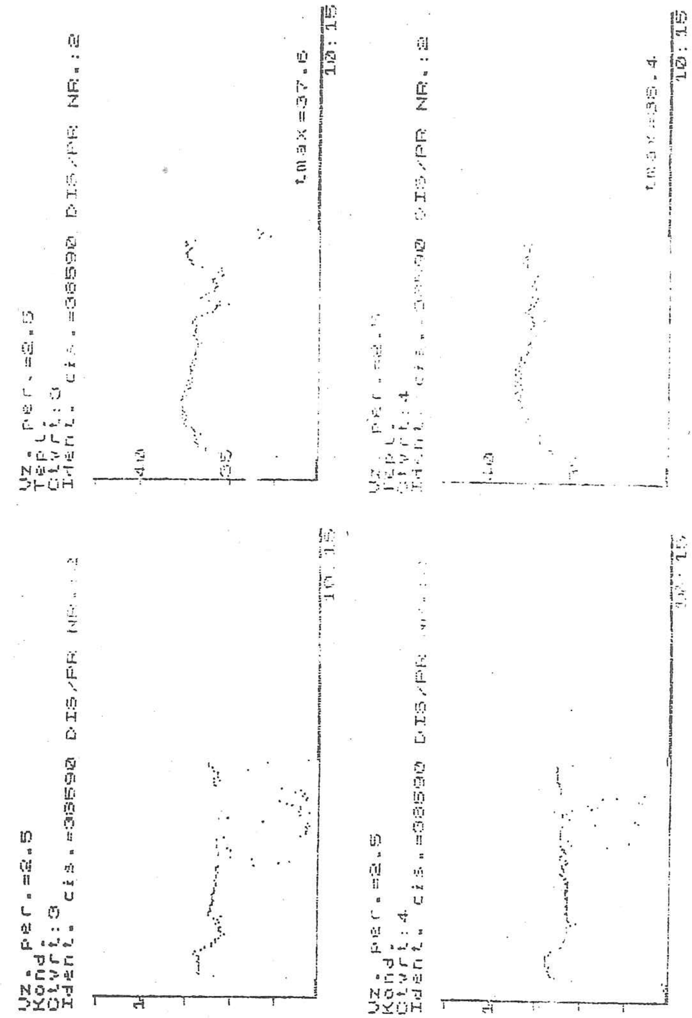

Fig.4b.The same course in the right quarters of the same milch cow:the front one on the top and the back one on the bottom.

TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

REGULATION AIR FLOW METER,RESEARCH AND DEVELOPMENT

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In consequence of the needs of the machine milking complex diagnostics,research and development of the regulation air flow meter were realized.The aim of the solution was the device which would find out desirable data of milking equipments,especially air flow quantity in the ranges 20-25000 liters of air per minute with the regulation underpressure level -50 ± 0.2 kPa and the accuracy up to 5% in the range 20 - 200 l/min,up to 2% in the range 200-2000 l/min.

milking diagnostics;air flow meter;calibration methods

1. INTRODUCTION AND PRESENT STATE

In connection with increased claims to optimalization of milk obtaining process and elimination of factors which affect inhibically the wealth of milch cows and the amount and the quality of milk,the diagnostics of milking is paid attention more increasingly /1/.

There are a lot devices on different levels of technical and functional perfection,which determine the course of underpressure in the teat cap chamber under the teat which makes possible to evaluate the milking machine characteristic.For the present the question of measuring of milking device air consumption,air pump efficiency,leakage losses of piping,distribution frames etc.is not solved quite satisfactorily.

The devices designated for this reason,the air flow meters are mostly hand-regulated.They included an anemometer,which measures underpressure in the underpressure system,and a hand-controlled mechanism,which operates as an regulation valve after connection to the milking device /2,3/.

There are flow meters regulated automatically which are more perfect from technical point of view.However,either they have not necessary operational ranges or they are too demanding and complicated from the point of technology and production /4,5/.

Till the present time no flow meter have not allowed providing a record and printing a protocol.

2. PRINCIPLE OF SOLUTION

On the basis of evaluation of the present state the principle of the flap placed in the pipe was selected as the definitive version of the solution.The flap operates as a load simulator for the underpressure milking machine system,and simultaneously the air flow is evaluated from the position of the flap with constant pressure gradient (50 kPa).The air measuring system is possible to compare with an electric system where voltage corresponds to underpressure,electric current corresponds to air flow,and resistance corresponds to aerodynamic drag of the flap.The electric system includes a current source (=an air pump) and a voltmeter (=an manometer)which measures voltage drop at the resistor.An analogical system is able to measure electric current through the calibrated resistor which is calibrated directly in electric current units.

Operation is as follows:resistance value at calibrated resistor is set in such order that voltage drop may correspond to the calibration constant,and further the current value is read from the calibration resistor.The measuring in the air system takes an analogous course.

The differences between electric and air systems consist paticularly in the linearity of measuring components.The large influence of turbulent flow is made in the air system and therefore the flap is generally nonlinear term.Therefore some approximation method must be used with calibration /5/.

3. DESCRIPTION OF THE DEVICE

The apparatus of regulation flow meter includes proper flap regulation flow meter and control computer.

The regulation flow meter consists of a pipe with a connection for underpressure system,in which the flap is placed and connected with a jogging motor through a gearbox and a clutch. The jogging motor is regulated through the control electronics. The underpressure probe designated for non-distorted taking underpressure behind the flap is placed in the pipe with the flap. Values are taken in the centre of piping through the hole in the tubule which is vertical to the flow direction.The turbulent flow in the pipe stifles the tending rose.

The underpressure probe is connected with a semiconductor manometer.

4. CONTROL COMPUTER

The device Sinclair Spectrum as the control computer was used for the first research-development work.For definitive solution the transformation of the system to the device for milking diagnostics Milkotest 2000 was made.In cooperation with the producer the functions of this device were extended on air flow measuring.The semiconductor pressure sensor of British production (DRUCK) or the Czechoslovak semiconductor pressure sensor MILK 1 are used as a manometer in the device.

The use of the diagnostic device Milkotest 1 with connection with the flow meter is very advantageous because the devise includes the microprocessor system applicable as control computer,makes possible to measure properly the pressure with temperature compensation,show the data at the displey and print the record of measuring.The device is also equipped with a battery current source which simultaneously supplies the air flow meter electronics.

5. CALIBRATION

Before approximation of flow meter calibration curve the flow meter calibration curve must be obtained at the special underpressure line which was constructed at the Milking Machine and Diagnostic Device Testing Laboratory at the Research Institute of Animal Production in Prague 10-Uhříněves.The accuracy of flow meter measuring depends on the calibration accuracy.

The air flow calibration is the co-ordination of air flow values to a corresponding number of steps of the jogging motor which controls the regulation flap.The serial and parallel calibration method were verified,and the calibration accuracy is higher with the parallel method.In definitive version the calibration curve is the calibration table stored in the memory of Milkotest 2000.The table includes break points of the calibration curve.During calculation it is interpolated linearly between two adjacent break points.The dispersion is less than 1% with this method.

For the calibration some measuring standards were used.From which the solution with a turbine gas meter with pulse output, which was connected with computer,was proved most.The calibration is controlled by personal computer to which the regulation flow meter is connected.Obtained data file on the disk which is transferred to the memory of the Milkotest 2000 computer after modification.The measuring error is less than 1% with this solution.

6.RESULTS OF TESTS

The tests realized at the Testing Laboratory of the Research Institute of Animal Production as well as the field tests at a pilot plant showed:

6.1. measuring accuracy in ranges 200-2000 (2500) l.min.is less than 1%.
6.2. for ranges up to 200 l it is necessary either to modify the demand on the measuring error with software by increase to ± 2.5% or to modify the measuring pipe and the flap.
6.3. the Milkotest flow meter system represents very good solution of the devices for milking diagnostics from the view of both operation and effective use of the two devices.
6.4. it is necessary to modify the way of connection of the flow meter with the underpressure system.

7. TOTAL RESULTS

The results of the work is:

The proposal of the regulation flow meter which operates with the regulation system that has not been used in the given area so far.The proposal is covered by author's certification.

The device meets the order and it surpassed the order in so-

me parameters (measuring accuracy).

The tests of available regulation flow meters,and basic principles of submitted solution were derived from measuring results.

The control of the regulation flow meter of the microcomputer Milkotest 2000.

The control program for air flow measuring was proposed and verified.

The proposal of the regulation flow meter calibration methodology,on which reached air flow measuring accuracy depends,was worked out.

The testing line for the testing and the calibration of the regulation flow meters was designed and constructed.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

MODELLE ZUR BESCHREIBUNG DES SCHWINGUNGSVERHALTENS VON ACKERSCHLEPPERREIFEN

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As a result of the increased speed of agricultural tractors during transportation the problem of unsuspended vehicles get more and more significant. The vibration characteristics and thus the ride comfort and the road safety depend on the spring and the damping characteristics of the tyre. To improve the ride comfort and the road safety, the exact knowledge specially of the dynamic tyre characteristics is necessary. The aim is to get a tyre-model, which delivers tyre characteristics in all three co-ordinates.

tyre-model; spring- and damping characteristics; drive conditions

1. Einleitung

Durch die zunehmenden Geschwindigkeiten bei Transportfahrten von landwirtschaftlichen Fahrzeugen gewinnen die auch von anderen ungefederten Fahrzeugen bekannten problematischen Fahrzustände immer mehr an Bedeutung.

Das Schwingungsverhalten und damit auch die Fahrsicherheit und der Fahrkomfort hängen in ganz wesentlichem Maße von den Federungs- und Dämpfungseigenschaften der Reifen ab. Die Anregungen der Schwingungen bei schneller Straßenfahrt können durch Unebenheiten in der Fahrbahn oder Inhomogenitäten des Reifens über dem Reifenumfang erfolgen. Um das Schwingungsverhalten hinsichtlich Fahrsicherheit und Fahrkomfort nachhaltig zu verbessern, ist eine genauere Kenntnis der dynamischen Reifenkennwerte in Vertikal-, Längs-, und Querrichtung erforderlich. Ziel ist die Entwicklung eines Reifenmodells, das den Fahrzustand in allen drei Koordinatenachsen beschreibt und Reifenkennwerte liefert, mit deren Hilfe numerische Simulationsrechnungen von Schlepper-Anhänger Kombinationen durchgeführt werden können.

2. Schwingungsuntersuchungen nach dem Voigt-Kelvin Modell

Von Schrogl [1] wurde ein Prüfstand entwickelt, mit dessen Hilfe er Modellparameter für die vertikale Schwingung eines Ackerschlepperreifens untersuchte. Dabei handelte es sich um einen Bandlaufprüfstand, auf dem der zu untersuchende Reifen mit Geschwindigkeiten bis zu 40 km/h auf ebener Aufstandsfläche abrollen kann. Als Reifenmodell bedient sich Schrogl des Ersatzmodells nach Voigt-Kelvin. Bei diesem Modell wird der Reifen gemäß Bild 1 als gedämpfter harmonischer Feder-Masse-Schwinger betrachtet, bei dem die Federkennlinie des Reifens als linear und die Dämpfung geschwindigkeitsproportional angenommen wird.

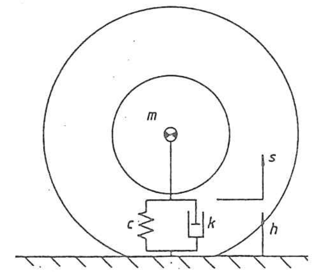

Bild 1 : Ersatzmodell eines Reifen nach Voigt-Kelvin

Die Federsteifigkeit wurde für den rollenden Reifen durch Messung der Reifeneinfederung und der Radlast, für den schwingenden Reifen aus der Schwingfrequenz ermittelt. Der Dämpfungswert wurde aus den abnehmenden Radlastamplituden beim Ausschwingversuch bestimmt. Dabei zeigte sich nach Bild 2, daß die Federsteifigkeiten für den rollenden Reifen und für den schwingenden Reifen einen unterschiedlichen Verlauf nehmen, jedoch bei hoher Rollgeschwindigkeit ansteigen, was durch die Ausfederung aufgrund der hohen Fliehkräfte erklärt werden kann.

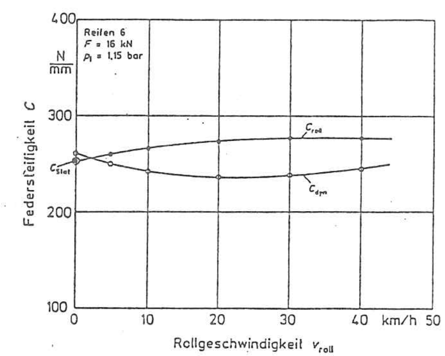

Bild 2 : Verlauf der Federsteifigkeiten von rollenden (c_{roll}) und rollenden und schwingenden Reifen (c_{dyn})

3. Schwingungsuntersuchungen für ein nicht-lineares Reifenmodell

Weitere Untersuchungen zur Reifenvertikaldynamik wurden von Langenbeck [2] vorgenommen. Dazu wurde der Prüfstand von Schrogl dahingehend modifiziert, daß der Rollwiderstand gemessen werden kann. Bild 3 zeigt den Prüfstand in der von Langenbeck benutzten Ausführung.

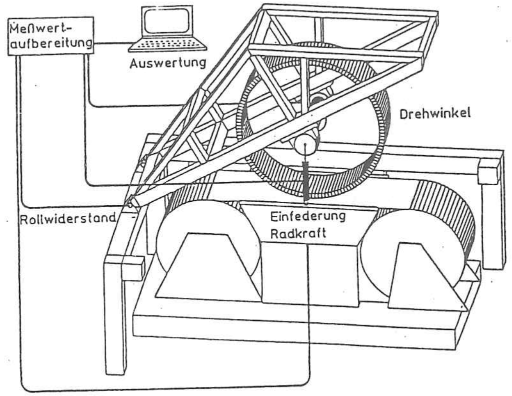

Bild 3 : Reifenprüfstand und Messwerterfassung

Der zu untersuchende Reifen rollt auf einem Laufband ab und wird in einer in Längsrichtung des Bandes angeordneten Schwinge geführt. Die Drehachse der Schwinge liegt in der Aufstandsfläche des Rades und verläuft senkrecht zur Laufrichtung von Rad und Band. An der Oberseite der Schwinge können Belastungsgewichte bis zu 4 t aufgebracht werden. Zur Meßwerterfassung werden jeweils der Rollwiderstand, die Aufstandskraft, die Achshöhe und die Radstellung simultan abgefragt. Sowohl die zwei Lastmeßbolzen in der Aufnahme der Schwinge und die Kraftmeßdosen unter der Aufstandsfläche als auch Weggeber und Drehwinkelgeber liefern analoge Signale.

Da das Reifenmodell nach Voigt-Kelvin unter anderem bei der Kraftberechnung nur zu ungenauen Ergebnissen führt, wurden von Langenbeck mit Hilfe des Reifenprüfstandes Parameter für ein neues, nichtlineares Reifenmodell ermittelt. Dieses Reifenmodell soll die Berechnung des Bewegungsverhaltens des Fahrzeugkörpers ermöglichen, jedoch die Vorgänge innerhalb des Reifens nicht erfassen.

Aus diesen Überlegungen enstand das Reifenmodell nach Bild 4. Für die Modellbildung in vertikaler Richtung werden nur die geschwindigkeitsproportionalen Dämpfungskräfte in Abhängigkeit von der Fahrgeschwindigkeit und die Federkräfte herangezogen. Diese beiden Effekte gehen in der Form in die Untersuchungen ein, daß die Federkennlinie durch eine Potenzfunktion angenähert wird und die Abnahme der Dämpfung bis zu einer Fahrgeschwindigkeit von 12 m/s als linear angenommen wird.

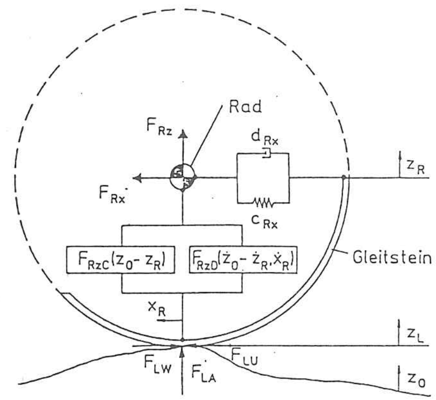

Bild 4 : Nicht-lineares Reifenmodell

Somit läßt sich für die Abhängigkeit der vertikalen Radlast folgende Gleichung aufstellen:

$$F_{Rz} = F_{RzD}\,(\dot z_0 - \dot z_R,\ \dot x_R) + F_{RzC}\,(z_0 - z_R)$$

Bei der Betrachtung der Reifendynamik wird das Verhalten des Reifens in Längsrichtung als vom Fahrzustand unabhängig angesehen. In dem beschriebenen Modell erfolgt die horizontale Anbindung des Reifens an das System durch eine Feder mit linearer Kennlinie und einem geschwindigkeitsproportionalen Dämpfer.

Um alle Fahrzustände des Reifens beschreiben zu können, müssen die Prüfstandsversuche bei verschiedenen Geschwindigkeiten aber sonst vorgegebenen Betriebsparametern durchgeführt werden. Nur so läßt sich der Einfluß der Fahrgeschwindigkeit auf das dynamische Verhalten des Reifens erfassen. Dazu wurden Versuche bei den Geschwindigkeiten 0; 1,4;3;6;9 und 12 m/s durchgeführt. Zur Versuchsdurchführung wird die Geschwindigkeit des Laufbandes auf den gewünschten Wert gebracht. Danach wird der Reifen soweit angehoben, bis er gerade noch Kontakt zum Laufband hat, d.h. die Rollgeschwindigkeit des Reifens der des Laufbandes entspricht. In dieser Position wird der Reifen ausgeklinkt und es wird die Ausschwingmessung vorgenommen. Bild 5 zeigt beispielhaft das Ergebnis einer Ausschwingmessung. Bei der Auswertung der Ausschwingmessung wird die Ruhelage zur Einteilung der Messung in einzelne Schwingungshalbwellen herangezogen.

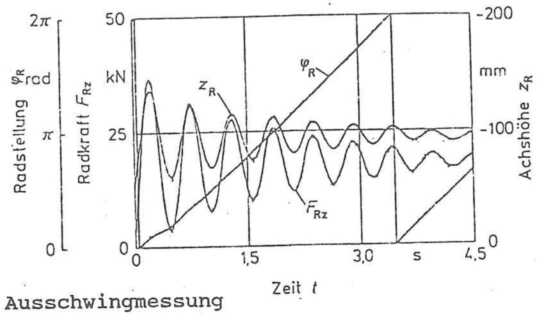

Bild 5 : Ausschwingmessung

Für das nichtlineare Modell wird eine Federkennlinie nach der Gleichung

$$F_{RC} = c_1 \cdot f^{c_2}$$

und eine geschwindigkeitsproportionale Dämpfungskraft

$$F_{RD} = d_v \cdot \dot{f}$$

angesetzt, wobei f die positive Differenz zwischen Fahrbahnhöhe und Achshöhe bezogen auf ihre Ruhelage ist. Mit den Daten aus der Versuchsauswertung sowie den o.g. Gleichungen läßt sich die gesamte Radkraft in vertikaler Richtung wie folgt bestimmen:

$$F_R = F_{RC} + F_{RD} = c_1 \cdot f^{c_2} + d_v \cdot \dot{f}$$

wobei sich d_v berechnet zu:

$$d_v = d_1 - d_2 \cdot v$$

4. Ergebnisse

Der Einfluß der Fahrgeschwindigkeit, der Betriebs- und Reifenparameter und der Reifenbauformen auf die Modellparameter wurde durch Prüfstandsversuche untersucht.
Es wurde dabei nur jeweils einer der Parameter verändert, alle weiteren Werte wurden auf dem Normzustand belassen.
Die Bilder 6 und 7 zeigen zwei Ergebnisse der Versuche.
Tabelle 1 beschreibt den Einfluß des Fahrbahnbelages auf die Modellparameter.

	c_1 [kN]	c_2 [–]	d_1 [kNs/m]	d_2 [Ns²/m²]
Stahl	634	1,19	3,10	124
Schmirgel	617	1,18	3,69	213

Tab. 1: Einfluß des Fahrbahnbelages auf die Modellparameter

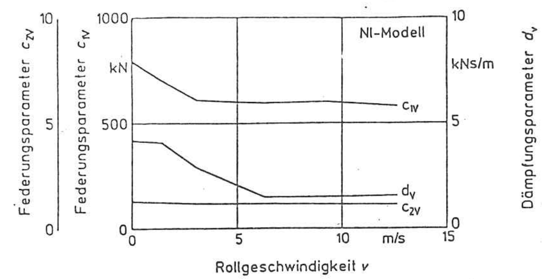

Bild 6 : Einfluß der Rollgeschwindigkeit auf die Parameter des Modells

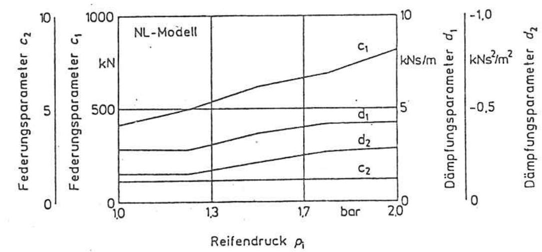

Bild 7 : Einfluß des Reifendrucks auf die Modellparameter

5. Zusammenfassung

Durch den Übergang zu einem nicht-linearen Reifenmodell werden die Schwingungseigenschaften eines Ackerschlepperreifens in der Vertikalen besser beschrieben als durch die Verwendung des Modells nach Voigt-Kelvin. Dies bestätigt auch die gute Übereinstimmung zwischen Prüfstandsversuchen und Rechenergebnissen.
Da in dem nicht-linearen Modell bisher nur die vertikalen Schwingungseigenschaften beschrieben sind, ist eine Erweiterung um die Horizontaldynamik durch die Einbeziehung von Längs- und Querschwingungen notwendig. Durch Untersuchungen der Schwingungen in allen drei Koordinatenachsen lassen sich genauere Aussagen über das Fahrverhalten von Ackerschleppern bei schneller Straßenfahrt treffen.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

PERSPEKTIVEN DER MASCHINENTEILRENOVIERUNG

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The rehabilitation of worn out machine parts is a method of providing spare parts usually cheeper than there is a production of new ones. This method makes possible to decrease consumption of materials and energy with a favourable ecological effect. The formula for determination of material rahabilitation savings can be used as the criterion of an ecological suitability of the rahabilitation process.

rehabilitation; metal savings; metal loss; coefficient of metal using; ecological effect of rehabilitation

1. EINLEITUNG

Die Renovierung wird gewöhnlich wie ein spezieller Fall einer Reparatur begriffen, wenn das Reparaturobjekt ein Maschinenteil ist. Die Besonderheit dieses Falles besteht darin, daß ein technologisches Verfahren keine Demontagen, Montagen und Einstellungen enthält. Weil der Arbeitsfähigkeitsverlust gewöhnlich durch eine Beschädigung von einem der mehreren Maschinenteile verursacht wird, handelt es sich bei der Renovierung um eine Beseitigung der Störungsursache. Dafür wird die Renovierung manchmal als "eine Echtreparaturarbeit" begriffen.

Die Renovierung ist aber auch wie "eine Maschinenteilquelle" zu begreiffen. In diesem Fall ist die Renovierung eine Alternative zur Neuherstellung der Maschinenteile. Die Wahl zwischen Neuherstellung und Renovierung der Maschinenteile ist dann nicht nur ein technisches, sondern auch ein ökonomisches Problem.

Gegenwärtig gibt es in der Tschechoslowakei eine gewisse Unlust und ein Mißtrauen zur Renovierung der Maschinenteile. Das kommt wahrscheinlich daher, daß vorherige Renovationslösungen manchmal technische und ökonomische Grenzen ihrer Realisation übergeschritten haben und daß unangemessene Ergebnisse erwartet wurden. Aber diese Unlust zur Renovierung der Maschinenteile ist nicht ganz angemessen. In der Welt ist Renovierung normalerweise mehr als in der Tschechoslowakei üblich. Es gibt dafür eine ganze Reihe von Gründen; in diesem Beitrag werden zwei von diesen Gründen näher durchleuchtet.

2. RENOVIERUNG ALS POTENTIELLE GEWINNQUELLE

Setzen wir eine Maschinenteileproduktion erstens als Neuherstellung, zweitens durch eine Renovierung voraus. Vergleichen wir diese Fälle. Wir sehen, daß in der Renovierung nur einige Fertigungsoperationen durchgeführt werden. Es handelt sich gewöhnlich um Endfertigungsoperationen. Einige Fertigungsoperationen kommen in der Renovierung nicht vor, einige Operationen sind für die Renovierung spezifisch. Schematisch sind diese zwei Fälle im Bild 1 auf dem Beispiel einer Kurbelwelle dargestellt.

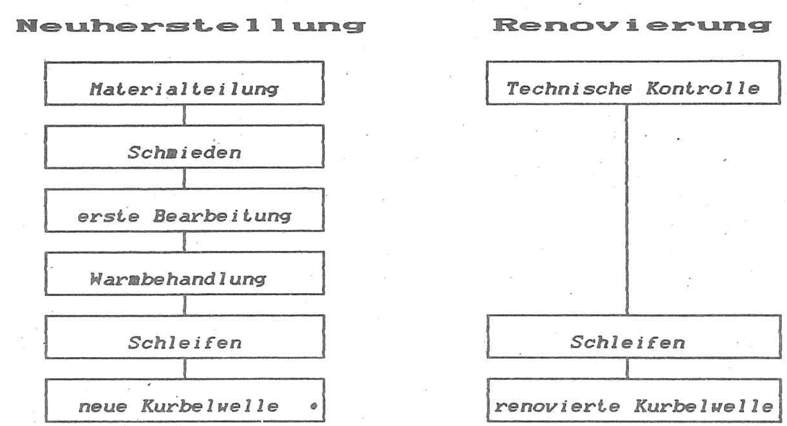

Bild 1 Schematischer Vergleich Fertigungs- und Renovierungsverfahren

Schon aus dem Vergleich bei diesem einfachen Beispiel kann man eine ganze Reihe von Schlußfolgerungen ziehen. Setzen wir zuerst voraus, daß die Qualität (dadurch auch die Lebensdauer, der Instandhaltungsverbrauch u.a.) in beiden Fällen die gleiche ist. Dann ist ganz egal, auf welche Weise das Maschinenteil hergestellt wird. Und auch der Preis des Teiles kann in beiden Fällen der gleiche sein.

Unter diesen Bedingungen ist zu berechnen, welchen Höchstpreis ein Materialeintritt der Maschinenteilproduktion haben darf: Setzen wir voraus, daß jede Produktionsverfahrenoperation den Maschinenteilpreis um eine Preiseinheit erhöht. Es betrage z.B. Preis des fertigen Maschinenteils 10 Preiseinheiten. Dann darf der maximal zulässige Materialeintrittspreis der Fertigung 5 Preiseinheiten betragen, und der maximal zulässige Materialeintrittspreis der Renovierung 8 Preiseinheiten betragen. Die während der Exploatation beschädigten Maschinenteile, die nicht renoviert werden, werden Schrott. Weil Schrott einer von den Materialeintritten für Hüttenproduktion ist, muß Schrott in unserem Beispiel einen niedrigeren Preis als 5 Preiseinheiten haben. Schätzen wir seinen Preis z.B. auf 2 Preiseinheiten. Die Differenz der Materialeintrittspreise (in unserem Beispiel 6 Preiseinheiten) ist eine potentielle Gewinnquelle für den, der diese Maschinenteile renovieren wird.

Es erscheint selbstverständlich, daß der Verkaufspreis der beschädigten, zur Renovierung geeigneten Maschinenteile, irgendwo zwischen Schrottpreis und maximal zulässigem Materialeintrittspreis der Renovierung liegt; in unserem Beispiel beträgt er z.B. 4 Preiseinheiten.

Wenn renovierte Maschinenteile nicht die gleiche Qualität haben wie die neuen Teile, kann die Renovierung trotzdem günstig sein. Dieses Problem ist aber einigermaßen kompliziert; in diesem Beitrag wird es nicht gelöst.

3. UMWELTSCHUTZASPEKTE DER RENOVIERUNG

Die Renovierung ist auch ein umweltfreundliches Verfahren. Wenn jeder Rohstoff- und Energieverbrauch umweltschädlich ist, ist in der Schlußfolge immer die Variante günstiger, die den geringsten Rohstoff- und Energieverbrauch hat.

Im Vergleich einer Maschinenteilproduktion durch Renovierung, neue Produktion mit der Ausnutzung der beschädigten Teile wie Schrott und der Neuherstellung ist immer die Renovierung das umweltfreundlichere Verfahren.

Im Bild 2 werden schematisch Maschinenteilproduktdionsverfahren durch Renovierung und durch eine neue Produktion aus Schrott dargestellt.

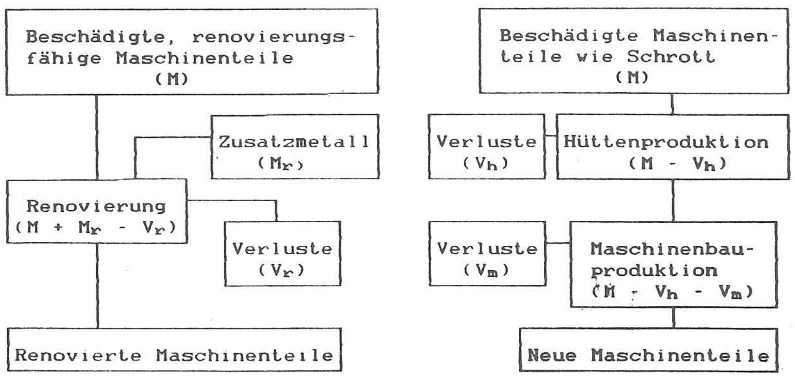

Bild 2 Schematische Darstellung des Maschinenteilproduktionsverfahren

Metallersparnisse können infolge verschiedener Metallverluste beider Produktionsverfahren entstehen. Gemeinsam sind Metallersparnisse nach Bild 2 folgend festzustellen:

$$E_M = V_h + V_m - V_r \quad (1)$$

wo bedeutet:
E_M Metallersparniß
M Masse der renovierungsfähigen beschädigten Maschinenteile
M_r Masse des Zusatzmetalls
V_r Metallverluste der Renovierung
V_h Metallverluste der Hüttenproduktion
V_m Metallverluste der Maschinenbauproduktion

Mit Hilfe dieser Symbole können die Koefizzienten der Metallausnutzung definiert werden:

$$k_h = 1 - \frac{V_h}{M} \quad (2)$$

$$k_m = 1 - \frac{V_m}{M - V_h} = 1 - \frac{V_m}{M.k_h} \quad (3)$$

$$k_r = 1 - \frac{V_r}{M + M_r} \quad (4)$$

wo bedeutet:
k_h Koefizzient der Metallausnutzung in Hütten
k_m Koefizzient der Metallausnutzung im Maschinenbau
k_r Koefizzient der Metallausnützung in Renovierung

Mit Hilfe dieser Koefizzienten kann die Gleichung (1) folgend umgeformt werden:

$$E_M = M(1 - k_h.k_m) - (M + M_r).(1 - k_r) \quad (5)$$

Die Gleichung (5) ist gemeinsam gültig und drückt die absolute Metallersparnisse durch Renovation aus. Der Wert der Metallausnutzungskoefizziente wird für jede Branche entweder gekannt, oder ist leicht festzustellen. Dadurch ist die Gleichung (5) direkt zu nutzen.

4. ZUSAMMENFASSUNG

Zum Schluß ist es möglich zusammenzufassen, daß Maschinenteilrenovierung nicht nur technisch, sondern auch ökonomisch lösen werden muß. Der gemeinsame Vorteil der Maschinenteilerenovierung besteht eben in der günstigen Umweltwirkung und Ökonomie. Zur Beurteilung der Renovierung muß man Rücksicht nehmen nicht nur auf das technologisches Verfahren, sondern auch auf ökonomische und ökologische Folgen auf dem Gebiet der Teilausnutzung. Als eine Meßeinheit der ökologischen Renovierungsgünstigkeit kann die obsolute Metallersparniß dienen. Sie ist nach der Gleichung (5) festzustellen.

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TRENDS IN AGRICULTURAL ENGINEERING
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THE MECHANIC-TECHNOLOGICAL BASIS OF PROCESSES OF WET GREEN PLANT FRACTIONATION

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To develop the mechanical-technological basis of process of wet fractionation the vegetable raw material was represented as the four-element Burgers model with non-linear subsystems of Maxwell and Kelvin-Foygt. Differential equation describing the model behaviour with the deformation by compression was received. The approximate solution of this equation allowed to determine the adequate dependency for calculation of stresses for deformation by compression of the vegetable raw material made with different velocity.

green plant; wet fractionation; deformation; model; differential equation

I. INTRODUCTION

Long investigations in our country and abroad showed the worthwile of fodder and protein supplement production by the green plant wet fractionation /I, 2/.

The process of the green plant wet fractionation is characterized by the deformation of the hard skeletal /fibrous/ phase with the help of compression and the selection by means of the filtration the fluid phase - the green /vegetable/ juice. For the next development of the mechanic-technological base of the given subprocesses it became necessary to substrantiate the green plant mechanical model and to trace its rheology behaviour during the processing of its deformation by compression.

2. RESULTS AND DISCUSSION

Analysis of a priory information showed that the four - element Burgers model with the non-linear subsystems of Maxwell and Kelvin-Foygt most closly reflected the vegetable raw material deformation by compression during the wet fractionation /Fig./.

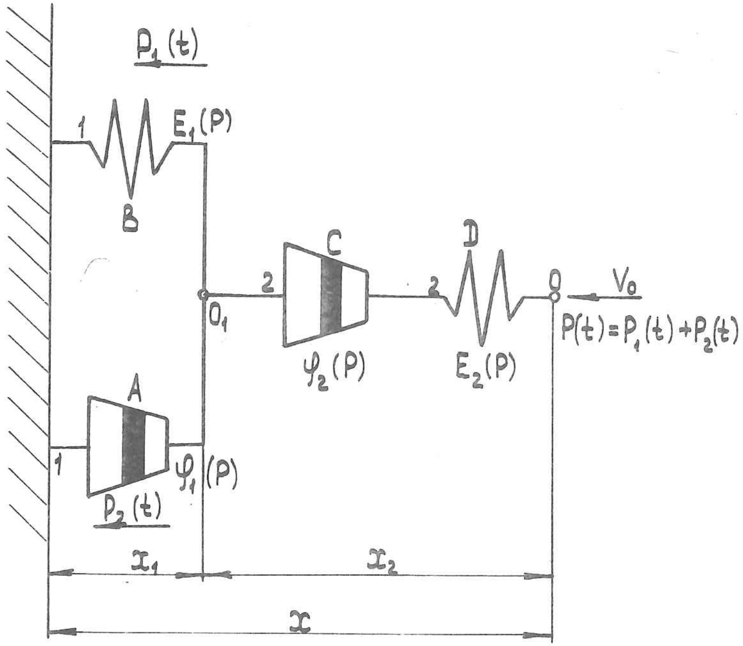

Fig. The four-element non-linear model Burgers

This model accounts completely the non-linear dependence between stress σ and deformation ε and some other main features of the process: instantaneous deformation, stress relaxation, elastic-visious after effect, residual deformation and etc.

Analysis of the rheology behaviour of the Burgers model consist in establishing the law of change of the coodrinat points grid reference in time current under the given stress action /see Fig./. With this as a stress representation proportional to the translocation, the non-linear elastic element-a spring with rigidity ε was taken. The strees proportional to the first derivation of translocation in time was simulated by the non-linear viscous element - the cylinder with the viscons liquid having the proportional coefficient φ.

Also, it was taken into account that the characterictic of the non-linear elastic /spring E_1 and E_2 / and non-linear viscous /cylinder φ_1 and φ_2 / elements were the time t functions. Moreover these relation were expressed by the strees function $P(t)$:

$$\left.\begin{aligned} E_i &= E_i(t) = E_i\left[P(t)\right] \\ \varphi_i &= \varphi_i(t) = \varphi_i\left[P(t)\right], \quad i = 1,2 \end{aligned}\right\}$$

System of differential equations describing Burgers model behaviour has the following view:

$$\left.\begin{aligned} & x = V_0 t = x_1 + x_2 \; ; \\ & x_1 = P_1(t)E_1(P) = \int_0^t \varphi_1(P)P_2(t)\,dt \; ; \\ & x_2 = P_1(t)E_2(P) + P_2(t)E_2(P) + \int_0^t \varphi_2(P)P_1(t)\,dt + \\ & \quad + \int_0^t \varphi_2(P)P_2(t)\,dt \\ & P = P(t) = P_1(t) + P_2(t) \end{aligned}\right\}$$

After differentiation of the data of the equations in time and the conducted transformation it was possible to get the non-linear differential equation of the second degree comparatively the function $P(t)$:

$$A(P)\ddot{P} + B(P)\dot{P} + C(P)\dot{P}^2 + D(P)\dot{P}^2P + F(P)\dot{P}P + \qquad /I/$$

$$+ G(P)P = H(P),$$

$$\ddot{P} = \frac{d^2P}{dt^2}, \qquad \dot{P} = \frac{dP}{dt};$$

$$A(P) = E_1(P)\varphi_1(P)\left\{E_2(P) + P\left[E_2(P)\right]'_P\right\};$$

$$B(P) = \varphi_1^2(P)E_1(P) + E_1(P)\left[\varphi_1(P)\right]'_P V_0 + E_1(P)\times$$

$$\times\varphi_1(P)\varphi_2(P) - \left[E_1(P)\right]'_{P_1}\varphi_1(P)V_0 + \varphi_1^2(P)E_2(P);$$

$$C(P) = -E_1(P)\left[\varphi_1(P)\right]'_{P_1}E_2(P) + 2\varphi_1(P)E_1(P)\left[E_2(P)\right]'_P +$$

$$+\left[E_1(P)\right]'_P\varphi_1(P)E_2(P);$$

$$D(P) = -E_1(P)\left[\varphi_1(P)\right]'_P\left[E_2(P)\right]'_P + \varphi_1(P)E_1(P)\times$$

$$\times\left[E_2(P)\right]''_{pp}+\varphi_1(P)\left[E_1(P)\right]'_p\left[E_2(P)\right]'_p\ ;$$

$$F(P)=-E_1(P)\left[\varphi_1(P)\right]'_p\varphi_2(P)+E_1(P)\varphi_1(P)\left[\varphi_2(P)\right]'_p+$$

$$+\varphi_1^2(P)\left[E_1(P)\right]\ ;$$

$$G(P)=\varphi_1^2(P)\varphi_2(P),\quad H(P)=V_0\,\varphi_1^2(P)\ .$$

It should be noted that the variable coefficients incoming in this equation are the unknown functions: $E_1(P)$ and $E_2(P)$ cheracterized the non-linear spring figidity; $\varphi_1(P)$ and $\varphi_2(P)$ describe the non-linear viscous elements /Pistons/.

As a result of the approximate solution of the equation /I/ by the disturbance method with the incoming of the parameter $\delta\,(0<\delta<1)$ was got:

$$P(t)=c_1e^{k_1t}+c_2e^{k_2t}+\frac{V_0}{\varphi_{20}}+\delta\left(c_3e^{k_1t}+c_4e^{k_2t}\right)+ \qquad /2/$$

$$+D_1te^{k_1t}+D_2te^{k_2t}+D_3e^{2k_1t}+D_4e^{2k_2t}+D_5e^{(k_1+k_2)t}+D_0\ .$$

Consequently for the deformation by compression with constant velocity V_0 of the non-linear four-element Burgers model it is necessary to apply stress equal to P .

Thirteen unknown coefficients C_1-C_4 , $D_1-D_5, D_0, \varphi_{20}, k_1, k_2$ incoming into the dependence /2/ should be determed experimentally. Parameter δ can be taken as equal to any value during the interval $0<\delta<1$.

To discover all the above mentioned coefficients it became necessary to determine thirteen value of pressure P_i corresponding to thirteen value of time t_i during the experimental investigation. Than the system cousisting of thirteen non-linear equation is to be solved, namely:

$$P_i(t_i)=c_1e^{k_1t_i}+c_2e^{k_2t_i}+\frac{V_0}{\varphi_{20}}+\delta\left[c_3e^{k_1t_i}+c_4e^{k_2t_i}+D_1t_ie^{k_1t_i}+\right.$$

$$\left.+D_2t_ie^{k_2t_i}+D_3e^{2k_1t_i}+D_4e^{2k_2t_i}+D_5e^{(k_1+k_2)t_i}+D_0\right],$$

$$i=1-13\ .$$

Comparision of the results of the theoretical investigations with the experimental data on the green plant wet fractionation corroborated their adequacy with the fiducial pro-

bability limit IO%.

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TRENDS IN AGRICULTURAL ENGINEERING
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RHEOLOGICAL PROPERTIES OF PRODUCTS OF VEGETABLE RAW MATERIAL COMPLEX RETREATMENT

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The discription of a new energy saving, wastless technology of the green plant complex retreatment is given. The results of the investigation of the main rheological properties of the produced products - the protein paste effective viscosity and the brown juice kinetic viscosity is given.

green plant; wet fractionation; protein paste; brown juice; rheological properties

I. INTRODUCTION

On the basis of the wet green plant fractionation the energy saving, wastless technology of annual and perennial grass complex retreatment into the high quality fodder and protein supplements - protein replacement in the ruminants and the broiler ration was worked out /I/. The vegetable raw material separation into the hard /vegetable press made of plants/ and fluid /green juice/ fractions by this given technology is provided. Then, the press made of plants is retreated into the high quality silage or grass flour with the increased carotin suitability. After injection coagulant and conservant mixture into the green juice the separation of the produced mixture into the protein paste and the brown juice in the field of gravitation occurs.

Taking into account the tradition of the processes of the press made of plants silage or the grass flour production of it one may note that the particular interest for the substantiation of the design - technological parameters of the recommended equipment is of the physic-mechanic properties of the protein paste /effective viscosity/ and the brown juice /dinamic and kinematic viscosity/.

2. MATERIALS AND METHODS

Determination of the protein paste effective viscosity

/non-Newtonian liquid/ took into account the measurement of the couple of values of shear stress τ and velocity of chear stress deformation $\dot{\gamma}$.

The determination of the relation of form $\tau = f(\dot{\gamma})$ in the condition of the simple protein paste shear of the various humidity was conducted by means of the rotational-type viscosimeter Rheotest-2. Then for every value $\dot{\gamma}$ the effective viscosity η was calculated:

$$\eta = \frac{\tau}{\dot{\gamma}} [Pa \cdot s] . \qquad /I/$$

The decreased humidity protein paste /W_I = 69.52%/ for the first seria of the tests was obtained as a result of the chemical coagulation of protein made of the alfalfa green juice by the mixture of formic acid /coagulant/ and formaldehyde /conservant/ in the valum of I% to the juice mass. Patterns of the increased humidity paste /W_2 = 74.22%; W_3 = 75.59%; W_4 = 77.52%; W_5 = 78.75%/ were abtained by means of injection a small dose of the brown juice. Patterns of the increased humidity paste /W_6 = 86.17%; W_7 = 87.88%; W_8 = 90.06%/ were obtained also by the chemical coagulation of green juice protein, but during the shorter time of the produced mixture separation.

In the process of the test conduction the protein paste temperature was equal to 293.7 K /20.7°C/, the protein mass weighed amount /speciment/ was changer from 0.0I7 till 0.05 kg, velocity gradient $\dot{\gamma}$ was changed from I till 27 S^{-I} in the first seria and from I till I45.8 S^{-I} in the second one.

Coafficients of the kinematic viscosity of the origin and concentration thermostatic brown juice patterns were determined by means of the capillary viscosimeter.

Coafficients of the dynemic viscosity were calculated with the following formula

$$\mu = \nu \cdot \rho [Pa \cdot s] \qquad /2/$$

where ρ - brown juice density.

3. RESULTS AND DISCUSSION

The rheograms characterizing the relation of shear stress τ from velosity gradient $\dot{\gamma}$ are shown in Fig.I and Fig.2. The relation of the effective viscosity η from velocity gradient $\dot{\gamma}$ is shown in Fig.3.

Analisis of the obtained rheograms /see fig.I/ shows that for the description of the increased humidity paste flow /W = 77.52 - 90.06%/. Ostwald, de Waele equation may be used, characterizing pseudoplastic material flow:

$$\tau = K \cdot \dot{\gamma}^{n} [Pa] \qquad /3/$$

where K - consistency coefficient;

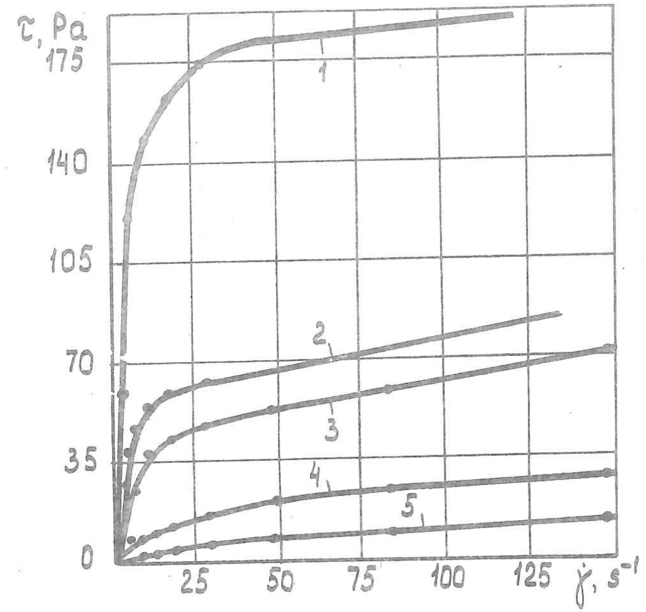

Fig. I. Relation of shear stress τ from velosity gradient $\dot{\gamma}$: I - W = 77.52%; 2 - W = 78.75%; 3 - W = 86.I7%; 4 - W = 87.88%; 5 - W = 90.06%

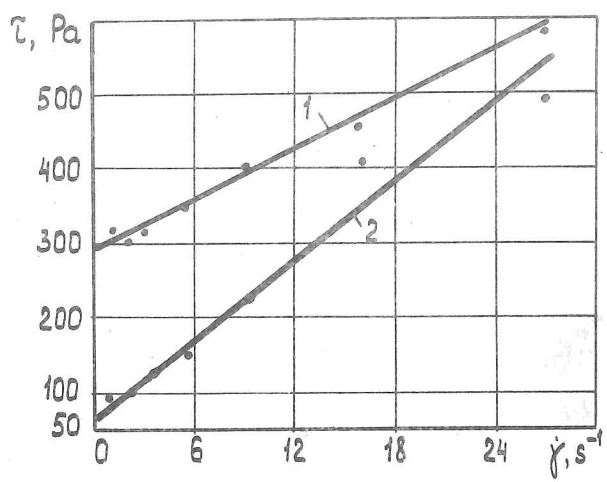

Fig. 2. Relation of shear stress τ from velosity gradient $\dot{\gamma}$: I - W = 69.52%; 2 - W = 74.22%

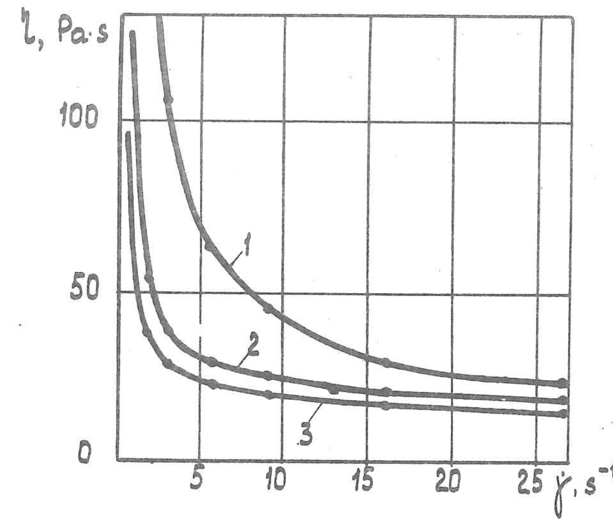

Fig. 3. Relation of the effective viscosity η from velosity gradient $\dot{\gamma}$: I - W = 69.52%; 2 - W = 74.22%; 3 - W = 75.59%

Table. Calculated values of rheological constants of equations of various humidity protein paste state

Paste humidity, W, %	Values of rheological constans			
	τ_o	η_{pl}	K	n
69.52	283.5I4	II.45	--	--
74.22	7I.3I	I6.93I	--	--
75.59	43.273	I9.568	--	--
77.52	--	--	36.I79	0.54I
78.75	--	--	I4.863	0.52I
86.I7	--	--	I3.68I	0.382
87.88	--	--	4.027	0.393
90.06	--	--	I.043	0.493

n - empiric coefficient.

The rheograms of the decreased humidity protein paste flow /W = 69.52 - 75.59%/ have the linear section /see fig.2/, typical for the Bingham bodies and corresponding to the ideal plastic flow.

For the description of the specified humidity paste flow Bingham equation was used

$$\tau = \tau_0 + \eta_{pl} \cdot \dot{\gamma} \; [Pa] \qquad /4/$$

where τ_0 - limiting shear stress;
η_{pl} - plastic viscosity.

Rheblogical constants of equations /3/ and /4/, definited by the least square method are given in table.

The coefficient relation of the brown juice dynamic viscosity from the content of dry substance in it obtained after analysis of the experimental data by the least square method may be described by the following equation

$$\mu = (1{,}272 + 0{,}004 \cdot c^2) \cdot 10^{-3}. \qquad /5/$$

Checking of the obtained equations /3/, /4/, /5/ with Fisher criteria showed that in all the cases they adequatly described the experimental data with the value level not higher than 5%.

With the investigation of the process of the protein paste long storage the objective laws of the change of its physic-mechanic properties were not established. After keeping the brown juice in the aerobic conditions during three months the change of its dynemic viscosity coefficient was not recorded.

Application of the obtained experimental data and relations simplifies the development of the technological time-limit and documentation on the equipment intended for unloading from the storage and sequent transportation of the various humidity protein paste and brown juice to the consumption place.

R e f e r e n c e s

/I/ PROYDAK, N. - DOLGOV, I.: Result of Leaf Protein Research in the USSR. Proceeding of the third International Conference of Leaf Protein Research. Italy, I990, p. I70

TRENDS IN AGRICULTURAL ENGINEERING
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DURABILITY OF HORIZONTAL SILOS

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The generally expected durability of horizontal silos has been evaluated on a base of 173 structures investigated. The silos were assorted into three categories according to their structural states and/or to the answering environmental damages. The results show that about 1/2 of silos evaluated as unsatisfactoty after a service period of about 22 years, which is much less than 1/2 of the planned one.

durability, horizontal silos, environment, environmental damages

The durability of farm buildings and their structural accessories in Czechoslovakia is usually taken to be 50 to 80 years. Naturally, it is supposed that they keep all the necessary properties during this whole period. Among these properties the watertightness and ecological undefectivity are of a special weight.

Criteria of HS evaluation TAB. 1

Class	Verbal score	Specification
I	good	- undamaged inner surface of HS and of its juice reservoir, - undamaged juice draining system, - checking system carried up, - adequate size of juice reservoir, - no traces of juice leaking into the environment,
II	uncertain	- the above conditions not fulfilled but no traces of juice leakage,
III	bad	- heavy damages of HS and/or its juice reservoir (e.g. visible ruptures in the structure, visible traces of juice leakage.

Note : the checking system is carried out as a second water insulation layer which drains the possible seepages, not held by the primary insulation, into an inspection shaft enabling thus the checking of HS proper function.

Horizontal silos (HS) are a common part of farm buildings accessory and, besides this, they are relatively simple structures. This means that even a lack of structural documentation need not interferre with the evaluation of their environmental functions. A good deal of their qualitative attributes may be ascertained even by visual investugation. This paper represents an attempt to evaluate the conditions of HS in Czechoslovakia, and to find out the parametres of their reliable service life.

The evaluation is based on a three-degree visual assessment expressing the structural state of HS and contingent traces of environmental damages caused by it (Tab. 1).

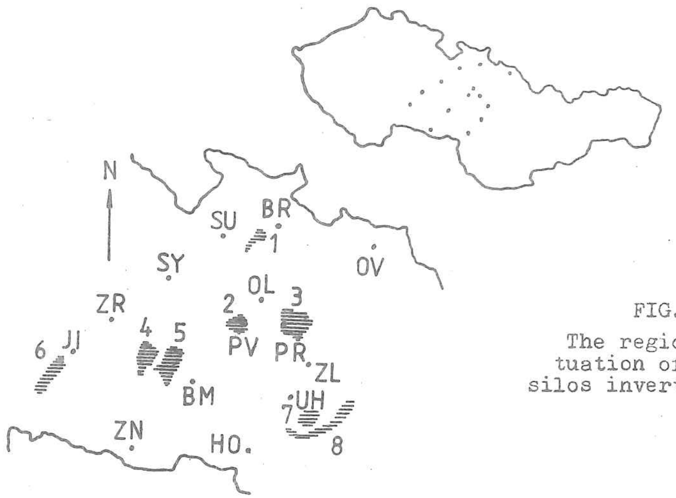

FIG. 1 : The regional situation of the silos invertigated

During the period 1985 - 1991, eight regions with altogether 173 HS investigated (Fig. 1). From the view point of HS durability and/or of environmental policy are the obtained results very unsatisfying (Tab. 2).

It is quite natural that there were different types of the investigated HS. Older silos were often from masonry, both of brick and stone, mostly with concrete or paved bottoms, only a little part was from monolite concrete. The newer HS were constructed using monolite or precast concrete with concrete, bitumen or hard-brick paved bottoms. The monolite structures require in general more site-work and therefore they are less used, even if they seem to be more corrosion-resistant and durable. A more detailed look shows that only the newest HS are satisfactory while the older ones usually show an uncertain or even bad condition.

In this context it is necessary to mention that HS were investigated at certain dates while their states conditioning the classification were reached earlier. Therefore, it is obvious that the service life calculated on the base of

the presented set of data might be in fact even shorter than 22.4 years (see Tab. 2, class III).

Numbers of HS in individual categories TAB. 2

Detailed data	Category I PRE	I MONO	II PRE	II MONO	II MAS	III PRE	III MONO
Total	44	2	27	6	12	52	30
Age yr							
mean	4.6	7	11.2	14.3	20.4	21.4	25.1
min	1	2	4	2	7	9	8
max	16	12	24	30	28	35	36
No. in individ. class	46		33			94	
Percentage	26.6		19.1			54.3	
Aver.serv. life	4.7		11.7			22.4	

Note : PRE means precast, MONO means monolite, MAS stands for masonry.

Renewed HS TAB. 3

Renewed after	Again in class III
serviceyears	
14	10
18 (two HS)	5
19	8
20 (two HS)	5
mean :	
18.1	6.3

Among HS investigated there were six precast ones which were reconstructed due to their unsatisfactory condition. It may be seen that after another several years of operation they showed the same bad condition as before (Tab. 3). It is supposed that the cause of this situation was a low shear resistance of the panel joints and, perhaps, an unsufficient foundation, too.

Conclusion

The presented work shows that a great deal of HS do not reach the expected service life. Reasons of this are seen both in structural-operation and in sillage-manufacturing fields. On the one hand the joints and surfaces of HS are often not maintained in time and properly enough, on the other the sillage solids are too low, hence the juice is produced in surplus.

TRENDS IN AGRICULTURAL ENGINEERING
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MECHANICAL CHARACTERISTICS AS INDICES DETERMINING APPLE MATURITY

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Apple testing aimed at finding correlations between fruit maturity indices,firmness and sensory estimation and their mechanical characteristics (13 determined atributes). Significant interdependence was found between tested characteristics, except for the relation between the plunger penetration depth, firmness and the sensory estimation for Starkrimson variety. In the period under study the yield energy index varied most of all.

apples, mechanical characteristics, firmness, sensory estimation, correlations

INTRODUCTION

A very popular and commonly used index for the estimation of apple quality and its degree of maturity is firmness. It is determined by means of instruments of Magness-Taylor, Effe-Gi and the like, which record the resistance exerted against the penetration of plunger of dia. 7/16 inch into the the apple flesh to a depth of about 8 mm (5/16 inch). As the apple mature the firmness reduces by an average of 20 %, while during storage - by about 50 % (3). Smock and Neubert (6) indicate factors, such as temperature, water/moisture content, which restrict the application of firmness for material evaluation. Fridley (5) on the other hand turned attention to the complex character of the stresses in the sample during firmness-meter plunger penetration.
Many researchers investigated the variation of other parameters. Bourne (3) determined the basis parameters of Red Delicious apple structure, such as: hardness, brittlness, viscosity, cohesiveness, elasticity, depending on the period of storage. Yamamoto at alii (7) have shown that strength spectrum frequency significantly reduces its value with the increasing time of storage as a consequence of intensifying process of flesh softening.
Finney (4) found out that, as the storage period becomes longer, the resonance frequency of apples becomes reduced and so do the elongation and lateral elaticity moduls. The loss coefficient, on the other hand, increases to confirm that, as apple hardness becomes reduced, their viscous and damping properties become more prominent (increase).

The aim of the tests was to determine the interdependance between indices of degree-of-maturity estimation, firmness and sensory estimation and the mechanical parameters.

TESTING METHODS

The object of study were the apples of three varieties selected in size and weight respects, namely McIntosh and Spartan - dia. 6.5-7.0 cm, weight 105-156 gram and Starkrimson - dia.6.0-6.5 cm and weight 98-122 gram. The selection of varieties aimed at accentuating differences in structure characteristics. The apples were picked manually from the outer borders of the tree head (corona) from a strictly determined height on the south-western side. They were stored in the cold store at a temerature of 274.7 K and humidity of 93 %.
The samples for measurements were taken from cold store, then kept in the (testing) room for 8 hours so that the apple flesh should reach the room temperature.
The firmness was determined with Effe-Gi firmness meter accordig to the technique developed by Blanpied at al (2). The top layer of the fruit of cut off and then the firmness tester is driven into the sample, to the mark made on its lateral surface, at a uniform speed in 2 seconds. The results are read from dial indicator.
Sensory estimation consisted in determining the apple surface suppleness to thumb pressure and hardness - as a result of biting the fruit. For the analysis of results the average estimation is taken into account for both the suppleness to thumb pressure and the hardness. The 5-point estimation scale is applied.
Mechanical characteristics were determined from various attempts of driving the plunger into the material structure. Following characteristics were determined: deformation, force and energy at the yield and rupture strength, depth of penetration of the spherical plunger into the surface layers at loading levels of 5, 10 and 15 N, as well as the resistance factor.
The static loading rig (1) served for determining the deformation, force and energy at yield and rupture strength (from puncture tests of cylindrical plunger). These characteristics were determined from the deformation/force curve as plotted by the XY-recorder,according to technique presented in the paper (1). The speed of puncture of the cylindrical plunger of dia. 7/16" was constant and amounted to 5×10^{-4} m/s. The measurement apparatus system contained the tensometric convertors for the measurement of deformation and force, as well as the tensometric bridge TT-6c.
In the apparatus described in the paper (1) the depth of spherical plunger penetration into the surface layer of the material had been determined at loading levels of 5, 10 and 15 N, after 10 seconds. The measurement was carried out according to the technique presented in the paper (1). These tests were carried out with the application of initial load of 0.2 kg and spherical plunger of dia. 19 mm.
The dynamic penetrometer (1) was used to determine the resistance factor combining 3 values, namely: deformation energy, volume of the damaged material and the speed of impacting element. The technique of measurement and calculating

of resistance factor is presented in the paper (1). In this test the speed of impacter of 0.445 kg at hitting was constant and equal to 1.62 m/s for harvest period and 1.31 m/s for storage period. The cylidrical plunger of dia 7/16" was applied as sample damaging element.

The tests have been carried out 20 times as concerns the firmness measurement and 10 times as concerns the penetration depth. All studied characteristics were determined for the same batch of apples either harvested or taken from cold store (while keeping a constant temperature of apple flesh during the measurements).

During the apple harvest time (McIntosh Sept.14-29, Spartan Sept.20 - Oct.05, Starkrimson Oct.14-29) the measurements were carried out at four dates a month apart from one another.

TEST RESULTS

13 Mechanical characteristics had been determined. Interrelations between those and the apple maturity estimation indices, firmness and sensory estimation were under study. their character has been defined by means of correlation factors presented in the Tables 1 and 2. For the McIntosh variety in harvest time (Table 1) a strong correlation between those characteristics has been found. High correlation factors, significantly differing from zero at significance level of 0.01 and 0.05, have been achieved. For the Spartan variety at harvest time (Table 1) the relations between characteristics were similar, except for the relation between rupture energy and sensory estimation and that between the size/depth of penetration for flesh samples at 10 N load level and the firmness. For Starkrimson variety at harvest time on the other hand a very low correlation factors, at a level of 0.05, have been obtained only between the plunger penetration depth at the investigated levels of loading and the firmness and sensory estimation (Table 1) In the remaining cases high correlation factors, significantly differing from zero, have been found, except for the relation between rupture energy and firmness and the sensory estimation. Therefore, in case of McIntosh variety, having the lowest hardness of the flesh (1), all relations between tested characteristics proved significant.
For the Starkrimson variety, having high hardness of the flesh, on the other hand there was no such relation as concerns the penetration depth. In the storage period the three varieties under study showed much higher correlation factors between mechanical characteristics and firmess and sensory estimation than those during the harvest. All correlation factors differed significantly from zero at a significance level of 0.01 - refer to Table 2.
It is also important that the mechanical characteristic be characterized by a certain variation.
In the harvest period the yield energy varied most of all (Table 3). Its coefficient of variation averaged at 15.7 %. The other two most varying characteristics were the resistance factor and plunger penetration depth at a load level of 5 N. Their variation coefficients averaged at 11.9 % and 8.7 % respectively. The lowest variation at harvest period was shown by the yield deformation and rupture deformation.

Table 1. Correlations among various mechanical characteristics and firmness and sensory estimation of the fruit, in harvest period

Varieties	Indices	Characteristics from puncture test of cylindrical plunger						Penetration of spherical plunger into surface layers						Resistance factor
		Yield			Rupture			Flesh			Flesh with skin			
								Level of loading/N/						
		Deformation	Force	Energy	Deformation	Force	Energy	5	10	15	5	10	15	
Mc Intosh	Firmness	$-0,96^b$	$0,97^b$	$0,97^b$	$-0,87^b$	$0,91^b$	$0,95^b$	$0,71^a$	$0,93^b$	$0,92^b$	$-0,88^b$	$-0,89^b$	$-0,92^b$	$0,94^b$
	Sensory estimation	$0,92^b$	$-0,95^b$	$-0,91^b$	$0,82^a$	$-0,95^b$	$-0,97^b$	$0,72^a$	$0,97^b$	$0,97^b$	$0,89^b$	$0,90^b$	$0,94^b$	$-0,96^b$
Spartan	Firmness	$-0,97^b$	$0,91^b$	$0,95^b$	$-0,93^b$	$0,93^b$	$0,73^a$	$-0,89^b$	-0,70	$-0,72^a$	$-0,76^a$	$-0,88^b$	$-0,91^b$	$0,96^b$
	Sensory estimation	$0,94^b$	$-0,91^b$	$-0,91^b$	$0,93^b$	$-0,97^b$	-0,62	$0,95^b$	$0,83^b$	$0,85^b$	$0,91^b$	$0,93^b$	$0,90^b$	$-0,94^b$
Star-krimson	Firmness	$-0,99^b$	$0,96^b$	$0,78^a$	$-0,96^b$	$0,97^b$	0,61	0,05	-0,14	0,05	0,02	0,05	0,06	$0,96^b$
	Sensory estimation	$0,96^b$	$-0,97^b$	$-0,78^a$	$0,98^b$	$-0,96^b$	-0,59	-0,01	0,21	0,04	-0,01	0,02	0,01	$-0,96^b$

a - significant at the 5 % level

b - significant at the 1 % level

Table 2. Correlations among various mechanical characteristics and firmness and sensory estimation of the fruit, in storage period

Varieties	Indices	Characteristics from puncture test of cylindrical plunger						Penetration of spherical plunger into surface layers						Resistance factor
		Yield			Rupture			Flesh			Flesh with skin			
								Level of loading/N/						
		Deformation	Force	Energy	Deformation	Force	Energy	5	10	15	5	10	15	
Mc Intosh	Firmness	$-0,87^b$	$0,86^b$	$0,77^a$	$-0,93^b$	$0,87^b$	$0,85^b$	$-0,94^b$	$-0,95^b$	$-0,94^b$	$-0,93^b$	$-0,94^b$	$-0,94^b$	$-0,79^a$
	Sensory estimation	$0,96^b$	$-0,96^b$	$-0,92^b$	$0,90^b$	$-0,94^b$	$-0,96^b$	$0,91^b$	$0,91^b$	$0,84^b$	$0,88^b$	$0,87^b$	$0,88^b$	0,94
Spartan	Firmness	$-0,96^b$	$0,87^b$	$0,88^b$	$-0,86^b$	$0,90^b$	$0,92^b$	$-0,93^b$	$-0,95^b$	$-0,95^b$	$-0,94^b$	$-0,95^b$	$-0,93^b$	$-0,78^a$
	Sensory estimation	$0,99^b$	$-0,96^b$	$-0,95^b$	$0,92^b$	$-0,97^b$	$-0,96^b$	$0,89^b$	$0,93^b$	$0,92^b$	$0,88^b$	$0,93^b$	$0,91^b$	$0,90^b$
Star-krimson	Firmness	$-0,82^a$	$0,89^b$	$0,90^b$	$-0,82^a$	$0,89^b$	$0,86^b$	$-0,82^a$	$-0,81^a$	$-0,82^a$	$-0,81^a$	$-0,82^a$	$-0,79^a$	$-0,84^b$
	Sensory estimation	$0,97^b$	$-0,97^b$	$-0,91^b$	$0,91^b$	$-0,97^b$	$-0,96^b$	$0,96^b$	$0,92^b$	$0,94^b$	$0,96^b$	$0,94^b$	$0,93^b$	$0,95^b$

a- significant at the 5 % level

b- significant at the 1 % level

Table 3. Variation coefficient of mechanical characteristics of apples/%/

Test Date	Varieties	Characteristics from puncture test of cylindrical plunger						Penetration of spherical plunger into surface layers						Resistance factor
		Yield			Rupture			Flesh			Flesh with skin			
								Level of loading/N/						
		Defor-mation	Force	Energy	Defor-mation	Force	Energy	5	10	15	5	10	15	
Harvest	McIntosh	4,3	6,58	16,0	5,1	6,28	7,2	8,77	7,62	6,53	11,38	8,41	7,78	12,31
	Spartan	3,2	6,38	15,6	4,5	6,7	6,8	7,04	5,25	4,35	7,56	5,78	5,53	11,94
	Star-krimson	3,8	10,5	15,4	4,5	6,8	6,8	7,68	4,99	5,54	7,28	8,31	4,53	11,35
Period	McIntosh	14,47	15,0	27,03	5,5	7,93	16,6	8,59	9,14	8,61	7,63	8,3	8,34	26,88
	Spartan	12,2	11,8	23,27	4,8	8,05	16,6	7,09	9,06	7,55	7,36	7,56	6,75	21,48
	Star-krimson	13,4	12,35	11,5	5,2	10,81	15,5	12,01	11,58	12,78	14,82	9,57	10,73	18,10

The variation coefficient for the varieties under study averaged here at 4.2 per cent.
At the period of storage (Table 3) the highest variation coefficients have been recorded for yield energy (11.5 - 27 %), resistance factor (18-27 %) and rupture energy (15.5 to about 17 per cent). The smallest variation in the storage period was exhibited by the rupture deformation. Variation coefficient for the varieties under study was 5.1 % on average.

CONCLUSIONS

On the basis of tests carried out, the following summary conclusions can be drawn:

- Significant interrelations were found between mechanical characteristics and firmness and the sensory estimation at both the harvest and storage periods. The Starkrimson variety with high flesh hardness was an exception showing no significant relation between plunger penetration depth and firmness and sensory estimation.
- In the period under study the highest variation was exhibited by the yield energy. The coefficient of variation was 16 % in the harvest period and 27 % in the storage period and differed much from variety to variety.
- The rupture deformation at both harvest and storage periods showed small variation. Its coefficient of deformation averaged at 4.6 % for the tested varieties.

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TRENDS IN AGRICULTURAL ENGINEERING
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TESTING APPLE RESISTANCE TO DYNAMIC LOADING

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The paper presents the results of resistance factor measurements taken during harvest and storage on apples.The behavior of this factor is studied versus testing date,variety,year of test and method of storage.

apples,resistance factor,variation

INTRODUCTION

Damage caused to fruits as a result of mechanical loading,most often due to hitting /impact/ against each other or due to being hit by operating elements of harvesting machines, reaches about 80 percent/ 10/.Loading rates are within 0.25 and 40 meters per sec.Simple drop tests,either of the product upon a rigid surface /13,16/ or of a mass upon the product/4/,as well as pendulum impact devices /8,9,14/,have been widely used to create dynamic loading in laboratory conditions.The measuring instruments utilize pneumatic impact devices /11/,spring-loaded arms /6/,or arms rotated by electric motors /2/.The deformation of sample /5/ and impact force versus time /2,4/ were record during impact tests and such parameters as:impulse, deformation energy and maximum force were determined as a measure of resistance to dynamic loading.Besides, the impact mass and impact velocity have been proven to have a significant effect on the characteristics under test.

This paper is an attempt to determine the variation of resistance factor as indices linking the deformation energy with impact velocity and extent /size/ of damage, during harvest and storage periods.

TESTING METHOD

The impact penetrometr /1/ has been utilized for the testing.

The angle of impact was fixed and its value shown on angular scale of dial.Once the pendulum is released, the plunger impacts on the sample,penetrates into the flesh and then bounces back slightly from the sample. The angle of rebound was recorded by means of a pointer on angular-scale dial.After the measurement the samples were kept for 48 hours at room temperature till the damaged flesh acquired a brown discoloration.Then, the diameter and the depth of damage were measured after cutting through the samples at the places of damage of cylindrical shape /area of macro structure damage and flesh discoloration being the evidence of cell damage/.

The resistance factor W was calculated according to following formula:

$$W = \frac{m\ /\cos\alpha_1 - \cos\alpha\ /}{2\ V\ /1 - \cos\alpha\ /} \quad /kg/m^3/$$

where:

m - mass of pendulum /kg/, α - impact angle
α_1- angle of rebound, V - volume of damage
$V = 0.785\ h\ d^2\ /m^3/$, h - depth of damage
d = diameter of damage /m/

The mass of pendulum and the angle of impact had been determined by trials,selecting it so as to cause the puncture of plunger tip through the skin.They were determined separately for harvest period /m = 0.445 kg,α= 70 deg.,v = 1.62 m/s/ and for storage period /m = 0.445 kg,α=50 deg., v = 1.31 m/s/.The test was carried out with a typical apple-puncture-test plunger of dia. 7/16 in.This selection had been confirmed by initial tests.

Tested were the apples of three varieties, McIntosh, Spartan and Starkrimson selected in terms of dimensions /size/ and weight i.e. in sizes of 6.5 - 7 cm and weights within 105 - 136 g for the first two varieties,and in sizes of 6.0 - 6.5 cm and weights within 98 - 122 g for the last one.The tested fruits were properly shaped and hard-picked from the same altitude on the south-western side of the tree.Apples for tests were stored in a regular store /at average temperature and humidity of 279.4 K and 89 % respectively/ and in cold store /at 274.7 K and 93 %/. The measurements were carried out at following dates for individual apple varieties:

McIntosh - harvested on September 14,19,24,29 - storage period till Nov. 24, Dec.23,Jan. 25,Feb. 24
Spartan - harvested on September 20,25,30 and October 5 - storage period till Nov.30, Dec.30, Jan.28, Feb.25
Starkrimson - harvested on October 14,19,23,29 - storage period till Nov.19, Dec.21, Jan.19, Feb.18

The differentiating factors for measurement results were: the variety, the date and the year of test, as well as the method of storage. The tests were carried out in twenty repetitions each.

RESULTS AND DISCUSSION

The variation in value of the resistance factor for three varieties of apples during harvest time is presented in Figure 1. Over the period of testing the value of this factor became reduced, which is the evidence that the resistance of apples to damage diminished. This reduction of resistance was caused by the slackening of trait structure. It was confirmed by the measurement of flesh firmness with the pressure tester /Fig.1/. The reduction in firmness was the consequence of processes taking place during ripening, which led, among others, to weakening of inter-cellular bonds. Similar relationships were observed by Mohsenin at an./12/ in reference to force /pressure/ and energy in static loading. It was found that the date of test and variety had a significant effect on the value of resistance factor / at significance level of 0.05/. The highest resistance factor was exhibited by apples of Starkrimson variety /see Fig.1/, which had greater firmness of flesh /consisting of smaller cells and intercellular spaces/ in comparison to Spartan and McIntosh varieties. Between 1982 and 1983 the values of resistance factors were found to differ significantly, this resulting from the observed differences in climatic conditions, fertilization and in chemical plant protection. Results of measurements from storage period are presented in Table 1. The higher values of resistance factor /average value of $283*10^3$ kg/m^3/ in comparison to harvest time values /average value of $175*10^3$ kg/ m^3/ result from significant increase in plastic characteristics of the flesh. This phenomenon has been paid attention to by Green /7/, who found that, as a result of water loss by the apple during storage, its tissue becomes soft and more easily deformable. This rise in plastic characteristics could have contributed to the reduction of cell damage and thus to smaller total volume of damage. As a consequence, an apparent rise in resistance factor occurred despite the marked reduction in deformation energy. The average values of deformation energy and damaged volume were 0.635 Nm, $1.58*10^{-6}$ m^3 and 0.346 Nm, $0.91*10^{-6}$ m^3 for the periods of harvest and storage, respectively. During harvest period it was observed that apples having greater firmness of flesh exhibit higher resistance factor. During storage period, on the other hand, the relationship was reverse /see Table 1/. Over the period of tests the resistance factor increased. It could have been influenced by the content of justice and that of dry mass in apples which varied over storage period /due to natural loss/, as well as from store to store /due to different conditions of storage/ /14/. According to Nilssen at an./15/ the cell juice has a significant effect on the strength of materials.
Besides, the viscosity and damping characteristics of apples rise over the period of their storage /3/ and they could have some effect on the specific reactions of samples to dynamic loading. Evaluations of variational components and variation coefficients are presented in Table 2. The variability of characteristics between apple varieties was 16.6 % in harvest time and 8.4 % in the period of storage, while the variability versus time was 7.9 % and 21.9 %, respectively.

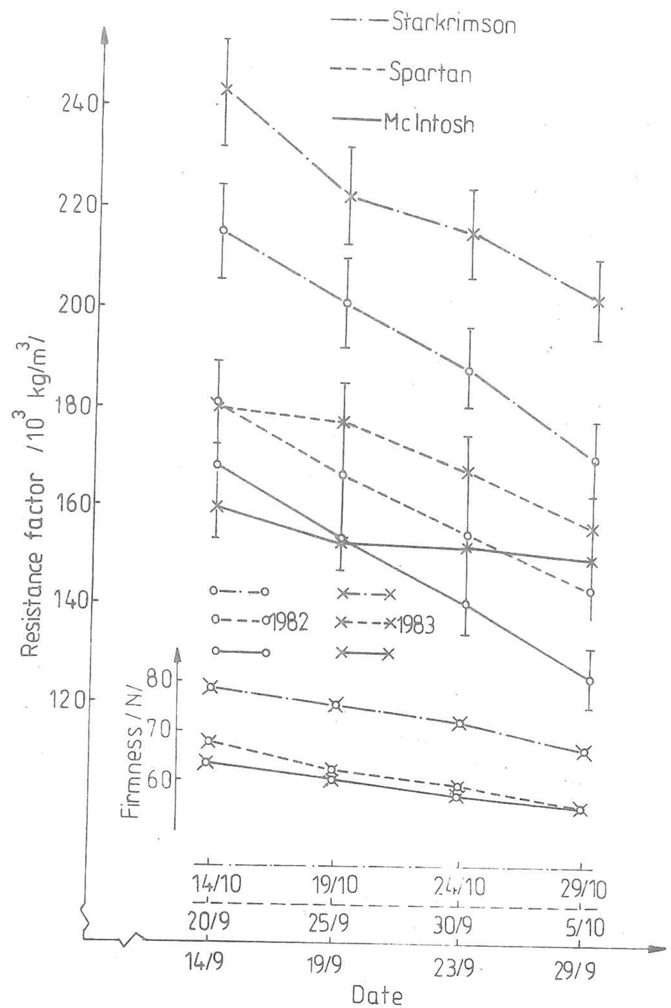

Fig.1.Resistance factor and firmness versus test date and variety, harvest period.

Table 1. Resistance factor W /10^3 kg/m^3/ firmness F /N/ versus test date of storage and variety /mean 20 replications/

Date for 3 varieties	Regular store						Cold store					
	McIntosh		Spartan		Starkrimson		McIntosh		Spartan		Starkrimson	
	W	F	W	F	W	F	W	F	W	F	W	F
24-30-19/11	251,0	29,6	233,3	36,9	221,5	53,6	230,5	32,1	210,9	38,1	203,2	65,0
23-30-19/11	281,0	27,2	289,0	34,7	244,0	46,7	244,5	30,3	230,3	36,3	214,6	55,2
25-28-19/1	347,9	26,5	337,3	33,6	293,0	45,8	273,7	29,8	309,3	36,5	240,9	49,2
24-25-18/2	427,2	24,9	389,1	31,0	329,3	43,2	361,3	28,3	340,8	33,8	300,5	44,3

Table 2. Estimations of Variation Components σ^2 /10^3 kg/m^3/ and coefficient of variance V /%/

Measured values	Variance source									
	Year		Method of storage		Variety		Date		Error	
	σ_a^2	V_a	σ_a^2	V_a	σ_b^2	V_b	σ_c^2	V_c	σ_d^2	V_d
Resistance factor harvest period	97,7	5,6	-	-	850,0	16,6	191,4	7,9	242,7	8,9
Resistance factor storage period	-	-	898,9	9,9	643,7	8,4	441,5	21,9	975,6	10,3

CONCLUSIONS

The tests carried out by authors permit the formulation of following conclusions:

- The resistance factor was found to be significantly influenced by the apple variety, date of test and by method of storage.
- Apples of greater firmness were found to have higher values of resistance factor during harvest;this is valid for apple variety and the date of test.
- The resistance factor was found to undergo apparent rise during storage, probably as a result of the rise in viscosity and damping characteristics of the material.
- The variability of characteristics between apple varieties was 16.6 % and 8.4 %, while the variability versus time was 7.9 % and 21.9 %,during harvest and storage periods.

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TRENDS IN AGRICULTURAL ENGINEERING
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EFFECT OF PLUNGER PENETRATION DEPTH ON MEASURED APPLES FIRMNESS

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Tests were carried out in order to determine the effect of measurement depth on the value of flesh firmness of apples.Depth of measurement had significant effect on the value of firmness.The firmness measurement error may reach values from 3 - 10 %.

apples,firmness measurement depth,error

INTRODUCTION

The pressure tester is a popular instrument for the evaluation of the degree of ripeness and quality of fruits.It measures,after previous peeling the outer layer with skin off, the pressure require for plunger tip penetration into the flesh to a depth of 7.9 mm (5/16 in) i.e.to a line scribed on the plunger. The "puncture" tests are widely used methods of measuring the fruit structure,despite other well known methods also being available /5/.The fruit firmness correlates strongly with its sensory evaluation /6/and therefore it is a good objective indicator of the commercial value of the agricultural product.Bourne /3/pay attention, though,to the poor repeatability of results obtained from pressure - tester measurements and to their extensive variability under the influence of human factor and of measuring technique.The differences in measurements may reach 20 percent /4/.Therefore the need for more detailed measuring technique to make the results comparable.

MATERIALS AND METHOD

Tests were carried out in order to determine the effect of measurement depth on the value of flesh firmness for apples of McIntosh, Spartan and Starkrimson varieties.

A test stand for static loading /1/ was used with plunger of dia 7/16 in /approx. 11 mm/ mounted on a loading beam and transmission ratiooselected to give plunger velocity of 4 mm per sec.

After peeling the outer layer off the sample/by means of vegetable peeler which enables cutting at constant depth/ the sample was put on a side support with an internal cavity in a form of cone.It enabled a stable fixing of the fruit and,due to large surface of support contact, the fruit was not deformed on the support side when plunger was pressed in.The sample was placed on the support,so that the surface plane of cut on the peeled sample was perpendicular to the direction of plunger movement. During measurement, the xy recorder plotted the graphic relationship between the resistance to plunger penetration and the plunger movement.

Determined plunger penetration depth from 1 to 3 mm in front of and behind proper depth of firmness measurement.

Tested were the apples of three varieties:McIntosh,Spartan and Starkrimson,selected in respect of dimensions and weight i.e..6.5 - 7.0 cm and 105 - 136 g, respectively, for the first two varieties and 6.0 - 6.5 cm, 98 - 122 g for the last one.They were properly-shaped fruits,hand picked from the same altitude on the south-western side of the tree.

The measurements were carried out at following dates for individual apple varieties:
McIntosh - September 14 /I/,19 /II/,24 /III/,29 /IV/
Spartan - September 20 /I/,25 /II/,30 /III/and October 5 /IV/
Starkrimson - October 14 /I/ and Oct.19 /II/.
The test were carried out in twenty repetitions each.

RESULTS AND DISCUSSION

As a result of tests involving plunger penetration into the structure of tested material the diagrams had been obtained which present plunger movement deformation versus loading pressure /force/.Figure 1 presents a typical curve of this relationship plotted for McIntosh apples.At first it run as straight line, thus evidencing direct - proportional relationship between penetration and pressure /force/.That is confirmed by Finney /7/ in reference to apples with the skin.As loading is further increased the diagram line bends and no longer obeys the Hooke law as a result of permanent deformations.That transition may take very different forms and be anything from smooth bend / see continuous line in the Fig.1/ to a sudden break of the line /see dotted line in the Fig.1/. This place on the diagram corresponds to bioyield point, after which the sample is further deformed even without any increase in loading.It also corresponds to the beginning of plunger penetration in to the structure of tested material /2/. The further part of Figure 1 shows a considerable rise in pressure force with the increasing depth of plunger penetration, which the increasing depth of plunger penetration, which is caused mainly by the variation in sizes of cells and intercellular spaces influencing significantly the strength of material /8/.

From the diagrams presenting the penetration versus pressure /force/,as recorded for apples,the firmness was determined at various plunger-penetration depth,are presented in Figure 2.

It was found that the depth of plunger penetration had significant effect on the value of flesh firmness /significant differences between average values at significance level of 0.05 a. 0.01/. For more firm apples/those with higher values of firmness/ of Starkrimson variety the increase in penetration depth by about 6 mm caused a corresponding rise in firmness by an average of 15 N and it was higher in comparison to Spartan apples - 12.1 N and McIntosh apples - 10.8 N.

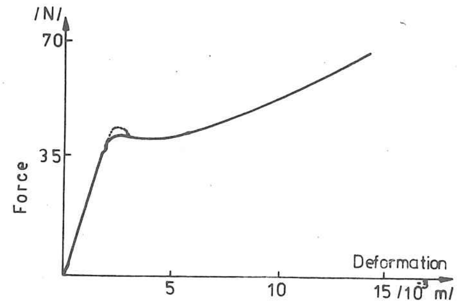

Fig.1.A typical force-deformation curve for McIntosh apples.

The average values of apple firmness with plunger pressed into the flesh to the mark scribed on its side surface /as it may be read from the diagram/were as follows:- 55.5 N for McIntosh /average values from four dates of tests /,- 62 N for Spartan /average values from four test dates/, - 81.1 N for Starkrimson /average from two test dates /.On the other hand, the differences in depth /Table/ of the order of +/-1, +/-2,+/-3 mm caused corresponding differences in firmness on an average of 1.6,3.5,5.4 N for McIntosh, 1.8,4.2,6.1 N for Spartan and 2.5,5.4,7.5 N for Starkrimson.The resulting error,as determined from average values from individual dates of tests /caused by different depth of plunger penetration/ may,for firmness measurement, reach values on an average between 3 and 10 percent, while for averages from individual measurements it reaches up to 14.6 percent.Such error may be imposed on measurements made by pressure tester.It results from imprecise determination of plunger depth caused by issuing juice and by visco-elastic characteristics of the flesh /5/. That is why the depth of penetration in pressure-tester measurements must be strictly controlled and,if possible, determined by mechanical or electric methods /mechanical stop, electric signaling device/.

CONCLUSIONS

- It was found that the depth of measurement /depth of plunger penetration/ had significant effect on the value of flesh firmness /penetration pressure force/.
- With increasing depth of measurement the values of flesh firmness rose as well, mainly a result of different sizes of cells and intercellular spaces.

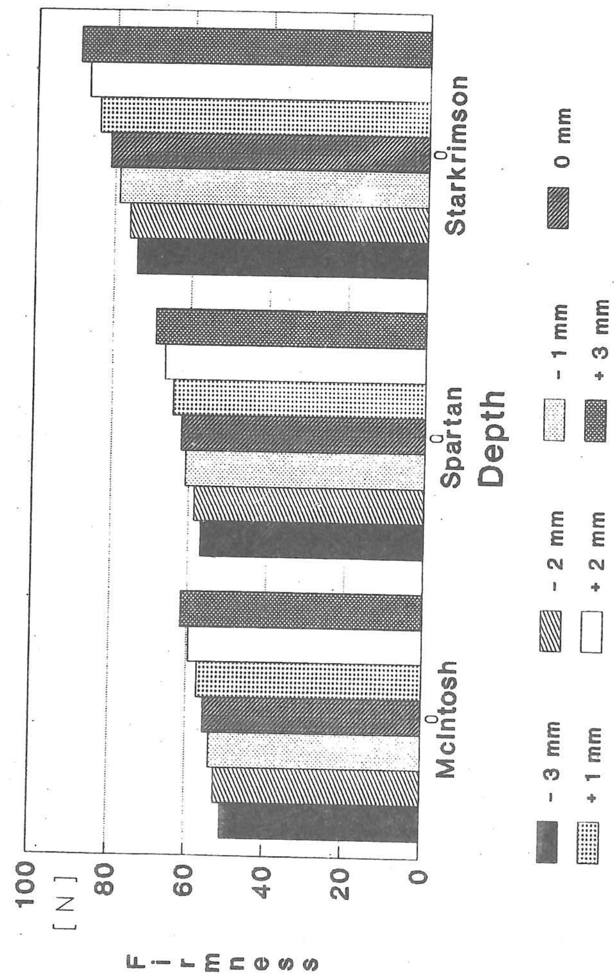

Fig.2. Effect of plunger penetration depth /regarding the scribed line at plunger - Level 0 mm/ on firmness /average values from 4 dates/.

- The firmness measurement error, caused by the differences in plunger penetration depth of 1 - 3 mm may reach values on an average from 3 up to 10 percent.

Table. The firmness measurement error /N/ a. /%/ versus plunger, penetration depth (regarding the scribed line at plunger), in different test dates (averages from 20 measurements)

Penetration depth	Date	McIntosh N	McIntosh %	Spartan N	Spartan %	Starkrimson N	Starkrimson %
3 mm in front of line	I	6.7	11.2	6.0	8.8	7.0	8.4
	II	3.3	5.9	6.6	10.5	7.1	9.0
	III	3.1	5.6	3.9	6.3		
	IV	5.5	10.7	4.1	7.4		
2 mm in front of line	I	4.2	7.0	4.2	6.2	4.8	5.7
	II	1.9	3.4	4.6	7.3	5.6	7.1
	III	1.9	3.5	2.3	3.7		
	IV	3.8	7.4	2.5	4.5		
1 mm in front of line	I	2.0	3.3	2.3	3.4	2.0	2.4
	II	1.0	1.8	0.0	0.0	2.5	3.2
	III	1.1	2.0	1.0	1.6		
	IV	2.3	4.5	1.4	2.5		
1 mm behind line	I	2.7	4.5	3.5	5.2	2.3	2.8
	II	0.7	1.3	2.4	3.8	3.4	4.3
	III	1.5	2.7	1.8	2.9		
	IV	2.0	3.9	1.5	2.7		
2 mm behind line	I	5.8	9.7	7.0	10.3	4.8	5.7
	II	2.1	3.8	4.8	7.7	6.2	7.9
	III	3.0	5.5	2.8	4.5		
	IV	5.1	10.0	2.9	5.2		
3 mm behind line	I	8.5	14.2	9.9	14.6	7.4	8.9
	II	3.9	7.0	7.5	12.0	8.4	10.7
	III	5.3	9.6	4.8	7.8		
	IV	7.0	13.7	5.5	9.9		

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TRENDS IN AGRICULTURAL ENGINEERING
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CHANGES IN SELECTED PHYSICO-MECHANICAL PROPERTIES OF TEAT CUP LINERS

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The paper describes an analysis of physico-mechanical properties of teat cup liners and their changes due to operation. The properties were examined on hand of results of the measurements conducted after processing with a tearing machine. Investigated were specimens obtained from both new and used teat cup liners manufactured from a V-395 mixture.

teat cup liner; tensile strength; modul 200 %; extensibility

1. INTRODUCTION

A teat cup liner is a part of milking machines, in daily direct contact with the teat and with the milk released. It is, therefore, without any doubt, that the properties of a teat cup liner can substantially influence, in the same measure both the milking from the viewpoint of both the engineering aspects and the technique, and the health condition of the gland, and consequently, the quality of raw milk. These are the reasons why they have to meet high and strict requirements.

In the functioning of the teat cup liner /pulsation/ a distorsion occurs /loss of shape stability/ of the liner in repeatedly the same place and in the same direction. As a consequence of this action, fatique cracks appear on the inner surface of the teat cup liners. No change of place and direction of the twist of the teat cup liner can be achieved by a turn round of the liner in the teat cup.

2. METHOD

Properties of the teat cup liners were determined from the results of measurements of the inner surface hardness and from tensile tests. The dependence of extension-versus-tensile stress is characteristic for each liner.

Tensile test specimens were prepared from non-used and used teat cup liners, manufactured from a V 395 mixture /30 % butadiene-styrene, 70 % acrylonitrile copolymer/ with a cutting knife.

The specimens were cut from the bodies of teat cup liners at the level of 9 cm from the end of the head. With reference to the literature available the value can be considered as conventional. Four specimens were made from each teat cup liner. The cutting of blades for tensile tests was taken symmetrically round the periphery of the conical surface of the teat cup liners. The blades were made from that part of the liner where no distorsions occurred, and equally from the surface where the distorsion during the atmospheric pressure phase of pulsation does occur.

The teat cup liners were used with the equipment of milking parlours of Czechoslovak production and subsequently removed after a certain time of operation and tested. Complying with the Czechoslovak Standard 140 teat cup liners were used for a statistical set, of which 20 were set aside as a reference etalon, i.e. not used in operation and all the others were used in practical operation with the milking equipment.

Comparative sets comprised only teat cup liners of the same production series.

3. RESULTS

Prior to comparing of the individual sets /with the hardness measurements/, the individual specimens of the same group were first mutually tested, using the statistical t-test, for unknown population scatterings. The t-tests conducted revealed, that between the individual specimens in groups, no statistically significant difference had occurred with the mean values at the level $\alpha = 0{,}01$.

It was proved in all comparisons carried out, that the hardness of the inner surface of the teat cup liners non-used and of the same series, which were operated 150, 400, 720 and 996 hours, had statistically not differed significantly /$\alpha = 0{,}01$/.

The second part of laboratory measurements was aimed to comparisons of tensile properties of the non-used teat cup liners, after 150 and 720 hours of operation. In a procedure complying with the Czechoslovak Standard 62 1436, test specimens were prepared from teat cup liners, to be examined using tearing machine FPZ 10/1. Graphic records were taken from the tests and the values of strength /F_r/ calibrated, to be further computer-processed.

The results obtained are given in table T-1, indicating mean values, their conclusive deviations and average variable coefficients.

Table T-1

Mean value of set	Standardized values of tensile tests: Tensile strength σ_r /MPa/	Modul 200 % σ_{200} /MPa/	Extensibility ε_r /%/
0/A	12,0683±0,921568	2,50833±0,087263	445,175±24,9363
150	12,9445±0,952251	2,17917±0,158766	523,042±31,6314
720	11,994 ±1,25342	2,50727±0,446746	491,055±40,5185
	Mean variable coefficients		
	σ_r	σ_{200}	ε_r
0/A	7,63625 %	3,47892 %	5,60146 %
150	7,35642 %	7,28561 %	6,04759 %
720	10,4504 %	17,818 %	8,25133 %

In view of unambiguously straight-line course of all graphic records, a linear regression passing through the initial point was used for the evaluation of the specimens. The necessary program was first developed for the regression analysis, print of results and drafting of regression straight lines. It was assumed, that for a linear regression passing through the initial point

$$Y_i = \alpha . x_i + e_i \qquad i = 1, 2, 3, \ldots\ldots n$$

the best estimate of the regression coefficient α

$$a = \frac{\sum_{i=1}^{n} x_i . Y_i}{\sum_{i=1}^{n} x_i^2}$$

where $e = \frac{1}{n} \sum_{i=1}^{n} Y_i - a \frac{1}{n} \sum_{i=1}^{n} x_i$ is error in measurement

Comprehensive results of the regression analysis of the dependence $\sigma = E . \varepsilon + e$ for the given sets of specimens are comprised in the table, including the conclusive deviations. To determine Young's modulus, the regression coefficient was used, in view of a high correlation of all regressions /> 0,99/.

The mean systematic error of measurement $\underline{e}$ occurs due to different prestressing of the specimen when clamping into the jaws of the tearing machine and to a cummulative play in the gear of the feed motion.

The size of the error was determined on hand of a regression analysis $\sigma = E \cdot \varepsilon + e$, but it has to be referred to the results given in table T-1 in column σ_r. For the tensile breaking strength σ_r e.g. 12 MPa the mean systematic error represents $e \sim 1$ %.

In view to obvious uniformity of the values of average sizes of regression coefficients of the three sets of specimens /with the inclusion of conclusive deviations/, it was refrained from the testing of parallelity of regression on the selected level of significance.

The comparison of tensile tests of all three sets given in table T-1 indicates, without a statistic test, that the average values, if conclusive deviation is taken into account, overlap in the major part of its tolerance field. This fact gives conclusive evidence, that σ_r, E, σ_{200} and ε remain nearly unchanged after mechanical stressing in conditions of practical operation.

A significant deviation in a set with 720 hours of mechanical stressing in conditions of practical operation is noticeable in the estimate of the population scattering and, consequently, with the conclusive deviation and variation coefficient. When devising the methods of measuring, it turned out to be questionable whether, with respect to the objectivity of the results, a higher number of teat cup liners with the minimum number of specimens of one lines should be measured /in view of the manageability of the measuring/, or whether to use a contrarywise procedure, i.e. the maximum number of specimens from one teat cup liner and reduced range of the individual groups.

A more objective survey of a possible anisotropy of the teat cup liner after 720 hours of operation gives the second method of specimens selection.

The same conclusion can be derived from the comparison of values of the regression analysis of dependence $\sigma = E \cdot \varepsilon + e$ in table T-2.

Table T-2

Mean value of set	E Average regression coefficient of Young's modulus (MPa)	– Average variation coefficient (%)	e Mean systematic error of measurements (MPa)
0/A	2,65752 ± 0,150293	5,65538	-0,111731 ± 0,031323
150	2,42383 ± 0,147116	6,06957	-0,119792 ± 0,045596
720	2,52112 ± 0,370695	14,7036	-0,005533 ± 0,107125

The values of the regression coefficient, interpreted here as Young's modulus $\underline{E}$, do not differ significantly as to the

conclusive deviation, and the fields of deviations overlap. Significant is again the difference in the conclusive deviations and, consequently, with the variation coefficient of the specimen stressed mechanically 720 hours.

This determination initiated the drafting of a graph to give practical illustration of the variability of tensile tests of the specimen with 720 hours of operation, by means of regression straight lines from the individual measurements of the set. In the graph /Fig.1/ two groups of regression straight lines are clearly situated, in which to higher values $\underline{E}$ are adjoined rather higher values σ_r and smaller values ε and vice versa.

Low values σ_r and corresponding values $\underline{E}$ determined from the regression straight lines ensue from those parts of the teat cup liner, where lengthwise breaks of the wall occurred with the loss of the shape stability of the body due to pulsation. As it is known, the lengthwise break of the wall occurs consistently at one level, intersecting parallel the lengthwise axis of the teat cup liner.

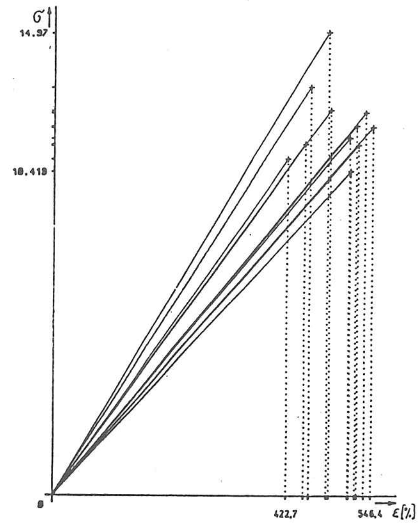

FIG. 1. VARIABILITY OF TENSILE TESTS OF SPECIMENS AFTER 720 HOURS OF OPERATION, EXPRESSED BY REGRESSION STRAIGHT LINES OF THE SET

4. CONCLUSION

The evaluation of the results of experimental measuring reveals, that the hardness of the inner surface and tensile properties of the teat cup liners manufactured from the V-395 mixture do not differ statistically in the course of their performance in practical conditions and at the significance level of $\alpha = 0{,}01$.

In further theoretical studies on the behaviour and service life of the teat cup liners, it is recommended to use regression coefficient obtained from the linear regression intersecting a known point for the determination, which is evidently more objective than the determination by means of modulus σ_{200}.

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TRENDS IN AGRICULTURAL ENGINEERING
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KORNDURCHSATZMESSUNG AUF DEM MÄHDRESCHER

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The actual grain flow rate in a combine harvester is an important input for automatic control systems on the combine. It is also required for new technologies resulting in a more economic and non-polluting use of fertilizer and chemicals for plant protection. The development of yield maps becomes possible when the grain flow is measured simultaneously with travel speed, cutting width and position of the combine. The site specific yield variations are essential information in a computer aided farming system.

combine harvester; grain flow measurement; yield mapping

1. Einleitung

Die Kenntnis des aktuellen Korndurchsatzes auf dem Mähdrescher ist die Grundlage für verschiedene Verfahren, die auf einen wirtschaftlichen und umweltgerechten Einsatz der landwirtschaftlichen Betriebsmittel zielen. Diese Verfahren sollen nicht nur die Getreideernte, sondern auch die nachfolgende Bestellung und Düngung des Feldes optimieren.

Für die Entwicklung von Systemen zur Steuerung und Regelung von Teilprozessen im Mähdrescher ist der aktuelle Korndurchsatz eine wichtige Eingangsgröße. Auch zur Ertragsbestimmung ist die Messung des Durchsatzes zusammen mit der Schnittbreite und Fahrgeschwindigkeit notwendig. In Verbindung mit einer Positionsbestimmung des Mähdreschers auf dem Feld ist die Erstellung von Ertragskarten möglich.

Die Entwicklung von Korndurchsatz-Meßeinrichtungen wird durch die in dem fahrenden Mähdrescher auftretenden Schwingungen und Neigungen sowie durch die großen Massenströme erschwert. Auch können sich ändernde Guteigenschaften die Meßergebnisse beeinflussen. Grundsätzlich kann der Korndurchsatz aus dem Massenstrom, dem Volumenstrom, der Kornabscheidung oder indirekt über eine andere mit ihm korrelierende Größe bestimmt werden.

2. Durchsatzbestimmung durch Massenermittlung

Möglichkeiten zur direkten Massenbestimmung sind in Bild 1 dargestellt. Die Messung mit Band- und Durchlaufwaagen auf dem Mähdrescher erfordert den Einbau zusätzlicher Fördereinrichtungen, wodurch Konstruktionsaufwand und Preis der Maschine erheblich ansteigen. Dies gilt auch für die Gewichtsermittlung des gesamten Korntankinhalts, weil sie eine Trennung des Korntanks vom Mähdrescherrumpf notwendig macht [1].

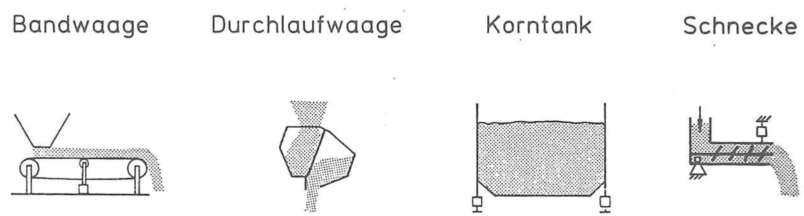

Bild 1 : Möglichkeiten der Korndurchsatzmessung durch Massenbestimmung

Ein in den USA entwickeltes Verfahren bestimmt den Korndurchsatz durch das Wiegen des Körnerstroms in der drehbar gelagerten Korntankbefüllschnecke. Gleichzeitig werden die auf die Schnecke wirkenden Beschleunigungen gemessen und im Meßergebnis berücksichtigt [2].

3. Durchsatzbestimmung durch Volumenstrommessung

Konstruktiv und meßtechnisch einfacher zu verwirklichen sind Durchsatzmeßverfahren über die Volumenstrombestimmung (Bild 2). Nach diesem Prinzip wurde eine Einrichtung mit Messung des Blendenausflusses entwickelt. Das Maß für den Durchsatz ist die vom Körnerstrom ausgefüllte Fläche der Schneckenaustrittsöffnung [3].

Der Füllstand des Kornelevators ist bei konstanter Fördergeschwindigkeit ebenfalls ein Maß für den Volumenstrom. Dazu kann die Belegung der Paddel im Elevatorschacht mit Hilfe einer Lichtschranke gemessen werden. Je größer der Durchsatz ist, desto länger wird der Lichtstrahl vom Volumen auf dem Paddel unterbrochen.

Der Mähdrescherhersteller Claas vertreibt ein Durchsatzmeßgerät (Yield-o-Meter), das auf Basis der Volumenstrommessung arbeitet. Der Volumenstrom wird mit Hilfe eines zwischen Kornelevator und Korntankbefüllschnecke angeordneten Zellenrades durch Zählen der zur Förderung des Körnerstroms benötigten Umdrehungen bestimmt. Um zu gewährleisten, daß die Zellen immer vollständig gefüllt sind, wird das Rad nur dann angetrieben, wenn sich an einem Füllstandssensor oberhalb des Gerätes Körner befinden.

Bild 2 : Möglichkeiten der Korndurchsatzmessung durch Volumenstrombestimmung

Bei allen Durchsatzmeßverfahren, die den Korndurchsatz aus dem Volumenstrom bestimmen, wird vom Mähdrescherfahrer eine häufige Kalibrierung auf die aktuelle Schüttdichte verlangt. Die Dichte ist nicht allein von der Gutart abhängig, sondern ändert den Wert innerhalb eines Feldes und auch im Tagesverlauf.

Eine automatische Dichtebestimmung auf dem fahrenden Mähdrescher kann den Fahrer entlasten und die Meßgenauigkeit steigern. Dazu wurde das in Bild 3 dargestellte Gerät mit Kompensation der auf das Meßsystem wirkenden Schwingungen und Neigungen entwickelt. Zwei mit DMS beklebte Biegebalken sind zu einem gabelförmigen Element angeordnet. An dem einen Balken ist ein Behälter zur Aufnahme eines definierten Kornvolumens befestigt, am anderen eine definierte Bezugsmasse. Zur Kompensation wird ausgenutzt, daß auf beide Elemente die gleichen durch die Fahrt des Mähdreschers hervorgerufenen Beschleunigungen wirken. Für die Anwendung dieses Gerätes auf dem Mähdrescher muß ein automatisierter Ablauf aus Probenentnahme, Dichtebestimmung und Entleerung verwirklicht werden.

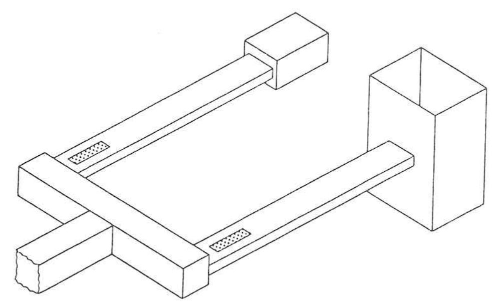

Bild 3 : Dichte-Kalibriereinrichtung nach [3]

4. Indirekte Durchsatzbestimmung über physikalische Effekte

Bild 4 zeigt Verfahren der indirekten Durchsatzmessung. Die Messung des Impulses bei bekannter Fallhöhe auf eine der Körnerschnecke nachgeschaltete Prallplatte wurde bereits intensiv untersucht [5].

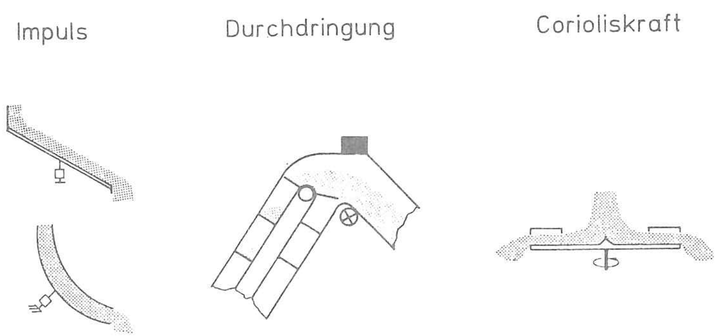

Bild 4 : Möglichkeiten der Korndurchsatzmessung durch indirekte Meßverfahren

Als die mit dem Massendurchsatz korrelierende Größe wird die beim Aufprall des Körnerstroms wirkende Reaktionskraft gemessen. Nach den Gesetzen des elastischen Stoßes ist diese von den Verformungseigenschaften des Gutes abhängig. Das Meßergebnis wird deshalb durch die Gutart, deren Stoffeigenschaften und vor allem der Neigung des Mähdreschers beeinflußt.

Bei Geräten, die den Körnerstrom in einem Krümmer umlenken, ist die gemessene Kraft proportional der Impulsänderung des Gutes in der Umlenkeinrichtung [6]. Dieses Verfahren ist im Gegensatz zur Prallplatte weitgehend unabhängig von den Stoffeigenschaften. Über den Reibungsbeiwert wird aber die Durchlaufgeschwindigkeit im Krümmer und dadurch auch das Meßergebnis beeinflußt.

Dronningborg bietet in Verbindung mit dem Informationssystem 'Daniavision' ein radiometrisches Meßgerät an, das den Korndurchsatz aus der Abschwächung Gammastrahlen beim Durchdringen des vorbeifließenden Körnerstroms bestimmt. Dazu sind eine Strahlenquelle und ein Detektor am Übergang von Kornelevator und Korntankbefüllschnecke angebracht. Das Signal ist bei gleichbleibender Durchflußgeschwindigkeit weitgehend unabhängig von der Gutart und -feuchte. Trotz der geringen Intensität der Strahlenquelle müssen die gesetzlichen Vorschriften im Umgang mit radioaktiven Materialien eingehalten werden.

Ein in der Fördertechnik bereits eingesetztes Verfahren ist die Durchsatzmessung über die Corioliskraft [7]. Das Gut wird einer rotierenden Scheibe zentral zugeführt und durch die Wirkung der Fliehkraft entlang von Leitschaufeln nach außen geleitet. Bei dieser Gutbewegung wirkt die Corioliskraft auf die Leitschaufeln. Das aus der Corioliskraft resultierende Drehmoment kann gemessen werden. Es ist bei konstanter Drehzahl der Scheibe proportional zum Massenstrom.

Es wurden auch Durchsatzmeßeinrichtungen entwickelt, die den aktuellen Korndurchsatz kapazitiv mit Hilfe eines Kondensators bestimmen [8]. Zur Anwendung kommen zylindrische oder rechteckige Kondensatoren. Zu beachten ist bei der Messung, daß die Kapazität eines Kondensators nicht nur von der Schichthöhe des vorbeifließenden Körnerstroms, sondern auch von dessen Dielektrizitätskonstanten und somit von der Gutart und Feuchtigkeit abhängt.

5. Durchsatzbestimmung aus der Kornabscheidung

Weil der gesamte Körnerstrom im Mähdrescher mit Ausnahme der Schüttlerverluste über die Reinigungsanlage geführt wird, ist die Ermittlung des Korndurchsatzes aus der Kornabscheidung der Reinigungsanlage möglich [9].

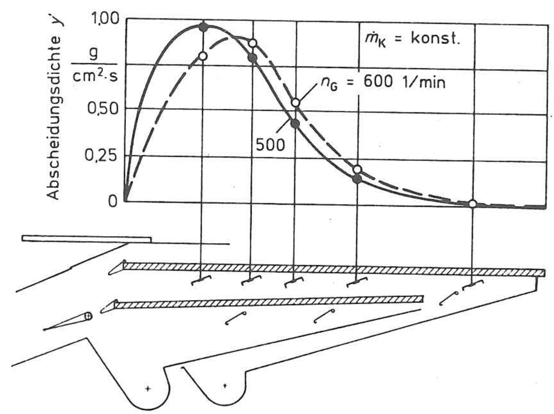

Bild 5 : Korndurchsatzbestimmung aus der Abscheidefunktion der Reinigungsanlage nach [9]

Dazu werden platten- oder stabförmige Sensoren an mehreren Stellen unter den Sieben angebracht (Bild 5). Die Sensoren arbeiten wie die bekannten Körnerverlustsensoren. Die innerhalb eines bestimmten Zeitintervalls auftreffenden Körner werden elektronisch registriert und aus der Anzahl der Signale die Abscheidung berechnet. Die Empfindlichkeit der Sensoren muß so eingestellt sein, daß eindeutig zwischen Korn und Nichtkornbestandteil unterschieden wird. Zur Kalibrierung des Korndurchsatzes ist bei diesem Verfahren die Bestimmung des Tausendkorngewichtes notwendig, das über die Sieblänge jedoch nicht konstant ist.

Zusammenfassung

Zur Korndurchsatzmessung sind verschiedene Meßverfahren entwickelt worden, von denen erst wenige die Serienreife erreicht haben. Besondere Anforderungen an die Meßgeräte werden durch den Einsatz auf dem Mähdrescher an die Robustheit gestellt. Auch soll der Fahrer durch die Gerätebedienung nicht zusätzlich belastet werden. Weiterhin soll das Meßgerät den Gutstrom nicht behindern. Eine Kalibrierung des Gerätes während des Ernteeinsatzes sollte deshalb nicht notwendig sein oder automatisch durchgeführt werden.

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TRENDS IN AGRICULTURAL ENGINEERING
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Probability of reliable function of a dairy cow and a dairy herd of a farm

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To determine the reliability of a dairy farm, representing a complex biotechnical system, with a man-machine-animal comprising unit and their subsystems of technique and technology, the knowledge of their elements is a necessity. The apprehension of reliability, i.e. the maintenance of the functioning quality of the object in time, can be related to each of the system elements, i.e. to the biological element as well, taking, of course, its special features in consideration.

If the coefficients of reliability and the distribution of the probability of failureless function of a dairy cow and of a herd are determined, processes influencing the reliability of the whole farm as a biotechnical system can be better evaluated and controled in practical operation. The larger the farm, the more relevant become the problems of reliability.

As the milk production in the Estonian Republic depends on both small and large farms, with herds of 600 animals on average, the reliability of dairy cows and herds was investigated at eight farms of similar size, in different regions of the republic. The techniques and equipments used at the farms were as follow: automated self-filling drinking bowls, milking parlours equipped with "Impulsa" or "UDA-16" milking machines, feedstuffs distribution and manure disposal with tractor mounted implements.

Records on cows culling were used in the investigation, comprising all data on the animals, including dates of birth and of culling, age, reason of culling (disease, injury), lactation etc. The culling of the animal from the herd was considered as a failure of function of a cow or of a herd. Data reflecting the state of a herd within a four- or five-year period were evaluated and analyzed.

The analysis of the data revealed, that the main reasons of the culling of cows from the herd were mastitis (21 %), low productivity (19 %) and gynaecological diseases (14 %). 4,8 % of animals were culled from the herd due to injuries. The average age of the cows was 5,37 years.

Considerable rate of diseases due to mastitis was caused by incorrect operation of automatic milking mechanisms, belated treatment of inflammations, injuries of teat and partly by using feedstuffs of poor quality for feeding.

A low productivity of the dairy cows can be caused by incorrect rearing of a herd of heifers to replenish the herd of dairy cows, and also negligent deportment of the breeder in selecting the animals for the herd.

Culling of cows due to injuries was of a low rate. The reasons were collisions with a tractor and implements, causing injuries of the rear part of the trunk or hinders of the animal. Injuries to teats by barbed wire on grazing land etc. were also recorded.

From data of the recordings on cows cullings statistical series of the age of cows were drafted, with times of two consecutive cullings of animals of a herd, the latter to be hereinafter termed as "production failure" of the herd.

In drawing up the statistical series a check-up of the information was made. The production failures, which were beyond the range

$$\bar{t} \pm 3\sigma$$

where $\bar{t}$ = average production failure (h)

σ = standard deviation (h)

were deleted in subsequent data processing.

The main coefficients of reliability of the dairy herd were determined as follows:

1. Average production failure

$$\bar{t} = \frac{1}{N} \sum_{i=1}^{N} t_i \qquad (h)$$

2. Standard deviation

$$\sigma = \left[\frac{1}{N-1} \sum_{i=1}^{N} (t_i - \bar{t})^2\right]^{1/2} \qquad (h)$$

In formulae N denotes the number of failures, t_i - i-th production failure

3. Parameter of stream of failures

$$\lambda = 1/\bar{t} \qquad (h^{-1})$$

4. Coefficient of corrections K_v and coefficient of disposability of the herd K_p

$$K_v = \bar{q}/\bar{t} \quad ; \quad K_p = 1/\ (1+K_v)$$

where: q - medium time required to restore the initial state. As a culled dairy cow was replaced by a new one from the herd of young cows in 8 hours on average, it can be assumed that q = 8 h.

The principal calculated coefficients of reliability of the herd of the farm are summarized in table I, revealing that a failure of the herd of 600 cows occurs on average after 171,5 h, i.e. once a week. An analysis of the records on culling revealed, that occasionally several animal were culled all at the same time. The explanation is, that when supplying the slaughetrhouse, several animals were comprised in one delivery.

To determine the experimental probablity of a reliable function of cow and herd as a total, graphs of age versus culling relationship(Fig.1) and production versus herd's failure (Fig.2) were drawn up. Interval method of random quantities was used for the purpose, with all production failures (age) integrated into time intervals and the number of failures in a corresponding interval determined.

Tab.I. Coefficients of reliability of a dairy herd

Coefficient	Value
Medium time between failures (production failure), h	171,3
Parameter of stream of failures, h^{-1}	$5,83 \cdot 10^{-3}$
Medium time required to restore the initial state, h	8,0
Coefficient of corrections (restoration of the initial state)	0,047
Coefficient of disposability	0,96

The length of the interval was determined from the formula

$$A = (t_{max} - t_{min}) / n$$

where: t_{max} and t_{min} - corresponding highest and lowest values of production failure in a statistical series, h

n - number of intervals (n = 6 ... 20)

The experimental probability of a failureless function of a dairy cow and herd was determined from the formula

$$P'(t) = 1 - \sum_{n=1}^{n} m / N$$

where: m - number of failures observed in n-th interval

For selection and evaluation of the theoretical law on the probability distribution of a failureless function of a dairy cow or a herd the variation coefficient was determined

$$\nu = \sigma / \bar{t}$$

It was found, that variation coefficients appear in intervals 0,64 - 0,81. For a theoretical law of the probability distribution of a failureless function of a dairy cow and a herd Weibull's law can be applied, i.e.

$$P(t)_K = \exp\left[- \left(\frac{t}{52945,45} \right)^{2,79}\right]$$

for the probability of cow's age

$$P(t)_{cT} = \exp\left[- \left(\frac{t}{182,40} \right)^{1,21}\right]$$

for the probability of failureless activity of a dairy herd.

These theoretical functions are given in graphical presentation in Fig.1 and Fig.2. The agreement of experimental and theoretical distribution was tested by means of Pearson's criterion χ^2 and by Kolmogorov's test. The possibility of practical utilisation of the two distributing functions for reliability descriptions of large dairy farms was thus confirmed.

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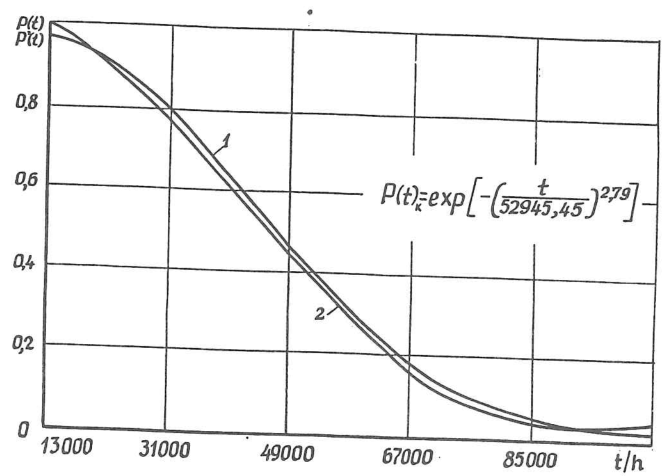

Fig.1: Theoretical (1) and experimental (2) probability of a failureless function of a dairy cow.

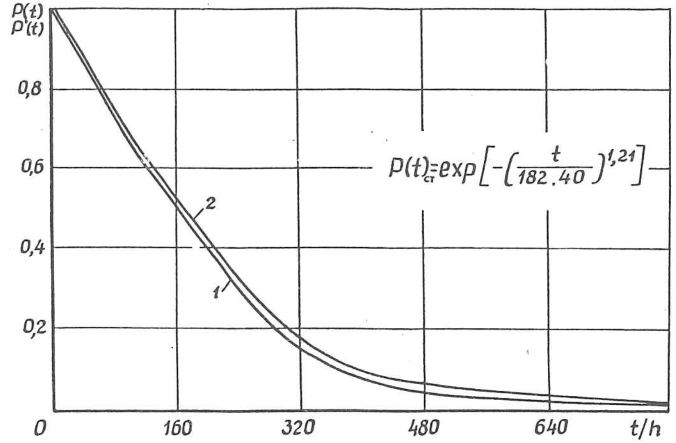

Fig.2: Theoretical (1) and experimental (2) probability of a failureless function of a dairy herd.

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SORTING OF PICKED HOPS

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The trajectory of falling hop-cone and leaves were pictured. During the fall the particles were influenced by horizontal air stream. The points of inicidence of hop-cones and leaves were analyzed. All particles were weighed. It is possible to separate hop-cones and leaves in vertical channel equipped with horizontal air stream.

Hops; separation

1. DIE EINLEITUNG

In unserem Land züchtet man Hopfen auf der grossen Fläche. Bei Hopfenpflegen gebrauchman übliche Maschinen und auch spezielle Maschinen. Zu diesem gehört z. B. Hopfenertemaschinen, die Stationär oder Mobill sind. Diese Maschinen haben die Aufgabe, reine Hopfentrollen aus Hopfenpflanzen zu gewinnen. Da konnte man nicht diese Aufgabe gerade lösen, wie bei Handernte, muss man zuerst die Hopfentrollen mit Blättern und zerbrochenen Zweigen pflücken. Diese Mischung muss man dann separieren.

Wenn das Pflücke des Hopfens einfach und ohne Verluste in einem Pflückmechanismen ist, dann ist Reinigung kompliziert. Zuerst muss man die leichten Teile, Blätter und dann die schweren Teile, die Zweige separieren. Zu Ende sind alle anderen Reste zu separieren. Bei dieser Technologie auf minimall drei Reinigungsmechanismen entstanden die Verluste und die Hopfentrollen sind noch nicht hundertprozenting rein.

Die Forschung am Lehrstuhl für Landmaschinen ist auf Reinigung des Hopfens eingestellt. Die Hopfentrollen haben bessere aerodynamische Eigenschaften als die Blätter. Das heisst, dass die Hopfentrollen bei Freinfall grössere Geschwindigkeit haben, als die Blätter. Wenn diese Mischung fliegt vertikal vor dem horizonteller Luftkanal, nehmen die Blätter von der Luft mehr

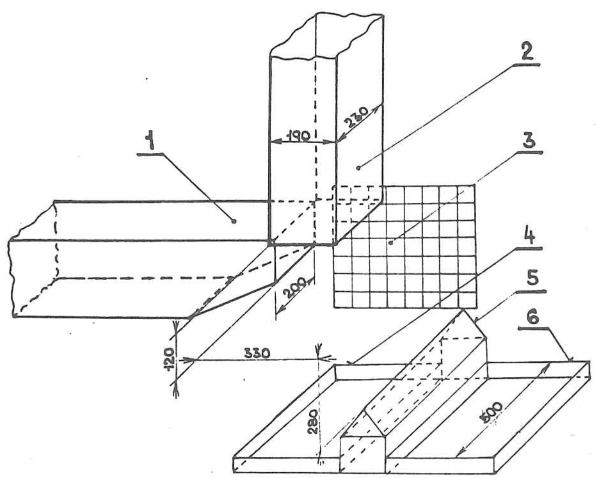

Bild 1: Die Messvorrichtung

1 - Luftdruckkanal
2 - Hopfenmischungkanal
3 - Netzt
4 - Hopfenbehälter
5 - Dach
6 - Blattbefälter

Energie, weil sie in dieser Luft längere Zeit bleiben. Wenn sich diese Mischung auf dem Sieb befindet, nehmen Hopfentrollen und die Blätter dieselbe Energie, weil sie im Luftstrom dieselbe Zeit exponiert werden.

2. MESSGERÄT

Messgerät [Bild 1] hat ein Luftkanal horizontal geordnet [1] mit Durchschnitt 120 mal 200 mm. Durch Kanal [2] fällt das Material, das heisst Hopfentrollen und Blätter. Dieser Kanal ist 1950 mm lang. Im Abstand 140 mm ab vertikaler Kanal und 200 mm von horizontaler Kanal ist ein Dach [5], das die Hopfentrollen in Behälter [4] und Blätter in Behälter [6] verteilt. An der Wand hinten ist ein Nezt 20 mal 20 mm gestricht.

3. DIE MESSUNGEN

Die Messung wurde von 7.bis 10. September 1990 durchgeführt.
1. Mit einer Videokamera wurden die fliegenden Teile gegen Netzt an der Wand hinten abgenommen. Die Strecke der Hopfentrollen und der Blätter war je nach einem Bild bewertet.
2. In den vertikalen Kanal wurden die Hopfentrollen und die Blätter gleichzeitig eingeworfen. Zuerst eine Hopfentrolle und ein Blatt und dann 2 und 2, 3 und 3, 4 und 4 und noch 12 Hopfentrollen und 12 Blätter. Das alles wurde bei verschidener Luftgeschwindigkeit durchgeführt.
3. In den vertikalen Kanal, bei verschidener Luftgeschwindigkeit in dem Luftkanal wurden nur die Hopfentrollen oder die Blätter geworfen. Die Hopfentrollen je 50 Stück und die Blätter je 20 Stück.
4. In den vertikalen kanal, bei verschidener Luftgeschwindigkeit in dem Luftkanal, wurde das Muster von 500 g der Hopfentrollen, oder 275 g Blätter geworfen. Man wiegt Hopfentrollen in Behälter [4] oder die Blätter in Behälter [6] die nach Bild 1 gefallen sind.

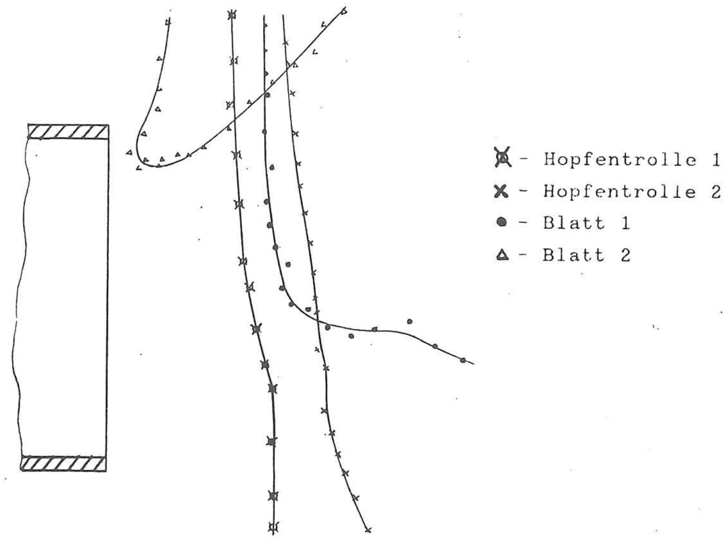

Bild 2: Die Strecke des Hopfens und der Blätter

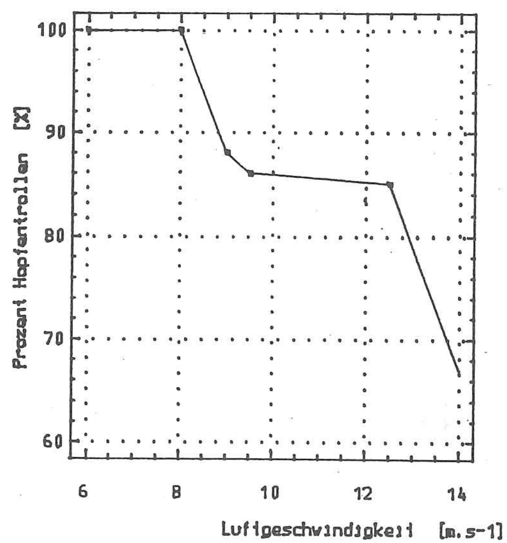

Bild 3: Die Abhängigkeit von Hopfentrollen im dem Behältr auf der Luftgeschwindigkeit

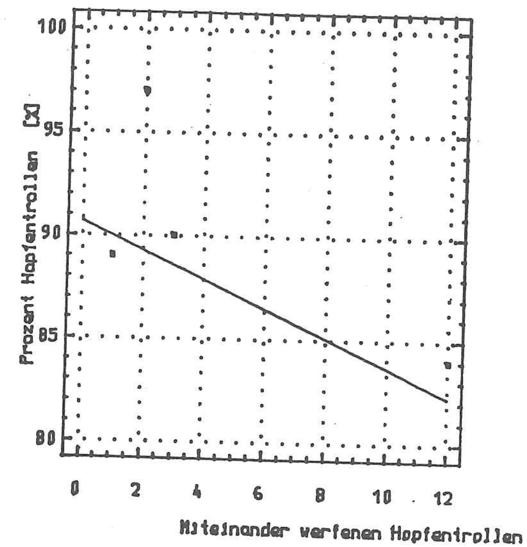

Bild 4: Die Abhängigkeit von Hopfentrollen in dem Befälter auf dem miteinander werfenen Stück

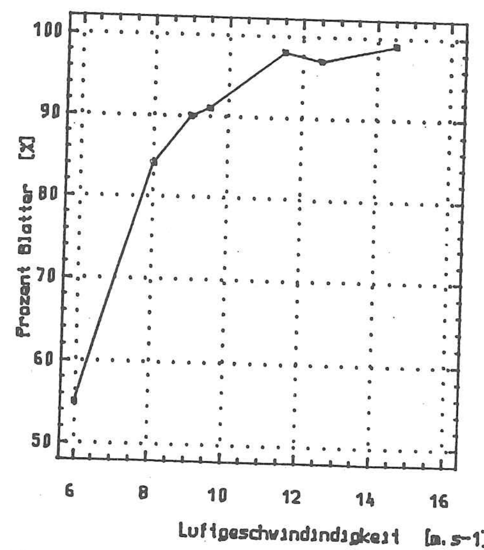

Bild 5: Die Abhängigkeit von Blätter in dem Behälter auf der Luftgeschwindigkeit

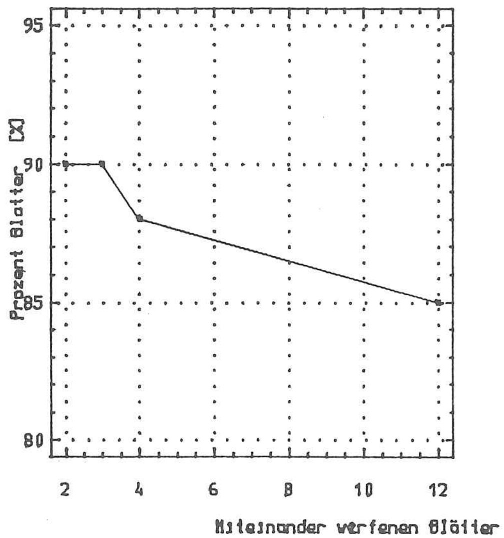

Bild 6: Die Abhängigkeit von Blätter in dem Bhälter auf dem miteinander werfenen Zahl des Stück

4. DIE BEWERTUNG DES ERGEBNISSES

1. Nach Bild 2 ist offentsichtlich, dass der Luftstrom die Hopfentrollen nur wenig beeinflusst. Dagegen ist die Strecke der Blat sehr beeinflusst . In dem Fall wenn die Hopfentrollen in Schatten das Blatt sind gewinnen sie die Strecke der Blätter.

2. Auf dem Bild 3 wird die prozentuelle Menge von Hopfentrollen in der Abhängigkeit von der Luftgeschwindigkeit dragestellt die in rechten Behälter gefallen sind. Das Bild zeigt es ohne Rücksicht auf die Zahl miteinander geworfene Stück. Auf dem Bild 4 wird die prozentuelle Menge von Hopfentrollen in der Abhängigkeit von der Zahl miteinander geworfene Stück die in rechten Behälter gefallen ist.

3. Auf dem Bild 5 wird die prozentuelle Menge von Blättern in der Abhängigkeit von der Luftgeschwindigkeit die in rechten Behälter gefallen sind. Das Bild zeigt es ohne Rücksicht auf die Zahl miteinander geworfene Stück.

Auf dem Bild 6 wird die prozentuelle Menge von Hopfentrollen in der Abhängigkeit von der Zahl miteinander geworfene Stück, die in rechten Behälter gefallen sind.

TRENDS IN AGRICULTURAL ENGINEERING
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The Uniformity of Water Distribution of the Irrigation Sprinker

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Abstract

The uniformity of application rate of the irrigation sprinkler(rain-gun) was measured during still air conditions. The wide variability of water application rate profiles is presented for a set of nozzles measured under different pressures. The uniformity of application rate is evaluated by Christiansen coefficient Cu. Problems of the instantaneous application rate and the average application rate are discussed in comparison with natural precipitation.

Inroduction

Water application uniformity is an important measure of performance used in the design and the evaluation of irrigation sprinklers. Procedures to determine the uniformity of water distribution round the irrigation sprinkler are given by standards(ASAE 1983,CSN 11 0046 Testing sprinklers). The source study that covered a large number of authors and different methods for the evaluating of water uniformity(application rate) was made by LATECKA,1976. Christiansen coefficient is usually used for the evaluating of uniformity application rate:

$$Cu = 100[1-(\Sigma|i_i - i_s|/n*i_s)] \quad ...\% \qquad (1)$$

in which i_i is the ith water application rate(water depth in ith rain gauges). The $\Sigma|i_i-i_s|$ is the sum of absolute deviation from the mean ,i_s,of all n observations. Coefficient Cu is calculated from application rate data which were arrived at after one hour test. There is necessary to remark that the used application rate is not instantaneous RUZICKA,KUBAT,1990.

Methods

The testing of irrigation sprinkler was carried out in outdoor condition. The impact sprinkler was located 0.75m above the the rain-gauges which were in four rows radially placed from the centre(FIG.1). The distances between rain-gauges were 1m. The sprinkler body used in the tests was manufactured by Sigma Olomouc Company* and had a 23 deg trajectory angle(FIG.2). Nozzle sizes of 12;14;16;18;20;22;26mm were tested at 0.3;0.4;0.5 and 0.6MPa.

*Mention of trademark products in this paper dopes not imply that they are recommended or endorsed by the Agricultural University in Prague, Czechoslovakia.

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All the tests were carried out with an endeavour to get results in still air conditions. Unfortunately it is not possible to ensure such conditions during outdoor experiments. Therefore the experiments were stopped when the velocity of wind was 1 m/sec. It is necessary to remark that the presented values of velocities of wind are determined as mean values e.g. values up to 0.5 m/sec are practically still air conditions and might be caused by sprinkler' outflow itself.

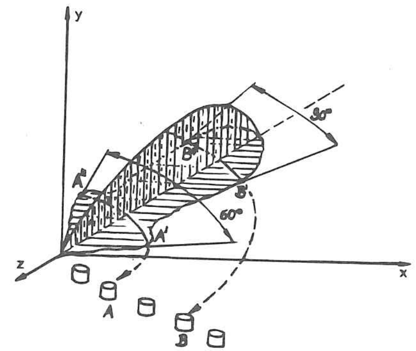


FIG.1: REPRESENTATION OF RAIN-GAUGE PLACEMENT

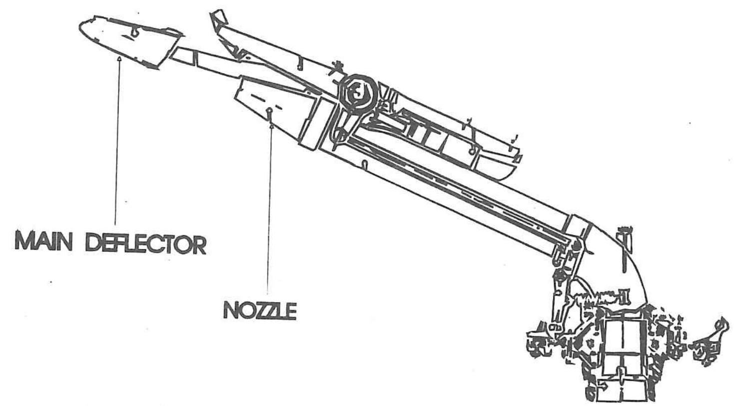


FIG.2: TESTED IRRIGATION SPRINKLER

Results and discussion

The results of measurement are presented in TAB.1.

TAB.1. Christiansen coefficient Cu(%) and mean velocities of wind (m/sec)

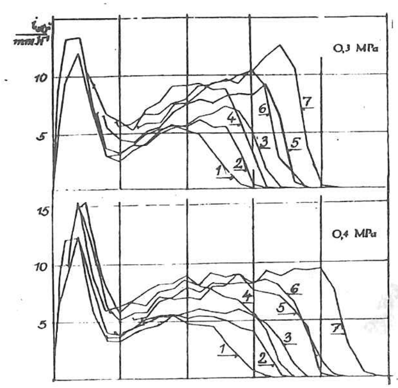
Pressure MPa	Sprinkler nozzle diameter mm							
	1 2		1 4		1 6		1 8	
	%	m/sec	%	m/sec	%	m/sec	%	m/sec
0.3	50.9	0.2	64.5	0.2	65.3	0.2	71.9	0.2
0.4	55.2	0.2	68.2	0.1	70.8	0.2	69.8	0.2
0.5	48.6	0.4	64.9	0	70.4	0.2	67.5	0.2
0.6	*	*	68.1	0.2	70.3	0.2	68.7	0.2
mean %	51.6		66.5		69.2		69.5	

TAB.1. - cont.

Pressure MPa	Sprinkler nozzle diameter mm						mean
	2 0		2 2		2 6		
	%	m/sec	%	m/sec	%	m/sec	%
0.3	73.2	0.2	67	0.2	64.7	0.2	65.4
0.4	74.8	0.2	72.8	0.2	71.5	0	69
0.5	72.4	0.2	73.1	0.2	73.9	0	67.3
0.6	71.1	0.2	72.9	0.2	71.3	0	70.4
mean %	72.9		71.5		70.4		

* test was not carried out.

The distribution of application rate for all experiments are shown on FIG.3, which presents the mean values of four rain guages position equidistantly from the sprinkler.



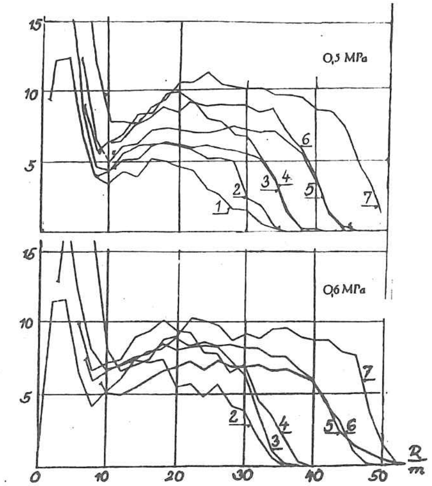


Fig 3. Distribution Profiles of application rate.

These results characterise the wide variability of geometrical water distribution profiles (distribution of application rate). The best results of application rate uniformity were found with 20 mm nozzle diameter (mean value of Cu = 72.9%). When results were compared from the point of different pressures it could be seen that the best application rate uniformity was under 0.6 MPa (mean value of Cu = 70.4%).

It is evident that the highest deviations from the mean value of the application rate can be found at the beginning of outflow radius (approximately up to 10 m). This irregularity is caused by the effect of a main deflector (FIG.2) and it is obvious that with higher pressures these deviations are higher as well. Nevertheless the rest of geometrical water distribution profile can influence the whole result of uniformity evaluation (Cu). This conclusion is confirmed by geometrical profiles under pressure 0.5 and 0.6 MPa (FIG.3).

Another important question, which should be discussed, is the difference between an instantaneous application rate and an average application rate. The question of the instantaneous application rate is linked with several problems such as erosion of soils, destruction of soil aggregate structure, soil crusting and consequent reduction of the infiltration rate etc. The utilisation of sprinklers (rain-guns) combined with various irrigation machines such as centre pivots JAMES, STILLMUNKES,1980; hose travellers KUBAT,1990; will bring the real need of evaluating the instantaneous application rate.

One should realise that the duration of water collecting is shorter then the duration of sprinkler testing. The shorter is water collecting the higher is the instantaneous application rate. From this point of view comparison might be interesting between values which were determined on the measurement of natural precipitation and the sprinkler application rate values. The FIG.4 presents natural precipitation LAKOMA,1979 measured during 849 rain occasions in former Western Germany. These values of 1 hour intensities ("application rate") are comparable with the results of measurement of irrigation sprinkler. But it is obvious that these values were obtained during longer time (time axis in minutes) then adequate values of application rate of the irrigation sprinkler.

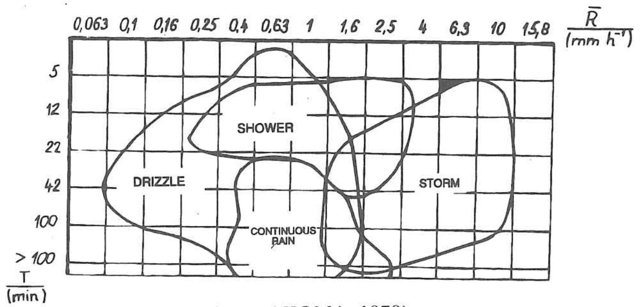


Fig.4. Natural Precipitation (LAKOMA, 1979)

Conclusion

The article describes results of measurement of the irrigation sprinkler (rain-gun) performance, especially the uniformity of application rate. These results can be used for skilled operating, for design modification and its performance improvement. The discussion underlines differences between the instantaneous application rate and the average application rate. There are enclosed results of natural precipitation intensities for comparison in this article. This discussion follows the aim to point the necessities of a new access in measure procedures. These new procedures of sprinkler testing should be accepted in newly created standards. These proposals aims to promote farm practices which combine care and concern for the environment with the responsible and economic use of modern methods to produce safe and wholesome food.

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TRENDS IN AGRICULTURAL ENGINEERING
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Faktoranalyse der unterschiedlichen Technik bei der Rapsbestandanlegung

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Resumee

Es wurden unterschiedliche Varianten der Arbeitsvorgänge bei Rapsbestandanlengung beurteilt. Aus den Versuchen folgten die Schlußfolgerungen, die eindeutig die Anwendung von kombinierten Maschinen mit getriebenen Arbeitsorganen für die Bodenbearbeitung und die Aussaat bevorzugen. Beim Vergleich der direkten Kosten an 1t der Rapsproduktion handelte es sich um minimale Unterschiede beu Anwendung von fünf verschiedenen Technologien - Kombinationen der Rüttelegge, des Grubbers oder der pneumatischen Überdruckaussaat mit Einbringung des Saatkorns mit den Drillschuhen oder in den abgeschleuderten Bodenstrom. Aus dem Gesichtspunkt der Kosten sind am besten die Technologien, bei denen nicht gepflügt wurde und die Aussaat direkt in die Schälfurche durchgeführt wurde.

Schwerpunkte

Bodenbearbeitung, Saatbett, Ungleichmäßigkeit der Aussaat, direkte Kosten

I. Einleitung

Beim Rapsanbau, sowie bei allen anderen Feldfruchtanbausystemen bildet die Grundlage eine verbindliche Anbautechnologie. Für die Anwendung der Grundsätze in der Praxis müssen unbedingt materielle und technische Mittel, d.h. auch die entsprechende Landtechnik gewährleistet werden. In dem Rapsanbausystem bildet die Technik einen bedeutenden Faktor besonders bei der Bodenbearbeitung, Saatbettbereitung und bei der Aussaat (Bestandanlegung). Die bisher in der ČSFR angewandten Maschinen entsprechen nicht immer den strengen agrotechnischen Forderungen. Die richtig gewählte Technologie der Bodenbearbeitung, der Saatbettbereitung und gleichmäßige horizontale und vertikale Saatkorn-Verteilung führt zur Eliminierung der negativen Faktoren, die das Ertragsniveau und die Ökonomik beeinflussen . Es ist nötig ein funktionierendes und gemeinsam koordiniertes System der bodenbearbeitenden Maschinen für die Rapsbestandlegung mit Rücksicht auf die gegebenen konkreten Boden- und Klimabedingungen einführen, bei denen der Feldbetrieb der Maschinen reduziert wird und beim Minimum der Arbeitsvorgänge Nutzeffekt der Bodenbearbeitung optimiert wird mit dem Ziel günstigen Bodenregim für den Rapsanbau zu sichern. Realisierung des technologischen Prozesses der Bestandanlegungen muß mit dem Ziel der maximalen Reduzierung der materiellen, energetischen und Arbeitsinput mit gezielter Einhaltung der Forderung ca 40-60 gleichmäßig aufgegangen Pflanzen während fünf Tage für 1 m² der Fläche durchgeführt werden.

II. Methodik der Versuche

Bei dem Versuchsbetrieb wurde im Jahre 1990-91 unterschiedliche Technik und Technologie für Bodenbearbeitung und Winterrapsbestandanlegung getestet mit dem Ziel die direkten Kosten und Erträge, Organisierung des Bestandes und die gesamte Arbeitsqualität der eingestzten Maschinen zu vergleichen. Das Versuch wurde an einem

Tab.1 **Versuchsagen**

No. der Variante R_1, R_2	Breite des Elementen	Bodenbearbeitung A_1 Schalung und Pflügeng A_2 Schalung	Technologie: Technik	Arbeitsabschnitt der Maschine	Zwischenreiheabstand	Aussaat: Specifische Aussaatmenge $V_1=3$ $V_2=5$	Anzahl der Saatkörner für 1 m
	m			m	mm	kg/ha	
1111 1112	24	A_1	T_1 Traditionelle Bodenbearbeitung und Sämaschine SE-060	6	125	V_1	8
1211 1212	24	A_1	T_2 Rüttelegge Amazone RED 60 und Sämaschine SE1-060	6	125	V_1	8
1221 1222	12	A_1	T_2 Rüttelegge Amazone RED 60 und Sämaschine SE1-060	6	125	V_2	14
1311 1312	16	A_1	T_3 Rüttelegge Amazone RED 40 und Sämaschine Amazone D8-40-E-N	4	80	V_1	5
1411 1412	16	A_1	T_4 Rüttelegge Amazone RED 40 und Sämaschine Amazone RPD 401	4	100	V_1	7
1511 1512	12	A_1	T_5 Drehgrubber und Sämaschine Rau - Rotosem	3	125	V_1	8
1611 1612	12	A_1	T_6 Drehgrubber und Sämaschine Rau-Rototiller und Säcompactor	3	125	V_1	8
2311 2312	12	A_2	T_3 Rüttelegge Amazone RED 40 und Sämaschine Amazone D8-40-E-N	4	80	V_1	5
2411 2412	12	A_2	T_4 Rüttelegge Amazone RED 40 und Sämaschine Amazone RPD 401	4	100	V_1	7
2511 2512	12	A_2	T_5 Drehgrubber und Sämaschine Rau - Rotosem	3	125	V_1	8

Grundstück mit Wintergerste als Vorfrucht durchgefürt. Für die Aussaat wurde die Saatgutsorte Darmor kalibriert im Interval 1,8-2,0 mm angewandt. Die Versuchsaufgliederung ist in der Tabelle 1 angeführt.

Arbeitsvorgänge, die für alle beurteilten Technologien gemeinsam waren, sind im weiteren Vergleich nicht einbergriffen. Es geht um: Schälung, Walzen (Umbruchbehandlung), Anwendung von Stallmist, TCA und Herbizide nach der Aussaat.

Die Schälung wurde in die Tiefe von 10 cm und Pflügen in die Tiefe von 22 cm durchgeführt. Der spezifischen Aussaatmenge von 3 $kg.ha^{-1}$ bei TKG=4,62 g hat 650 000 stück keimfähige Saatkörner und der spezifischen Aussaatmenge von 5 $kg.ha^{-1}$ 110 000 Stück keimfähige Saatkörner entsprochen. Jede Technologie wurde zweimal wiederholt. Der Raps wurde am 28. August 1990 zwei Wochen nach dem Pflügen event. nach der Schälung in die Tiefe von 1,5 cm ausgesät (außer Technologie T_5). Die Abrechnung des Auflaufens wurde 2 Monate nach der Aussaat (25. Oktober 1990) durchgeführt. Bei jeder Variante wurden zufällig 6 Reihen gewählt, wo in einem Abschnitt von 200cm Anzahl der Pflanzen festgestellt wurde. Bei den Varianten mit der Technologie T_5 wurde die Pflanzenanzahl an der Fläche von 2 500 cm 6 mal festgestellt (d.h. im Quadrat 50x50 cm).

III. Ergebnisse und Diskussion

Auf Grund der Unterlegen und der konkreten Rechnungen für die einzelnen Garnituren und Maschinen sind in Tab. 2, außer anderen Angaben, Werte der direkten Kosten eingetragen, die wieter in Abb. 1, 2 Graphisch dargestellt sind.

Die Vorbereitung des Versuches ging von dem Ziel aus, die klassische Technologie der Bodenbearbeitung, Saatbettbereitung und der Aussat mit den Technologien, wlche die getrieben Arbeitsorgane ausnützen, Anzahl der Arbeitsvorgänge und den Feldfahrtbetrieb reduzieren und

5	1411	74,0	77,7	114	120	100	128,7	2,889	3,038	589,55	562,07	724,13	690,38	4	8
	1412	81,3		125				3,186		534,59		656,62			
6	1511	54,0	48,7	83	75	125	164,3	3,312	3,011	527,23	578,92	618,36	678,99	8	5
	1512	43,3		67				2,759		630,62		739,62			
7	1611	58,6	54,0	90	83	125	148,1	3,137	3,103	572,27	578,71	668,22	675,74	7	4
	1612	49,3		76				3,068		585,14		683,25			
8	2311	60,6	57,3	93	88	80	218,2	3,329	3,117	198,89	213,41	245,72	263,65	1	1
	2312	54,0		83				2,905		227,92		281,58			
9	2411	65,3	63,3	100	97	100	158,0	3,107	3,057	221,47	225,15	306,08	311,17	2	2
	2412	61,3		94				3,007		228,83		316,26			
10	2511	53,3	52,3	82	80	125	153,0	2,817	2,855	259,53	256,12	321,97	317,75	3	3
	2512	51,3		79				2,893		252,71		313,52			

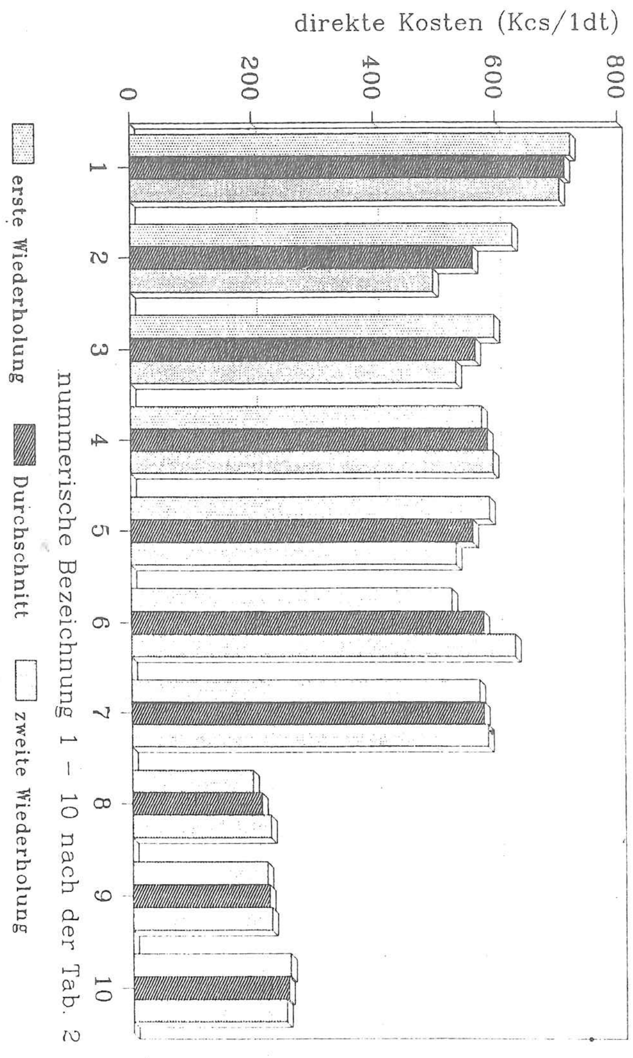

Diagramm 1
direkte Kosten in Kcs fur Dt (3% Zinse)
bei einzelnen Varianten

Einhaltung der agrotechnischen Termine erleichtern, zu vergleichen.

Von der Kostenanalyse sind drei Stufen deutlich. Aus dem Gesichtspunkt der direkten Kosten an 1 t der Produktion sind die Technologien T (Varianten 2311, 2312, 2411, 2412, 2511 2512) eindeutig die günstigsten. Bei diesen Technologien wurde nicht gepflügt und die Aussaat in die Schale durchgeführt. Die Ausschließung des Ackerns bring die Kostenreduzierung um 906,- event. 988,- Kčs.ha^{-1}. Die angeführten Technologien haben auch die Nachteile in relativ schlimmer voebereiteter Feldoberfläche und die Ausbröckelung der vorangehenden Frucht ist evident. Die Verukrautung bildet eine der wichtigen Kriterien der Vorteilhaftigkeit. An der anderen Seite war das Feld flächer, weil bei den Technologien mit den Pflügen die Aneinanderreihung der Arbeitsabschnitte des Beetpfluges einschließlich die Zusammensetzung und das Aufackern evident waren. Das bestätigt wieder die Vorteilhaftigkeit der Kehrpfläge mit der gleichzeitigen Zerkrümmelung der Erdschollen für die Einfachere folgende Bodenbearbeitung für die Aussaat.

Die zweite und zahlreichste Gruppe bilden die Technologien $T_{1,2,3,4,5,6}$ bei denen das traditionelle Pflügen der Saatbettbereitung voranging. Die Bodenbearbeitung wurde entweder mit der Rüttelegge oder mit dem Grubber gemeinsam mit der Aussaat während einer Fahrt durchgeführt. Die Kostenunterschiede zwischen den angeführten Technologien sind minimal und bewegen sich im Interval cca 20,- Kčs t^{-1}. bei der pneumatischen Aussaat ($T_{5,6}$) betrachten wir die Ungleichmäßigkeit der Aussaat und Bildung größerer Anzahl von Anhäufungen (Doppelsaat). Die Sämaschine Rotosem, die in den abgeschleuderten Bodenstrom aussät, bildet sichtbare Unebenheiten, Streifen und Lücken auf der Bodenbearbeitung, der Saatbettbereitung und der Aussaat die schlimste. Die direkten Kosten sind im Vergleich mit der vor her gehenden Gruppe um ca 100,- Kčs event. um 220,- Kčs.t höher. Die Mehr als doppelte Anzahl der Feldfahrten führt zwar zur guten Bodenbearbeitung, verursacht aber höhere Kosten, unverhältnismäßig hohen Grad der Bodenverdichtung und Risiko der Nichteinhaltung der agrotechnischen Termine.

IV. Zusammenfassung

Die Abkehr von der traditionellen Bodenbearbeitung und Tendenz zur Durchführung nur solcher Arbeitsvorgänge, die für das geforderte Ergebnis unbedingt nötig sind, führen zur Verbreitung des Maschinensortiments der Kombinationen von Maschinen. Das Ziel der angeführten Forschung war Beurteilung der Anlegungsqualität des Rapsbestandes bei verschiedenen Varianten der Arbeitsvorgänge mit Rücksicht auf die Kostenreduzierung.

Wenn wir die Technologie der traditionellen Bodenbearbeitung, Saatbettbereitung und der Aussaat für die Grundlage als 100% Kosten für 1 t nehmen, dann die fünf Varianten der Technologien mit getriebenen Arbeitsorganen die sich einander nur gering in Kosten unterschieden, betrugen die Kosten durchschnittlich die Höhe von 78%. Die selben Technologien, apliziert nach der Schälung, wiesen die durchschnittlichen Kosten in der Höhe von 33% auf. Die angeführten Schlußfolgerungen bevorzugen den Einsatz von kombinierten Maschinen mit getriebenen Arbeitsorganen für die Bodenbearbeitung und die Aussaat. Die Versuche haben bestätigt, daß der gesamte Anbauerfolg mit der sorgfältigen Bestandanlegung zusammenhängt. Es wurde bestätig, daß die Qualitätsmaschinen für die Vorbereitung der günstgen Bodenstruktur in der Tiefe des Saatbetts unbedingt nötig sind. Die Sämaschinen müssen mit den Aussaatmechanismem für präzise Einstellung der optimalen Aussaatmenge ausgerüstet sein. Sehr wichtige Forderung an die Sämaschinen bildet Präzisionsaussaat in die optimale Tiefe mit eventueller Ausnützung der Gleitschienen bei den Drillschuhen und mit eventuellen Drillschuhen für die Streifensaat und die Gewährleistung der optimalen Nährfläche.

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TRENDS IN AGRICULTURAL ENGINEERING
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FLUID FLOW EXAMINATION OPTICAL METHODS FOR TECHNOLOGY AND AGRICULTURE

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The objective of this article is to offer some brief information on important experimental methods of modern fluid mechanics and applied optics: flow visualization. The definition, the survey of methods, and the theoretical principles of the most frequently used methods are given. The selected results which demonstrate the application of flow visualization methods both in technology and agriculture are also presented.

1. INTRODUCTION

The optical methods that are most appropriate and most frequently used in fluid flow studies are the flow visualization methods. The term "flow visualization" represents a variety of methods that use information from a flow under study, and that give a visual image of the characteristics of the flow field such as velocity, pressure, density, temperature etc. The information may be obtained from both on line flow experiments and from experimental or theoretical knowledge obtained beforehand.

Studies in the field of flow visualization have become essential sources of knowledge for a wide spectrum of problems associated with the flow of fluid. Because the function and even existence of the majority of animate and inanimate systems are connected with fluid flows, flow visualization is one of the most important regions of modern technical informatics, lending necessary information to all branches of science and technology.

2. METHODS

The contemporary methods of flow visualization can be divided according to principle in the following way:

1. Methods exploiting tracing particles in the streaming fluid - particle methods

- direct injection (smoke, vapor, dye lines, single particles) electrical effects (discharges, afterglow)
- chemical reactions (also photochemical and electrochemical)
- tufts (free flow field)
- use of LDV
- use of speckle velocimetry and particle specklegram

2. Surface tracing methods
   - mechanical (surface tufts, oil dots, liquid coating)
   - physical (sublimation, coating dissolution, liquid crystals, thermography)
   - chemical (chemical reactions)

3. Methods exploiting the effect of streaming fluid on passing radiation field
   - shadowgraphy
   - schlieren
   - interferometry
   - holography
   - refractive index speckle photography
   - streaming birefrigence
   - nuclear magnetic resonance
   - elementary particle rays absorption (electron, ion absorption)
   - X-rays
   - ultraviolet radiation
   - ultrasound

4. Computer aided flow visualization
   - computer generated flow field images
   - computational fluid dynamics

The flow visualization methods can be applied both to the examination of real objects and models. Most frequently they have been used for two dimensional modelled flows. /1/, /2/

3. THEORETICAL APPROACH

Let us outline the symbols for the variables used:

m - particle mass
ϱ_p - particle density
V - particle volumen
d - characteristic particle dimension
v_p - particle velocity
a_p - particle acceleration
p - fluid pressure
ϱ_F - fluid density
ν - fluid kinematic viscosity
g - gravitational acceleration
v_F - fluid velocity
a_F - fluid acceleration

$u = v_p - v_F$

Equation for tracing particle motion:

$$\varrho a_p - \varrho g - \text{grad } p - \varrho_F \frac{u}{d} f\left(\frac{ud}{\nu}\right) u = 0$$

Equation of fluid particle motion:

$$\rho_F a_F - \rho_F g + \text{grad } p = 0$$

These two equations give:

$$\rho a_P - \rho_F a_F = - \rho_F \frac{u}{d} f\left(\frac{ud}{\nu} \right) u + (\rho - \rho_F) g$$

For small u and for $\rho_F \quad \rho_P$

$$a_P - a_F = - Ku = \frac{du}{dt} \longrightarrow u = u_0 \exp(-Kt)$$

For example for a spherical tracing particle with a diameter of 10^{-4} m in water when $\rho_P = \rho_F$, u/u_0 decreases to 0.01 within approximately $2.5 \cdot 10^{-3}$ s. In this case the motion of the tracing particles visualizes truly enough the motion of the fluid particles. If the fluid is a gas, then $\rho_F \ll \rho_P$. As $g \ll a_P$ the tracing particle motion equation is $a_P = K(v_F - v_P)$. For tangential and normal direction of the particle trajectory the following equation holds

$$dv_P/ds_P = K(v_F \cos\alpha - v_P)/v_P \quad ; \quad v_P^2/R_P = K \, v_F \sin\alpha$$

α is the angle between v_P and v_F, R_P is the curvature radius of the tracing particle trajectory and ds_P is an element of the trajectory. If we denote $v_P - v_F/v_P = \lambda$ then

$$(1 - \lambda) \cos\alpha = 1 + dv_P/K \, ds_P \quad ; \quad (1 - \lambda) \sin\alpha = v_P/K \, R_P$$

R_P, v_P and dv_P/ds_P can be determined by photos of tracing particles moving together with the fluid using an intermittent light sheet. α and λ characterize the true of the flow visualization. α is the deviation angle between the trajectory of the tracing particle and the trajectory of the fluid particle. λ is the relative velocity difference. A true flow visualization can be reached when α and λ are small. Then

$$\lambda = - dv_P/K \, ds_P \quad ; \quad \alpha = v_P/K \, R_P$$

For example, aluminium powder tracing particles having $v_P \geq 100 \text{ ms}^{-1}$, $R_P \geq 8$ cm, $dv_P/ds_P < 500 \text{ s}^{-1}$, $\alpha \leq 1.5^o$, $\lambda \leq 0.01$ enable sufficient true flow visualization. That means that the image of the tracing particle trajectory can be considered as a fluid particle trajectory and as a streamline if the flow is stationary. /1/

Let us now deal, using a simplified theoretical description, with methods exploiting the effect of streaming gas on passing light. Changes of the gas density ρ due to the flow cause changes of the refractive index n of the gas. This fact is described by the Lorentz-Lorenz formula:

$$(n^2 - 1)/(n^2 + 2) = \rho K$$

K is a constant. For air, n does not differ much from 1 and the Gladstone - Dale law can be used:

$$(n - 1) = \rho K$$

Using these methods, the information about the flow under study is given by the change of illumination of the used optical device viewing field - screen as compared with the state of the viewing field when the examined fluid layer does not flow. In this case, if the fluid layer is homogeneous, a particular light ray encounters the screen at a spot P at a time t and in a direction given by an angle D. If there are inhomogenities in the layer, due to the flow in this situation, the light ray encounters the screen at a spot P^+ at a time t^+ in a direction D^+ and a local change of illumination of the screen happens. By means of appropriate optical instruments, one can obtain on the screen either an image of the phase shift corresponding to the time difference $\Delta t = t^+ - t$ (using interferometers), or an image of the ray direction angle deviation $\Delta D = D^+ - D$ (using schlieren devices) or an image of the shift of the ray incidence point $\Delta P = P^+ - P$ (using shadowgraph methods). The evaluation of images of Δt, ΔD and ΔP enables one to obtain the local values of the refractive index n and then the local values of density ρ and other data.

The trajectory of the light ray passing a gas layer under study between two points 1 and 2 is described by the Fermat principle

$$\delta \int_1^2 n \, ds = 0 \quad ; \quad \delta \int_1^2 n \sqrt{1 + y'^2 + z'^2} \, dx = 0$$

The respective Euler equations are:

$$\frac{\partial n}{\partial y} \sqrt{1 + y'^2 + z'^2} - \frac{d}{dx} \left(n \frac{y'}{\sqrt{1 + y'^2 + z'^2}} \right) = 0$$

$$\frac{\partial n}{\partial z} \sqrt{1 + y'^2 + z'^2} - \frac{d}{dx} \left(n \frac{z'}{\sqrt{1 + y'^2 + z'^2}} \right) = 0$$

$y' = \frac{dy}{dx}$ and $z' = \frac{dz}{dx}$ are the angle deviations of the passing light ray from the original direction that was parallel to the x axis. If $y'^2 \ll 1$ and $z'^2 \ll 1$

$$\partial n/\partial y = d(ny')/dx \quad ; \quad \partial n/\partial y = d(nz')/dx$$

For two-dimensional field and when the ray encounters the layer perpendicularly

$$\partial n/\partial y = ny'/(x_2 - x_1) \quad , \quad \partial n/\partial z = nz'/(x_2 - x_1)$$

and

$$n(y, z_0) = n_0 + \int_{y_0}^{y} \frac{\partial n}{\partial y} dy \quad , \quad n(y_0, z) = n_0 + \int_{z_0}^{z} \frac{\partial n}{\partial z} dz$$

where n_0 is the refractive index of the streaming gas at a point x, y_0, z_0.

Using Gladstone-Dale law one obtains

$$\partial n/\partial y = K\, \partial\rho/\partial y \quad , \quad \partial n/\partial z = K\, \partial\rho/\partial z$$

The measured values of y' and z' enable one to determine the density gradient $\partial\rho/\partial y$ and $\partial\rho/\partial z$ and the density ρ at an arbitrary point of the streaming gas layer. Using a homogeneous beam of light rays one can in the viewing field obtain an image of the local values of the displayed measured quantities, that can be recorded by means of photo, ciné or video systems, and evaluated using various image analysers and processors. /1/, /2/

4. RESULTS

In this paragraph, some results both of qualitative and quantitative character, in a graphic form, will be given. /1/, /2/ Figure 1a shows the flow image of streaming air in a threshing machine air separator. Tracing particles (lycopodium powder) on the surface of a water model were used to visualize the flow. Fig. 1b shows the derived streamlines.

Fig. 2 shows a modelled ventilation inside a cowshed. /3/ Alluminum tracing particles on the surface of a thin water layer are used in order to model the air flow of a very low velocity.

Fig. 3 shows the air flow around and through a permeable wall (wind-break) modelled in a smoke tunnel.

Fig. 4a shows the surface air flow behind a backward facing step. It is a very complicated kind of flow that nevertheless happens very often. An oil-film surface tracing method was used. In figure 4b, the measured results of the surface flow shape characteristics for various Re numbers are demonstrated.

Figures 5a and 5b are interferograms obtained by means of a birefrigence method. Fig. 5a refers to the free channel two-dimensional flow and fig. 5b refers to a flow around a cylinder inside the channel.

Fig. 6 is an interferogram of an air flow through a turbine blade cascade. A Mach-Zehnder interferometer was used.

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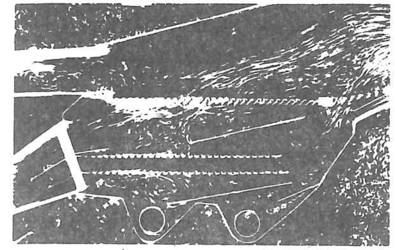

Fig. 1a

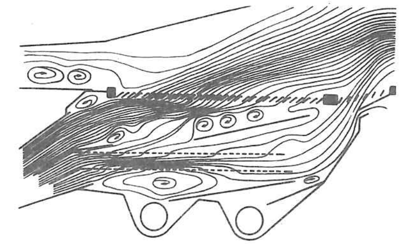

Fig. 1b

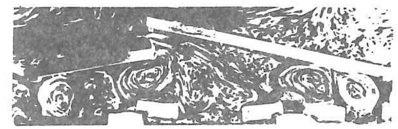

Fig. 2

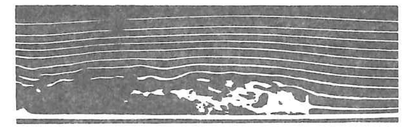

Fig. 3

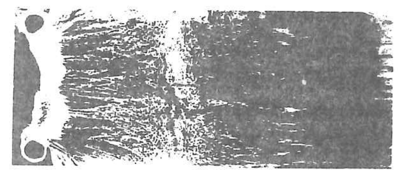

Fig. 4a

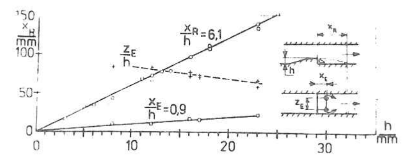

Fig. 4b

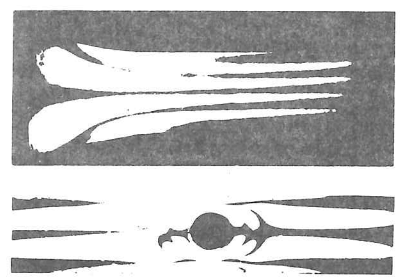

Fig. 5a, 5b

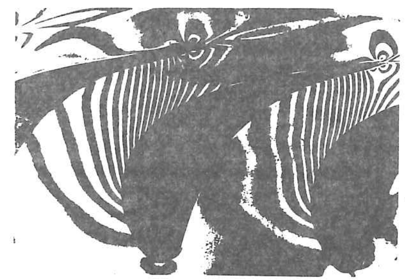

Fig. 6

TRENDS IN AGRICULTURAL ENGINEERING
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ECOLOGICAL ASPECTS OF MAIZE PRODUCTION.

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Process of accumulation of atrazine - the most used pesticide in maize production - is studed together with physiological-biochemical characteristics of plants of different genotypes. It is shown, that disturbances in biosynthesis of amino acids, some classes of lipids under pesticide treatment are the reasons of loss of stability of plants. Ecological aspects are closely interlinked with biochemical investigation of process of xenobiotic detoxication.

Maize of several forms (lines and hybrids) were grown on control and treated with large doze of atrazine (experimental) fields. One more surface treatment with 2,4-D called damage of leaves on experimental fields and made no influence on control plants. Thus, we investigated the loss of resistance of plants to surfase treatment under influence of pesticide. We studied surface waxe of leaves of maize on different stages of growth of plants. We showed that more resistent plants had more fully formed spectrum of hydrocarbons, wich were the main componets of wax. Atrazine disturbed biosinthesis of some wax components, that may be the reason of nonstability to new exogeneous action.First of all, we studied process of metabolization of atrazine in different types of maize. It was

shown, that stability and productivity of a species and quantity of unmetabolized pesticide in plant tissues had revers correlation interconnection. Then we showed that there are significant quantities of atrazine and its metabolites in grain of all types of plants.The most quantity of pesticide was found on the early stages of graine development. Dynamics of pesticide in graine was genetically determined and showed that process of xenobiotic inactivation took place not only in vegetative but also in reproductive organs of maize. The most important question is about the last residues of toxic pesticide in graine, wich presence in the reproductive organs is unacceptable. We think, the process of accumulation of atrazine and other toxic compounds depends on amino acid exchange in plant, becouse dynamic of its accumulation and of free amino acids had the same directions. Also, it is known,that atrazine detoxication process requires peptides expression. Imbibition of xenobiotic by plants from soil depends on penetrability of inner membranes of roots. We took two lines, wich differ on this characteristic and realized that atrazine accumulation did correlate with penetrability of root membranes. Thus, accumulation of atrazine depends on many physiological-biochemical propeties of plants and ecological aspects of maize production is closely interlinked with biochemical investigations of process of xenobiotic detoxication.

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EQUILIBRIUM OF THE BODY WITH HIGHER DEGREE OF STATICAL INDETERMINACY

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In this paper is described a control procedure of the solution of equilibrium (force analysis) statically indeterminate portal beam with two fixed supports. Original calculation, that was made exactly with second Castigliano's Theorem is controlled by use of minimum strain energy of structure. We have used a computer with programme MATHCAD

statically indeterminate supporting; second Castigliano's theorem; minimum of strain energy; MathCAD; force analysis; equilibrium

Many bodies (structures, machine elements) are supported statically indeterminately. It means that the constraints of body to frame are more numerous then necessary for maintaining the unmovability. The reason of this structure solution is diminution of stresses. Examples of statically determinate and statically indeterminate supporting (at plane) are shown in Figures 1 and 2.

Solution of equilibrium (reactions in supports) is for the case of statically determinate supporting very simple: with conditions of equilibrium

$$1)\sum F_{ix}=0,\quad 2)\sum F_{iy}=0,\quad 3)\sum M_i=0 \qquad (1)$$

It is easy to calculate all reactions in supports A and B: F_{Ax}, F_{Ay}, F_B- Figure 1.

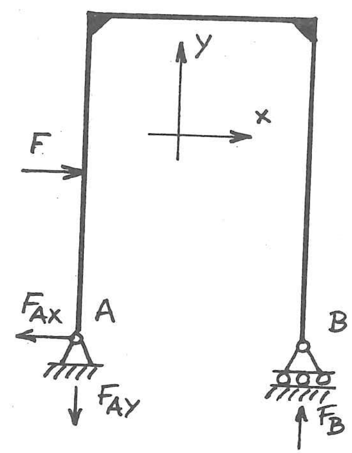

Fig.1. Statically determinate supporting

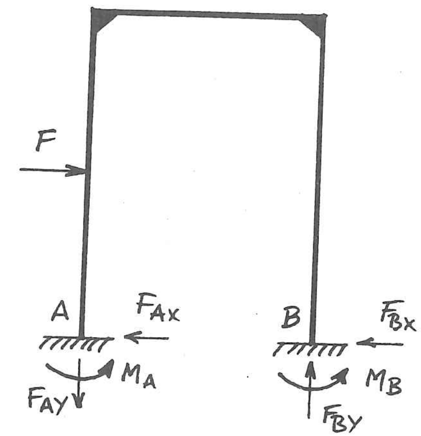

Fig.2. Statically indeterminate supporting (n=3)

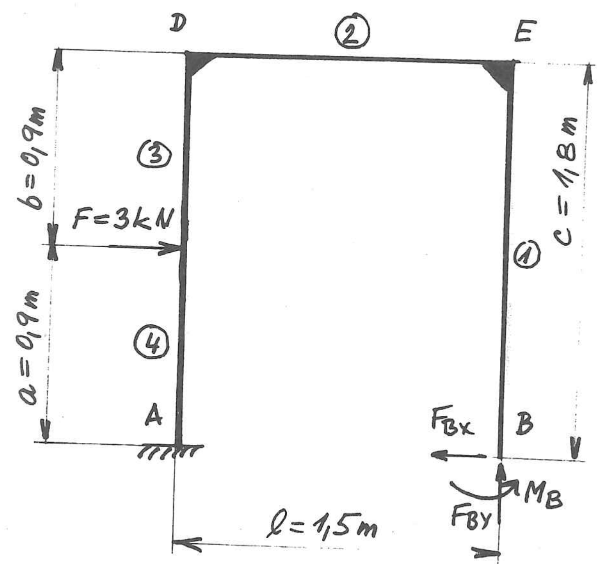

Fig.3. Free body diagram for calculation

More complicated problem is calculation of reactions in the case of statically indeterminate supporting (Fig. 2). Degree of statical indeterminacy "n" gives number of redundant constraints and it equals the difference between number of all reaction components and number of equilibrium conditions (Fig.2: 6 reaction components minus 3 equilibrium conditions for plane system of forces => n=3). Statically indeterminate supporting (Fig.2) comes from adding one constraint to hinged support A (M_A) and adding two constraints to plane support B (F_{Bx}, M_B, Fig. 1). Amount of work grows with increase of the degree of statical indeterminacy.

The degree of statical indeterminacy gives the number of missing equations, that are necessary to add to equilibrium conditions (1). These complementary equations follow from strain (deformation) properties of the statically indeterminate system. In this case (Fig.2) deflection and slope of structure at B (fixed support) equal zero - reactions at B were chosen as redundant quantities. There are more procedures of force analysis (or solution of equilibrium) in case of statical indeterminacy. One of them, that express the deformation equations (or compatibility conditions) is the use of second Castigliano's theorem. This theorem express condition, that above mentioned displacements (deflection and slope at B) are equal to zero.

$$1)\ \frac{\partial U}{\partial F_{Bx}} = 0,\quad 2)\ \frac{\partial U}{\partial F_{By}} = 0,\quad 3)\ \frac{\partial U}{\partial M_B} = 0 \qquad (2)$$

These relationships express also - with aid of more general mathematics point of view - that the values of statically indeterminate quantities (F_{Bx}, F_{By}, M_B) make the strain work (or strain energy) minimal. Here "U" is strain energy of the whole portal beam (Fig.3). In this figure are given also necessary numerical values, because we will make the numerical calculation, too. At all parts of the portal beam are used the same cross-sections and the same materials. We assume elastic deformation in the whole body, i.e. $\sigma \leq \sigma_E$ (elastic limit). From this follows that strain work (A) and strain energy (U) are equal => A=U. If we assume validity of Hooke's Law ($\sigma \leq \sigma_U$, proportional limit), too, we can easily calculate the strain energy from simple relationships.

The parts of portal beam (Fig.3: 1, 2, 3, 4) are subjected to tension, compression and bending. The most important is bending and the other tension and compression are negligible. For part "1" were calculated the strain energies from compression and from bending. The strain energy from bending is 3000 times higher then from compression. The parts of portal beam are strained by reactions F_{Bx}, F_{By}, M_B and by external force F, i.e. all these forces influence the strain energy.

$$\frac{\partial U}{\partial F_{Bx}} = f_1(F_{Bx}, F_{By}, M_B, F, \text{length, cross-section, material})=0$$

$$\frac{\partial U}{\partial F_{By}} = f_2(F_{Bx}, F_{By}, M_B, F, \text{length, cross-section, material})=0 \qquad (3)$$

$$\frac{\partial U}{\partial M_B} = f_3(F_{Bx}, F_{By}, M_B, F, \text{length, cross-section, material})=0$$

From system of three equations (second Castigliano's Theorem) it is possible to calculate all reactions at support B and also cross-sections of portal beam.

But conscientious designer cannot be content with this procedure of solution and he cannot finish, because he has made no control. There are more possibilities how to make the control:

- designer himself can control the calculation
- better is when other designer makes this control
- even better is when designer will calculate all unknown components of reaction by another procedure.

He can use the computer: the problem is to calculate minimal strain energy U_{MIN} and especially the values of parameters F_{Bx}, F_{By}, M_B (unknown components of statically indeterminate reaction), that make strain energy minimal. There is the simplest solution with aid of programme MathCAD. The computerised calculation is completed at specific programme places by manual inputs made by user, who gradually approaches the solution.

Accurate solution according to equations (3) was completed by numerical solution. Output accuracy of the solution is set by designer according to the need of the solved problem. For the portal beam (Fig.3) follows from both methods

F_{Bx}=574 N

F_{By}=395 N

M_B=611 Nm

Accurate solution according to equations (3) was checked with aid of the computer and MathCAD, so designers conscience can be clear.

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SCHAUMBILDUNG VON KUHMILCH BEIM MELKEN UNTER BESONDERER BERÜCKSICHTIGUNG DER MILCHMENGENMESSUNG UND EUTERGESUNDHEIT

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FOAMING OF MILK AS RELATED TO MILKING, MILK MEASUREMENT AND UDDER HEALTH

Foam formation in milk was recorded with a special milk meter using 720 cows of 22 herds during one morning and evening milking each. A second trial covered 2 x three weeks of a research herd with 35 cows. While the total foam fraction averaged 36 %, foam turned out to be an individual characteristic for each cow, especially varied by milking system and milk flow. Furthermore, the parameter is influenced by udder health. Milk foam from different quarters of the same cow showed considerable deviations. As an applied result, major systematic errors may be expected if small volumetric milk meters are adjusted to the foam average of the herd.

Milk foam, Milk meter, Mastitis

1. EINLEITUNG

Für die Bildung von Milchschaum werden vor allem die Proteine der Milch durch ihre oberflächenaktiven Eigenschaften verantwortlich gemacht. Dabei tragen die Molkenproteine und die Caseine der Rohmilch /1, 2/ in unterschiedlicher Weise sowohl zum Schäumen wie zur Schaumstabilität in Abhängigkeit von Temperatur, pH-Wert und Salzen bei /3/. Einen gegenteiligen Effekt, also Schaumhemmung und Schaumbrechung, bewirken die Fette der Milch, insbesondere deren amphiphile Bestandteile, wie die Freien Fettsäuren, die Monoglyceride und die Phospholipide /1, 2, 4/.

Fütterung /5/, Laktationsstatus /6/ und Melkzeit /7/ können die Menge und Zusammensetzung des Protein- und Fettgehalts der Milch wesentlich beeinflussen. Besonders gravierende Abweichungen in Milchmenge und -zusammensetzung treten bei Mastitiden auf /8/. Insbesondere die schaumbildenden α-Lactalbumine und β-Lactoglobuline sowie die schaumstabilisierenden Caseine sind bei Euterentzündungen deutlich erniedrigt. Zusätzlich labilisiert der

erhöhte Anteil an Freien Fettsäuren die Schaumstruktur /1/.

Größere Mengen von Schaum können beim Melken zum Problem werden; dabei nehmen Melktechnik, Melkverfahren und Melkroutine erheblichen Einfluß auf die Schaumbildung. Selbst bei fachgerechter Installation einer Melkanlage ist aufgrund mehr oder weniger starker Verwirbelung der Milch mit Luft beim Melken und anschließendem Abtransport mit deutlicher Schaumbildung zu rechnen. Hinzu kommt noch eine beträchtliche Schaumvermehrung durch z.B. undichte Anlagenteile und Lecklufteinbrüche an den Zitzenbechern /9/. Die beträchtliche Oberflächenzunahme bei der Verschäumung findet auch ihren Niederschlag in der verstärkten Bildung von Freien Fettsäuren /10/.

Milchmengenmeßgeräte haben es also mit einem Fluid mit unterschiedlichem Milch-Luft-Verhältnis zu tun /11/. Für Milchmengenmesser der verbreiteten volumetrischen Bauart resultieren daraus systematische Fehler, wenn keine hinreichende Entgasung erfolgt.

Vor diesem Hintergrund wird nachstehend über die beim Melken von 22 Versuchsherden auftretenden Schaummengen und deren Schwankungen berichtet, sowie darüber, inwieweit diese tierindividuell bedingt sind, also eine charakteristische Eigenschaft des Einzeltieres darstellen. Zusätzlich werden Zusammenhänge zwischen Schaumbildung und möglichen Einflußfaktoren wie Rasse, Melkverfahren und Durchschnittliches Minutengemelk (DMG) dargestellt. Weiterhin wird auf der Grundlage des ausführlichen Datenmaterials aus einer Versuchsherde besprochen, ob die Schaummenge im Gesamtgemelk, oder besser in Viertelgemelken, zur Früherkennung von Euterentzündungen verwendet werden kann.

2. MATERILAL UND METHODEN

Es standen 720 Kühe (478 Fleckvieh, 140 Braunvieh und 102 Schwarzbunte) aus 22 Betrieben (durchschnittliche Jahresleistung 4800 bis 8200 kg Milch) für Versuche zur Verfügung. In den je 11 Betrieben mit Rohrmelkanlagen bzw. Melkständen -alle mit Standardmelkzeugen ausgerüstet- wurde jedes Tier jeweils morgens und abends gemolken. Ferner wurde die institutseigene Herde (35 Braunviehkühe; 7000 kg/a) in zwei aufeinanderfolgenden Jahren jeweils für drei Wochen hintereinander in den Melkversuch genommen. Bei diesem Versuch sind parallel Viertelproben aus dem Vorgemelk gezogen und in ihnen neben den Milchinhaltsstoffen auch Zell- und Laktosegehalte als Parameter für die Eutergesundheit bestimmt worden.

Zur Ermittlung der Milchmengen und der Schaumanteile ist ein spezieller Milchmengenmesser /11/ am Ende des langen Milchschlauches der betriebseigenen Melkzeuge eingebaut worden. Die Milchmenge wurde im Durchfluß gemessen, wobei zunächst indirekt die elektrische Leitfähigkeit bestimmt, daraus die Dichte und dann die Masse der durchfließenden Milch berechnet wurde. Im Versuch mit den 720 Kühen ist der Milchfluß alle 2.8 s und der Schaumanteil alle 11.2 s abgetastet worden. Die Melkdaten der institutseigenen Herde sind im ersten Jahr online erfaßt worden /12/, während der Milchfluß im zweiten Jahr in einem leicht abgewandelten Verfahren alle 0.7 s und der Schaumanteil alle 2.8 s gemessen wurde /13/. Die etwa 30000 Daten je Kuh und Melkung wurden vom Milchmengenmesser auf einen PC übertragen. Die

Auswertung der während des Melkens vom Computer gespeicherten Daten ist mit einem für diese Auswertungen modifizierten Schaumprogramm /14/ vorgenommen worden. Alle statistischen Berechnungen erfolgten mit SAS /15/.

3. ERGEBNISSE UND DISKUSSION

Das Schaumprogramm hat alle Melkungen in Form von Milchflußkurven aufgezeichnet. Beispielhaft ist in Abbildung 1 die gesamte durch den Milchmengenmesser geflossene Milch als Hüllkurve dargestellt und in die Anteile "verschäumte Milch" (weiß) und "schaumfreie Milch" (schraffiert) aufgeteilt. Wie an dem zeitlich verzögerten Auftreten des Milchschaumes zu erkennen ist, baut sich dieser mit zunehmendem Milchfluß innerhalb der ersten Minute in dem Gefäß des Milchmengenmessers auf. Im weiteren Verlauf der Melkung schwankt der Anteil der verschäumten Milch dann mehr oder weniger stark und nimmt teilweise erhebliche Prozentraten an.

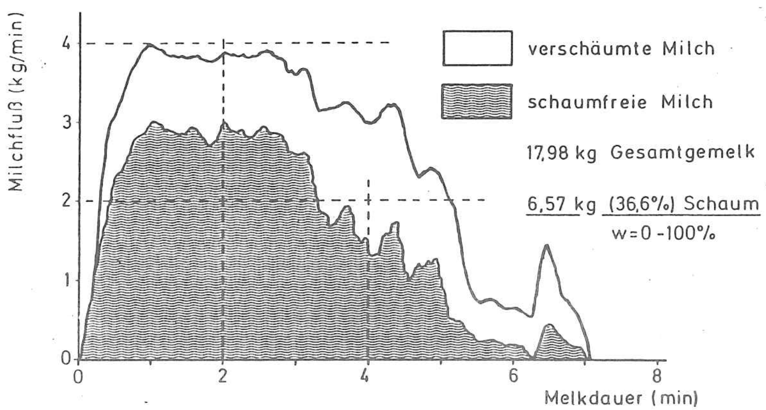

Abbildung 1: Schaumanteile während des Melkens (Beispiel)

Um einen Überblick über die aufgetretenen Schaumanteile der 22 Herden zu geben, ist in Abbildung 2 der durchschnittliche Milch-im-Schaum-Anteil (in %) jedes Betriebes, sortiert nach aufsteigenden Mittelwerten, dargestellt.

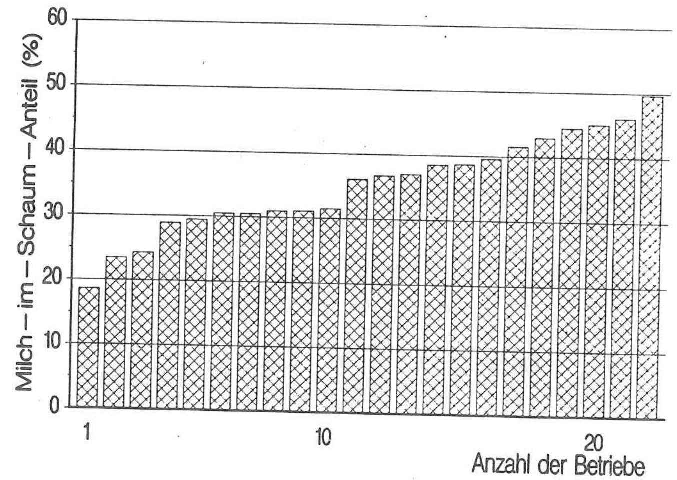

Abbildung 2: Durchschnittliche Schaumanteile (in %) je Betrieb (aufsteigend sortiert; n = 1464 Melkungen)

Abbildung 2 zeigt mit 18 bis 49 % eine große Spannweite im Schaumanteil der einzelnen Betriebe auf. Zusätzlich ergaben varianzanalytische Berechnungen hochsignifikante Unterschiede ($p \leq 0.001$) im Schaumanteil zwischen den einzelnen Kühen innerhalb jedes Betriebes, was auch schon in früheren Untersuchungen beobachtet werden konnte /12/. Somit stellt die Schaumentwicklung bei gleichbleibender Fütterung ein tierindividuelles Merkmal dar. Dieses Ergebnis zeigt deutlich, daß systematische Fehler zu erwarten sind, wenn mit Milchmengenmessern der verbreiteten volumetrischen Bauart gemessen wird, und keine hinreichende Entgasung erfolgt: Wenn die Messungen auf einer durchschnittlich angenommenen Schaumentwicklung der Herde aufbauen, wird zwangsläufig zu viel oder zu wenig Milch für das Einzeltier angegeben. Fehler bei der leistungsgerechten Fütterung sind zu erwarten. Besonders schwerwiegend ist ein systematischer Meßfehler bei der offiziellen Milchleistungsprüfung (MLP), da hier keine betriebsspezifische Vorjustierung möglich ist. Eine grundsätzliche Lösung dagegen stellt die Erfassung des Massestromes dar, wie sie z.B. auch das vorgestellte Gerät aufweist.

Eine weitere Aufschlüsselung der Ergebnisse nach Melksystemen und Rassen zeigt, daß beim Fleckvieh und Braunvieh, die mit einer hochverlegten Rohrmelkanlage gemolken wurden, mehr Schaum aufgetreten ist als bei Kühen, die im Melkstand gemolken wurden. Abweichend davon verhielt sich nur ein Schwarzbuntbetrieb (60 Melkungen) mit einer hochverlegten Rohrmelkanlage und niedrigeren Schaumanteilen. Über alle Melkungen betrachtet hat sich der Unterschied -hochverlegte Rohrmelkanlage 40 % Schaum gegenüber 35 % Schaum beim Melkstand- als signifikant ($p \leq 0.05$) herausgestellt. Dies läßt sich damit erklären, daß bei der hochverlegten Rohrmelkanlage die Milch vom Euter zur Rohrleitung hochtransportiert wird. Infolgedessen kommt es zur stärkeren Verwirbelung der Milch und gegenüber dem Melkstand vermehrter Schaumbildung.

Neben Rasse und Melksystem können weitere Parameter Einfluß auf die Höhe des Schaumanteiles nehmen: Im zweiten Datensatz wurde die Abhängigkeit des Schaumanteiles vom Milchfluß geprüft, indem die Korrelation zwischen dem Schaumanteil und dem DMG berechnet wurde. Es konnte eine signifikante ($p \leq 0.001$) negative Korrelation von $r = -0.28$ festgestellt werden. Also kommt es mit zunehmendem Milchfluß zu einer Abnahme des Schaumanteiles, wie es aufgrund der Strömungsverhältnisse in der Melkeinheit zu erwarten ist.

Außer strömungsmechanischen Einflüssen auf den Schaumanteil haben die Milchinhaltsstoffe Fett und Eiweiß Einfluß auf das Schaumverhalten. Da bei Euterentzündungen eine starke quantitative Verschiebung zugunsten der Schaumbrechung stattfindet, wurde mit den Labordaten der Braunviehherde, einschließlich der Eutergesundheitsparameter Zellzahl und Laktose-Gehalt, versucht, Beziehungen zum Eutergesundheitsstatus herauszufinden.

Zwischen den jeweiligen Schaumanteilen je Melkung und den gemittelten Zellzahlen konnte eine negative Korrelation von $r = -0.17$, sowie zum Laktosegehalt eine positive Korrelation von $r = +0.09$ festgestellt werden (beide schwach signifikant mit $p \leq 0.05$). Diese Korrelationen weisen auf Beziehungen zwischen dem Schaumgehalt und dem Eutergesundheitsstatus hin. Daraufhin wurden Gruppen aufgrund der Zellzahl und des Laktosegehaltes gebildet. Diejenigen Viertel wurden als krank eingestuft, deren Zellzahlen zum Zeitpunkt der Melkung über 150.000 / ml Milch bzw. unter 4.6 % Laktose lagen. Es ergaben sich keine signifikanten Unterschiede im Schaumgehalt zwischen den Zellzahlgruppen (0, 1, 2, 3 oder 4 kranke Viertel). Hingegen wiesen die Melkungen mit weniger als 4.6 % Laktose einen signifikant niedrigeren Schaumanteil auf als Melkungen, bei denen höhere Laktosegehalte im Vorgemelk gemessen wurden.

Zweifelsohne ist in diesen Messungen von Nachteil, daß der Schaum aller vier Euterviertel gemischt ist, so daß sich Schaumanteile aus kranken und gesunden Vierteln gegenseitig überlagern. Deshalb sind bei 10 institutseigenen Kühen, die jeweils morgens und abends gemolken wurden, Schaum - Viertelmessungen durchgeführt worden. Sie ergaben hochsignifikante ($p \leq 0.001$) Unterschiede im Schaumanteil von Euterviertel zu Euterviertel, die die physiologische Selbständigkeit jedes Euterviertels eindrucksvoll unterstreichen. Für die Mastitisdiagnose dagegen erscheint der "Viertel - Schaum" als zu aufwendig im Vergleich zur Leitfähigkeitsmessung zwischen den Vierteln. Über diese Arbeit wird an anderer Stelle berichtet.

4. ZUSAMMENFASSUNG

Es wurde die Bildung von Milchschaum mit einem speziellen Milchmengenmesser bei 720 Kühen aus 22 Herden, in jeweils einer Morgen- und Abendmelkung, verfolgt. In einer anderen Milchviehherde sind analoge Messungen in zwei aufeinanderfolgenden Jahren jeweils drei Wochen hintereinander durchgeführt worden. Der durchschnittliche Schaumanteil, über alle Melkungen betrachtet, betrug 36 %. Das Schaumverhalten ist als individuelles Merkmal jeder Kuh anzusehen. Einfluß auf den Schaumanteil nehmen

Melksystem, Rasse, Milchfluß und Eutergesundheit. Die einzelnen Euterviertel derselben Kuh wiesen große Unterschiede in ihrem Schaumanteil auf. Aus diesen Ergebnissen folgt, daß die Eichung volumetrischer Milchmengenmeßgeräte auf den durchschnittlichen Schaumanteil der Herde zur systematischen Über- oder Unterbewertung der Milchmenge des Einzeltieres führt.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

BIOMASS-PRODUKTION OF MISCANTHUS AND ARUNDO DONAX ON A CLIMATIC FAVOURABLE PLACE IN THE RHINE-VALLEY

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KEY-WORDS: Miscanthus, Arundo, Rohstoffe, Pflanzen, Biomasse, Ertrag, Ökologie, Anbau

SUMMARY

In the Rhine-valley two species of sedge were grown in a field experiment. The aim was to get practical experience such as fertilizing, irrigation, harvest and storage. The perennial plants reached a biomass-production of nearly 30 t per ha in the second and third year. This is a caloric value of 12000 l oil. It needs fertilizing only 80-100 kg N per ha in the first and second year. Pesticides are not necessary, because parasites and diseases are not present itself. The ecological effects are very good, leaching of nitrate is very low, the green and yellow colours stimulates the view.

1. EINLEITUNG

Nachwachsende Rohstoffe sind eine Gruppe sehr unterschiedlicher Pflanzen mit verschiedenen Nutzungsformen. Ihr gemeinsames Merkmal ist, daß sie nicht der Nahrung von Mensch oder Tier dienen /1/. Es gibt zwei Gründe, die für verstärkte Forschungen zu Fragen des Anbaues sprechen:

1. In Europa werden viele Nahrungs- und Futterpflanzen im Überschuß erzeugt. Sie müssen mit hohem finanziellen Aufwand vermarktet werden. Für bestimmte landwirtschaftliche Betriebe kann der Anbau von neuen Pflanzen eine gute Alternative zu den herkömmlichen Nutzungen sein.

2. Die Vorräte an fossiler Energie reichen nicht unbegrenzt. Zudem verursacht die Verbrennung von Kohle, Öl und Gas eine ständige zusätzliche Abgabe von CO_2 in die Atmosphäre. Dem dadurch drohenden Treibhauseffekt mit seinen nachteiligen Folgen kann nur mittels alternativen Energiequellen begegnet werden.

Große Unternehmen der Energieversorgung haben daher auch die Verbrennung von Biomasse als eine von mehreren Energiequellen eingeplant. Demzufolge werden die Forschungen über den Anbau geeigneter Pflanzen verstärkt. Unter anderem könnten dabei einige Schilfarten sehr erfolgreich sein /2/, /3/.

In Zusammenarbeit zwischen der Energieversorgung Schwaben, Stuttgart und der Landesanstalt für Pflanzenbau, Forchheim kam es im Frühjahr 1989 zum Anbau von "Miscanthus" und "Arundo donax" in der Rheinebene. Es sollten bei diesem Projekt auf einem klimatisch begünstigten Standort Erfahrungen über die Biomasse-Produktion gesammelt werden.

2. VERSUCHSANLAGE

2.1 Eigenschaften des Standortes

Versuchsstandort ist das Gelände der Landesanstalt in der Rheinebene, südlich von Karlsruhe.

Niederschlag:	knapp 800 l/m^2, in der Versuchszeit aber erheblich niedriger
Temperatur:	langjähriges Mittel von 9.6°C, in der Versuchszeit aber wesentlich höher
Boden:	sandiger Lehm, Ackerzahl 32
Humusgehalt:	2.4 %, Nährstoffgehalt mittel bis gut
Vorfrucht:	Getreide
Spätfröste:	Gefahr bis Mitte Mai (sehr wichtiges Kriterium)

2.2 Versuchsplan (Tab. 1)

Die Anlage des Versuches erfolgte im Frühjahr 1989 auf einer 10 ar großen Parzelle als Dauerversuch. Der zum Vergleich angebaute Mais sollte vorläufig auch alljährlich auf der gleichen Fläche stehen.

Pflanzenarten:	1. Miscanthus sinensis giganteus (Chinaschilf)
	2. Arundo donax (Pfahlrohr)
	3. Körnermais (Sorte Alba, FAO=600, spätreif)
N-Düngung:	1. 100 kg N/ha als ALZON (zwei gleiche Gaben)
	2. 150 kg N/ha " "
	3. 200 kg N/ha " "

2.3 Pflanzenentwicklung

Arundo donax entwickelte sich nach der Pflanzung sehr langsam, etwa 15-20 % der Pflanzen gingen kaputt. Bei Miscanthus kam es zu keinem nennenswerten Ausfall. Der Austrieb in den folgenden Jahren beginnt im April, allerdings werden die jungen Pflanzen durch Spätfröste sehr stark geschädigt.

Tab. 1: Daten der Versuchsdurchführung

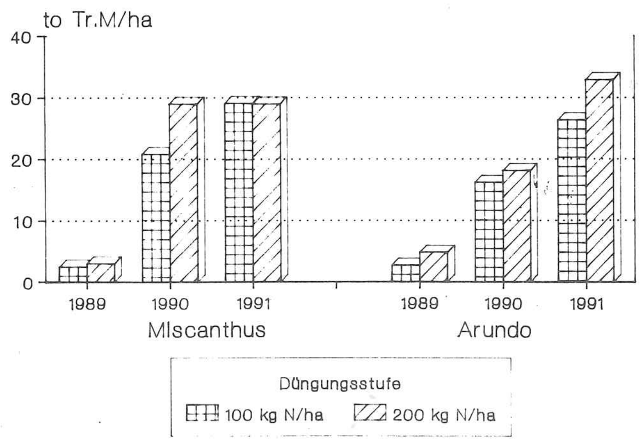
		Arundo	Miscanthus	Mais
Parzellengröße		27 m^2	27 m^2	27 m^2
Anzahl Parzellen		9	9	9
Pflanzung/Saat	1989	4.4.89	7.6.89	3.5.89
	1990	-	-	8.5.90
Pflanzgut		Rhizome nicht getopft	Rhizome getopft	
Pflanztiefe		4-5 cm	4-5 cm	6-8 cm
Reihenabstand		75 x 50 cm	75 x 50 cm	75 x 17 cm
Pflanzen/m^2		2.7	2.7	6
Düngungstermine	1989	3.5./2.6.	7.6./5.7.	3.5./2.6.
	1990	20.4./8.5.	20.4./8.5.	14.5./28.5.
Erntetermine	1989	23.11./20.2.	23.11./20.2.	23.11./20.2.
	1990	26.11./7.2.	26.11./7.2.	26.11./7.2.

3. ERGEBNISSE

3.1 Erträge an Biomasse

Erwartungsgemäß war der Ertrag an Biomasse im Pflanzjahr sehr gering. Aber bereits im 2. Jahr erreichten beide Pflanzenarten zwischen 15 und 24 t/ha je nach Erntetermin bzw. Düngung (Abb. 1).

Abb. 1: Biomasseerträge von Miscanthus und Arundo donax



3.2 Gehalt an Trockenmasse im Erntegut

Für die Verbrennung der Pflanzen ist ein Trockenmassegehalt von mindestens 80 % erforderlich. Wenn dieses zum Erntezeitpunkt nicht erreicht ist, muß mit großem Aufwand nachgetrocknet werden. Wie die Ergebnisse zeigen (Tab. 2), ist dieser Wert bei Miscanthus im Februar annähernd möglich.

Tab. 2: Tr.M.-Gehalt(%) im Erntegut zu verschiedenen Terminen

	Miscanthus		Arundo		Mais
	Nov.	Febr.	Nov.	Febr.	Nov.
1989/90	33.6	71.0	35.7	48.0	39.4
1990/91	50.8	79.2	44.7	50.2	40.0

Arundo donax dagegen liegt erheblich darunter. Dieses ist nicht verwunderlich wenn man bedenkt, daß bei Arundo kein einheitliches Wachstum erfolgt, sondern das ganze Jahr über neue Triebe nachwachsen. Der höhere Tr.M.-Gehalt ist ein sehr wichtiger Grund, der Miscanthus wesentlich bessere Chancen gibt, im Anbau eine größere Bedeutung zu erreichen.

Wie einfache Lagerversuche zeigten, findet auch bei höheren Wassergehalten kaum eine nenneswerte Fäulnis statt.

3.3 Nährstoffgehalte im Erntegut des 2. Jahres

Der geringe Gehalt an Nährstoffen ist sehr wichtig, weil er gleichbedeutend mit geringem Verbrennungsrückstand (Asche) ist, der in jedem Falle beseitigt werden muß (Tab. 3).

Tab. 3: Nährstoffgehalte in der Pflanzenmasse

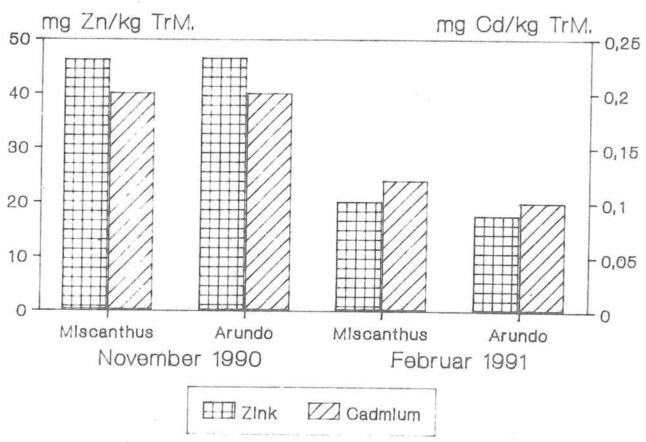
Nährstoff	Miscanthus		Arundo donax	
	Nov.	Febr.	Nov.	Febr.
Gesamt-Asche (%)	2.5	1.7	4.6	4.5
Gesamt-N (%)	0.2	0.1	0.6	0.5
Phosphat (% P_2O_5)	0.12	0.05	0.30	0.20
Kalium (% K_2O)	0.50	0.30	2.00	1.80
Calcium (% CaO)	0.11	0.10	0.09	0.12
Magnesium (% Mg)	0.05	0.03	0.04	0.03

Die Gehalte an Asche und einzelnen Nährstoffen liegen bei Arundo deutlich höher als bei Miscanthus. Das gilt sowohl für den Erntetermin im November wie auch im Februar. Der Grund dafür ist wohl in der Hauptsache der Wachstumsrhyttmus der Pflanzen; bei Miscanthus kommt es zu einer gleichmäßigen Abreife im Spätherbst, während bei Arundo zu dieser Zeit auch noch sehr junge Pflanzen vorhanden sind.

Besonders auffallend ist der Rückgang des Aschegehaltes zum Erntetermin Februar. Unter dem Einfuß der Witterung sind bis dahin alle feinen Pflanzenteile abgefallen, die einen relativ hohen Gehalt an Nährstoffen aufweisen. Damit ist zwar ein Verlust von Biomasse von etwa 20 % verbunden, die Verbrennungseigenschaften verbessern sich aber erheblich. Zudem bewirken die abgefallenen Pflanzenteile eine starke Unterdrückung des Unkrautes und sind gleichzeitig eine Zufuhr von Pflanzennährstoffen. Es ist zu erwarten, daß bei länger stehenden Kulturen dadurch die Mineraldüngung erheblich reduziert werden kann.

Auch bei den Schwermetallen weisen die Pflanzen im Februar weitaus geringere Gehalte auf als im Spätherbst (Abb. 2).

Abb. 2: Zink- und Cadmiumgehalte von Miscanthus und Arundo



3.4 Ökologische Aspekte

Neue Kulturen können eine verstärkte Förderung bei ihrem Anbau nur erwarten, wenn sie keine nenneswerten ökologischen Nachteile aufweisen. Obwohl Schilfpflanzen schon längere Zeit in Europa eingeführt sind, liegen darüber nur wenig Erfahrungen vor. Trotzdem zeichnen sich bereits jetzt deutliche Vorteile ab.

Untersuchungen über den Nitratrest zu Vegetationsende ergaben Mengen von weniger als 10 kg N/ha; ein Wert, den nur wenige Kulturen erreichen. Es ist daher von einer denkbar geringen Gefahr der Nitratauswaschung auszugehen.

Die Pflanzen bleiben im Herbst sehr lange grün und wechseln dann in eine gelbe bzw. goldgelbe Farbe. Das bedeutet für das Landschaftsbild eine willkommene Abwechslung. Allerdings sollte der Anteil der Schilfpflanzen in der Flur etwa 5-10 % nicht übersteigen, sonst könnte der Eindruck einer Schilfwüste entstehen.

Das dichte Wurzelwerk der Pflanzen bietet zusammen mit den abfallenden Blättern einen hervorragenden Schutz vor Bodenerosion. Überdies bedeutet das eine starke Unterdrückung von Unkraut mit der Folge, daß Herbizide nur aus Sicherheitsgründen im Anpflanzjahr eingesetzt werden müssen.

Schädlinge oder Krankheiten sind bislang nicht bekannt und aufgrund der sehr dicken Kutikula der Pflanzen auch nicht sehr wahrscheinlich. Fungizide oder Insektizide sind nicht notwendig.

4. DISKUSSION

Ein hoher Ertrag an Biomasse je Flächeneinheit ist sicher ein sehr wichtigstes Ziel beim Anbau der Schilfpflanzen zu Verbrennungzwecken. Einzelne Varianten brachten bereits im 2. Jahr etwa 30 t/ha. Die in Wirtschaftlichkeitsberechnungen unterstellte Menge von 40 t/ha scheint zumindest auf günstigen Standorten nicht unrealistisch. Besonderes Kriterium für weitere Ertragsteigerungen ist der Wasserverbrauch. Zwar ist der Transpirationskoeffizient sehr niedrig, für 40 t Biomasse/ha sind aber trotzdem etwa 1000 l Wasser/m^2 notwendig /4/.

Diese Menge an Wasser dürfte aber in Europa nur in jenen Gebieten zur Verfügung stehen, bei denen die Temperatur sehr niedrig und somit ertragsbegrenzend ist. Im Anbau wird man sich entweder für eine geringe Produktion oder für eine ausreichende Beregnung entscheiden müssen. Dabei werden sicherlich die politschen Urteile über die Bedeutung des Treibhauseffektes und die dadurch ausgedrückte Höhe der CO_2-Abgabe entscheidend sein. Für die Pflanzenbauer ist es in unzweifelhaft eine wichtige Aufgabe, Erfahrungen über den Anbau zu sammeln.

5. LITERATUR

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

Calculation of fructose properties

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Paper deals about calculation of physical properties of fructose solutions. The equations for calculation the following properties are described : solubility in water, density and viscosity. Formulas for calculation for refractive index, concentration, specific heat and heat conductivity were taken from literature. These and the other chosen properties for fructose solutions are possible calculate and tabulate by means of program for tabulation.

fructose solution; calculation; solubility; viscosity; density

Introduction

The modelling of complex processes in chemical engineering such as the technology of fructose production, requires the knowledge of physico-chemical properties of intermediate products and their dependence on basic technological parameters. The calculations of these properties are based on physico-chemical constants and coefficients from empirical equations which differ to the calculation and can be obtained relatively accurately from literature, tables and graphs. It would be unsuitable to search for these data anew for each simulation calculation; the data are therefore collected in a data bank and can thus repeatedly withdrawn and used.

General information

The conventional systems of tables or nomograms are unsuitable for modern data processing. Analysis of the existing materials in the field of fructose solutions shows that the physico-chemical data on fructose solutions are not well known. It is thus necessary to systematically gather and complement data, especially in data-poor fields, transforms tabulated values into functional formulas, revise tabulated values from the literature, simplify and improve the accuracy of the current computation formulas, etc.

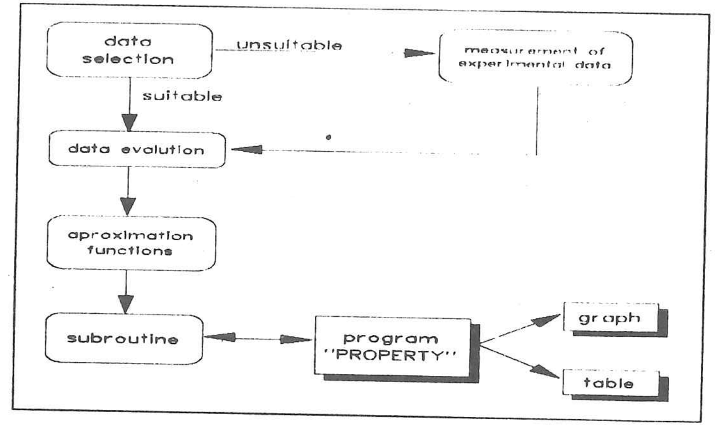
The processing of data characterizing properties of substances can proceed generally along the lines of Fig. 1. The data are selected from the literature; the selection

should be critical as to the accuracy and reliability of the data, the measuring technique and machinery used, the source of measured samples, etc. This selection and analysis of data will determine which data and in what intervals of dependent variables can be safely used and which have to be experimentally determined.

Data evaluation includes then the processing of both literature and measured data, which should delineates their mutual relations and applicability for further work.

Results of data evaluation are approximation functions, which represent concrete property of fructose solutions. These functions are used for building of subroutines to program "Property". The ensuing approximation functions, which are usually valid in limited intervals of independent variables, are transformed into subroutines which then cover whole concentration and temperature interval. Output from this program are the graphs or tables of concrete fructose solutions properties.

Fig. 1 Scheme of data processing approach



Subroutines for calculation of properties of fructose solutions

Formulas for calculation were derived gradually and subroutines were processed for these properties of fructose solutions.

Solubility of fructose in water

The subroutine supersedes a table of fructose solubility in water [1] and our experimental data. It is one of the basic subroutines used in all technological calculations. The solubility of fructose in water is possible to compute from equation (1) :

$$c = 70{,}14 + 0{,}365.t - 8{,}9.10^{-4}.t^2 \qquad (1)$$

Density of fructose solutions

The subroutine replaces a table of densities of fructose solutions [1,2] and is based on our empirical data [3]. It can be used in all industrial and balance calculations requiring the conversion of a volume of sugar solutions to weight. The calculation is based on the following equation (2).

$$\rho = a_{11} + a_{11}.c + a_{13}.c^2 + (a_{21} + a_{22}.c + a_{23}.c^2).t + (a_{3i} + a_{32}.c + a_{33}.c^2).t^2 + (a_{41} + a_{42}.c + a_{43}.c^2).t^3 \qquad (2)$$

Constans of the functions (2) for densities of fructose solutions are given in Table I.

Table I.

Costants of the functions (2) for densities of fructose solutions

i	Constants a_{ij} from equation (2) for j:		
	1	2	3
1	999,99	4,1824	$1{,}0093 \cdot 10^{-2}$
2	$3{,}22 \cdot 10^{-2}$	$-1{,}215 \cdot 10^{-2}$	$-1{,}482 \cdot 10^{-5}$
3	$-6{,}634 \cdot 10^{-3}$	$-2{,}8527 \cdot 10^{-2}$	$2{,}1892 \cdot 10^{-6}$
4	2,387	$3{,}5593 \cdot 10^{-2}$	$-3{,}1252 \cdot 10^{-8}$

Viscosity

Application in technological and simulation calculation concerning centrifugation, crystallization, filtration and other operation whose course is significantly affected by viscosity. Foundation for this subroutine are data from literature [4,5] and mainly our experimental data. Calculation is done according to equation (3) with constants given in Table 2.

$$\ln \eta = a_{11} + a_{12}.c + a_{13}.c^2 + (a_{21} + a_{22}.c + a_{23}.c^2).t + (a_{31} + a_{32}.c + a_{33}.c^2).t^2 . \qquad (3)$$

Refractive index

Determination of an approximation to the so-called dry substance content which is the sum of all solid substances dissolved. All data for building this subroutine are from literature, for example [6].

Table II.

Constants of the equation (3) for viscosity of fructose solutions

i	Constants a_{ij} from equation (3) for j:		
	1	2	3
1	48,7777	-1,479238	0,012506
2	0,015747	$2{,}740477.10^{-3}$	$-5{,}865697.10^{-5}$
3	$-4{,}771013.10^{-3}$	$1{,}058957.10^{-4}$	$-4{,}736484.10^{-7}$

Concentration

Very important subroutine facilitating calculate the concentration of fructose solution from refractive index [6].

Specific heat, heat conductivity

Specific heat and heat conductivity values are necessary for calculations of all heat balances [7,8].

Program for tabulation of physical properties of fructose solutions

The tabulation program makes use subroutines listed above to calculate and tabulate individual properties of fructose solutions. The program performs the tabulation of the following properties of fructose solutions :

- concentration fructose in fructose solutions
- solubility of fructose in water
- refractive index
- viscosity
- density
- specific heat
- conductivity

Graphic possibilities of this program are very limited, but it is possible transform tables from this program to some other graphical program and make graphs there.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

MECHANICAL DAMAGE OF GRAIN IN CONVENTIONAL CLEANING-UP PROCESSES

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The paper presents the results of studies which aimed at checking the possibilities of separating grains with mechanical damages. Grains of rye, wheat and triticale cleaned on 17 typical technological lines were examined. The separating efficiency of the current methods proved to be rather poor.

mechanical damage of grain, cleaning-up of grain, separate characteristic

1. INTRODUCTION

The current separation lines are composed of many machines and devices whose regulation parameters make it possible to obtain the required moisture and cleanness of the finished product (Fig.1). The notion of "cleanness of the material" is understood as the quality grain (above the minimum dimension specified for each species and variety) without any impurities. Studies (1,2,3) prove that mechanical grain damages decrease the field germination and make the storage of grain more difficult; however, these findings have been disregarded in the regulation processes and it is only the quantity of halved and crumbled grains that is measured.

2. AIM AND METHODS

Practice has lead to establishing conventional cleaning-up methods which make use of geometric and aerodynamic properties as the separate characteristics.

The paper aims at checking it is possible to separate mechanically damaged grains by means of the current methods.

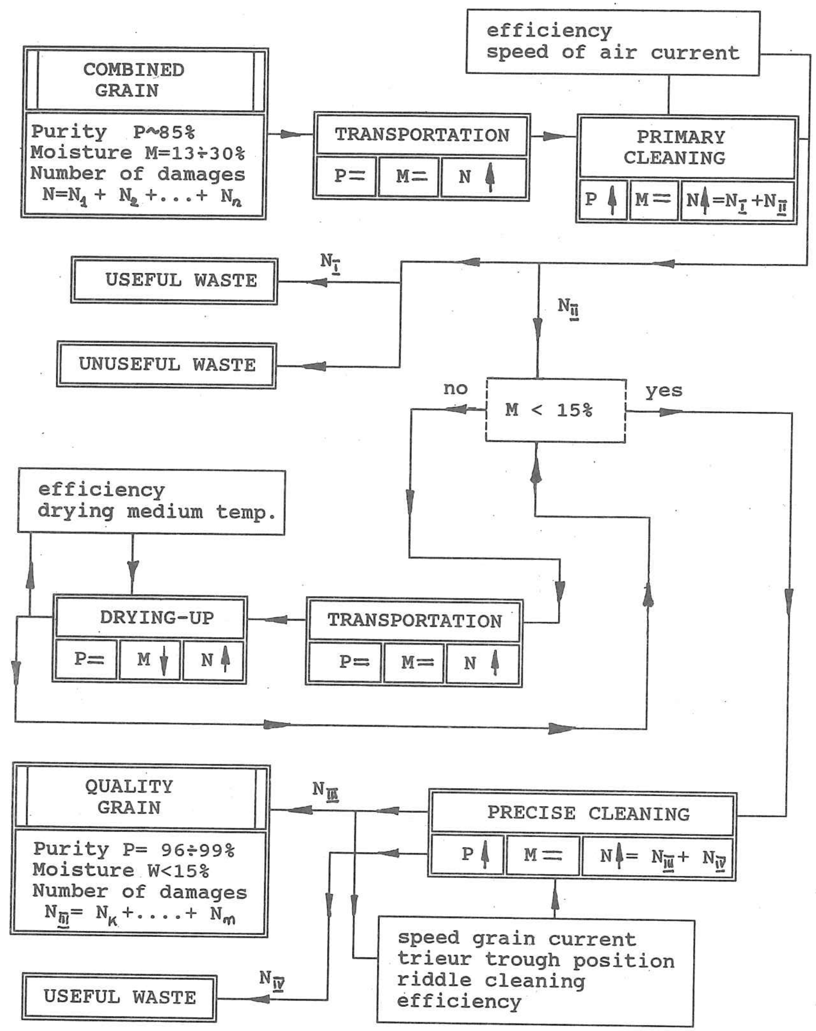

Fig.1. Change of select parameter in cleaning processes.

The kinds of damaged grains which can be separated by means of a pneumatic tunnel, sieve and trieur (which are the basic separators in winnowing machine and precise cleaner) were determined. An analysis of the operation of these separators, distribution of the forces which influence grain as well as of the geometric and aerodynamic properties which are the result of the grain damage, allowed us to distinguish three damage types: attritions, halves, bereavement of material by 1/4. It is only grains with these damage types that can be separated on the cleaning-up lines.However, there is a group of grains with microdamages which - as the analysis showed - are not very likely to be separated by means of the present methods.

The studies were carried out in the years 1986-1989 on 17 cleaning and separating lines, and focused on two stages of the technological line: "primary cleaning" made on the Petkus K-523 and K-525 winnowing machines and "precise cleaning" on Petkus K-531, K-541, and K-545 which was connected to the Petkus K-231 trieur. Samples of rye, wheat and triticale were taken at the input and output of each machine and then, after a laboratory sample of about 4x500 grains had been selected, grains with mechanical damages were separated and grouped.

The degree of separation of mechanically damaged grains was determined by means of the cleaning-up efficiency coefficient calculated as follows:

$$W = \frac{U_1 - U_2}{U_1}$$

where U_1 and U_2 - number of grains with mechanical damages of a given type in the input and output respectively.

3. RESULTS

The mean results of the cleaning-up efficiency coefficient for particular types of damages are presented in table 1. Both in primary and precise cleaning only a part of the damaged grains was separated. The cleaning-up efficiency coefficient in the case of the bereavement of material, was between 0.24 and 1,00, according to the grain type. Thus only the percentage of grains even with macrodamages was only 24%, whereas the percentages of attritions and microdamages did not decrease as expected, but grew and was 29% (wheat - precise cleaning) up to 52% (rye - primary cleaning). We can see that not only do the cleaning and separating machines fail to meet the requirements (as for the separation of damaged grain) but increase the total number of damages by active influence of the working parts on the grains. The destructive effects of the contact between the grain working elements are further magnified by the fact that some grains are damaged earlier by the working parts of a combine harvester. Moreover, there may occur a "fatigue" of the material which is due to the multiple loads to which the grain in exposed in the course of harvesting, drying-up and transportation.

Tab.1. Mean values of cleaning-up efficiency coefficient for damage

Kind of operation	Species of cleaning grain	Type of damage			
		Attri-tions	Halves	Losses of 1/4 mass	Micro-dama-ges
Primary cleaning	rye	-0.31	+0.50	+0.83	-0.52
	wheat	0.00	+0.48	+0.37	-0.43
	triticale	-0.26	+0.29	+0.24	-0.50
Precise cleaning	rye	-0.24	+0.51	+0.53	-0.48
	wheat	-0.42	+0.64	+0.63	-0.29
	triticale	-0.08	+0.93	+0.33	-0.45

The studies also show that an optimization of the regulation parameters as for the number of mechanically damaged grains brings about a considerable increase in the bereavement of the material, which makes the separation process uneconomical (Fig.2)

To sum up, we can say that the conventional separation machines do not allow the separation of damaged grains. It is therefore necessary to try and determine the properties of the stream of mass containing the quality and damaged grain as well as the impurities. First the surface grain properties should be examined (friction coefficient, texture...), its electromagnetic properties and elasticity.

4. CONCLUSION

1. The current cleaning methods do not allow an effective separation of mechanically damaged grains.
2. It is only the number of grains with the bereavement of material that drops in the cleaning-up process.
3. The number of attritions and microdamages of various grain types increases in the cleaning-up processes by 29÷52%.

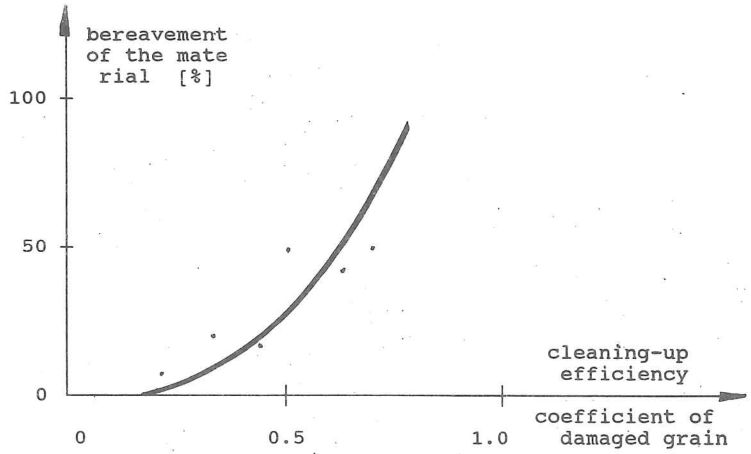

Fig.2. Bereavement of material depending on efficiency coefficient of damaged grain (wheat, macrodamages).

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

THE INFLUENCE OF THE GRAIN LOADING CONDITIONS ON ITS BIOLOGICAL VALUE

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The research of grain done so far that the grain damages which occur in different conditions, could be grouped according to their external features. This paper aims at defining the influence of the kind and multiplicity of the load on the biological quality of damaged grain. A pot experiment for grains damaged by static and dynamic loads also for grains damaged during a combine harvesting was carried out. The results of the pot experiment show a statistically significant influence of the damage conditions on biological quality of grain.

mechanical damage of grain, kind of damage, biological quality of damaged grain

1. INTRODUCTION

The current harvesting and cleaning-up technologies cause considerable grain damages. Numerous studies show a negative influence of the mechanical damage of the grain on its biological quality. This damage decreases its germinal capacity, weakens resistance to stress condition, causes low germination and small crops /1,3/.

The latest papers on biological effect of grain damage indicate the influence of the damage location in the grain, its kind and size on the germination and plant growth /2,3/. On this basis it was possible to ascribe to various damages a certain "potential harmfulness index" understood as the expected percentage of the decrease in germination of grains with a particular kind of damage. Thus the damages could be put into a sequence according to their negative influence on the grain /2/. All the experiments were made in order to evaluate the biological quality of the damaged grain. It should be noted that in most of the papers referred to, the authors simulated grain damages. However, in real harvesting conditions the damaging processes are much more complex: grains are hit, pressed and rubbed repeatedly and with forces of various strengths and directions until the damage tensions are exceeded. The authors /3/ pointed to such a summing of tensions by making an experiment where a repeated loading of grains with small forces showed a significant decrease in the germination capacity, even though there were no external symptoms of damage. The kind of load, i.e. its value, direction and multiplicity are expected to affect the biological quality of the damaged grains.

2. AIM AND SCOPE OF THE STUDIES

In the presented papers the damages could be sometimes grouped according to their external features, although the conditions in which they occurred differed considerably.
That is why this paper aims at determining the influence of the damage conditions on the biological quality of the grain. The studies comprise an experimental verification of the hypothesis which says the biological quality of the damaged grain is affected not only by the kind and size of the damage but also by the conditions in which it occurs.

3. METHODS

The pot experiment compared the biological qualities of grains with certain types of damage caused by various load types. The grains were loaded statically and dynamically, and grain samples were also taken during a combine harvest. After the damages had been determined, they were classified as follows (table 1):
- macrodamages (losses, cracks, crushes)
- microdamages (in the germ and cover)

The germination capacity of the damaged grains was determined according to the rules, in three repeated measurements.
To determine the germinations and make biometrical measurements of the seedlings, each set was sown four times, in pots filed with soil (4x100). After a month the plants were rinsed and the following values were determined:
- height of the seedlings
- root length
- number of germinal roots

4. RESULTS

The mean values of the parameters are presented in table 1. The mean values were statistically compared by the t-Student test. We can see that the growth parameters of grain samples with

the same damage type differ considerably and depend on the damage conditions. It is only the grains with the "crush" type of damage which was the result of pressing in the laboratory conditions and during the combine harvesting that do not show any vegetation difference.

Tab. 1. The comparison of average values of germination and biometrical parameters of seedlings which has grown from damaged grain depend of damaging conditions.

Kind of damage	Parameter	Statical load	Dynamical load	Combined grain
Longitudinal defects	germination	-	89.3	88.1
	emergence	-	74.2	73.5
	plant height	-	76.0	84.6
	root length	-	120.0	129.0
	root number	-	3.1	2.9
Transversal defects	germination	-	87.9	83.4
	emergence	-	75.5	70.2
	plant height	-	51.0	50.0
	root length	-	85.0	80.0
	root number	-	2.3	2.5
Crushes	germination	71.0	-	72.0
	emergence	60.2	-	63.5
	plant height	53.1	-	54.2
	root length	70.6	-	79.3
	root number	2.7	-	2.8
Transversal crack	germination	88.9	-	87.5
	emergence	83.5	-	79.2
	plant height	92.2	-	52.0
	root length	128.7	-	109.6
	root number	3.2	-	2.9
Longitudinal cracks	germination	82.7	76.3	70.7
	emergence	71.5	63.0	60.0
	plant height	88.0	86.0	86.1
	root length	129.3	128.0	128.3
	root number	2.3	2.9	2.9
Micro-damage of germ	germination	-	73.2	68.5
	emergence	-	51.0	46.2
	plant height	-	100.1	103.0
	root length	-	138.9	122.5
	root number	-	3.1	3.0
Micro-damage of cover	germination	98.1	97.7	96.7
	emergence	91.1	85.3	88.7
	plant height	99.1	103.3	56.0
	root length	156.3	145.6	94.0
	root number	3.6	3.6	3.2

Notice: the significant differences were underlined.

The other three damage types can be put into three main groups:

1. Grain damages whose growth parameters do not depend on the type of simulated load (microdamages of the cover) - difference were found for the grain harvested with a combine harvester.
2. Damages of the seedlings whose growth is similar when loaded dynamically and in the combine (transverse defects, longitudinal cracks).
3. Damages of grains whose biological quality differ considerably when loaded in the laboratory conditions and in the combine harvester (longitudinal defects, transverse cracks, microdamages of the germ).

Although the results presented here are of probing type, we can make certain observations. A significant influence of the load conditions on the growth and development of the grain was noted in most of the studied damage types. Thus the hypothesis assumed in the experiment was verified. However, the existing difference can suggest the summing of the load effects, which indicates a phenomenon analogous to the "fatigue of material".

4. CONCLUSIONS

1. The influence of the damage conditions on the biological quality of the grain was noted.
2. The dynamic grain load caused a similar decrease in the biological quality for most damage types. We can therefore state that this load type in the laboratory conditions is a more reliable method of evaluating the damage resistance of grains.
3. When evaluating the damage resistance of grain by means of the laboratory methods, both the value and type of load and its multiplicity should be taken into account.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

RESISTANCE OF BEANS TO MECHANICAL DAMAGE UNDER VARIOUS LOADS

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The paper presents the results of tests on the effect of moisture content in beans on their resistance to mechanical damage in various conditions of static and dynamic loading. The optimum range of moisture content in bean seeds differed, depending on variety characteristics and on loading conditions. Under static conditions the values of optimum moisture content were lower than those under dynamic loading. This is an information of significance for the determining the optimum bean threshing period.

beans, moisture content, mechanical damage, static and dynamic loading

INTRODUCTION

Beans belong to easily threshable plants exhibiting high sensitivity to mechanical damage. Their low resistance to damage results from specific anatomic and morphologic characteristis of beans (1, 3, 5, 6). A significant factor influencing the level of sustained damage is also their moisture content. Knowledge of the optimum moisture-content range within which the beans exhibit their highest resistance to damage enables a significant reduction of losses at threshing (2, 4, 5).
For this reason the tests, aiming at determining the optimum moisture content when beans have the highest resistance to damage under both static and dynamic loading, were initiated.

TESTING METHODS

The testing of resistance of beans (seeds) to mechanical damage consisted in creating artificially a certain load and estimating damage caused, as a main effect. Measurements were carried out in both static and dynamic conditions. In static measurements individual beans were subjected to compressive loads and, on the basis of recorded curves of applied forces, the value of force at which the bean cracked was determined.

In the conditions of dynamic loading the beans were hit by a turning steel bumper having a specific circumferencial speed. The loads were directed along the bean length. The resistance to damage was determind by the number of damaged beans in the

tested sample expressed in percentage. The evaluation of damage was carried out in both qualitative and quantitative respects. The cases of damage were subdivided into two groups of macro- and microdamage. All damage visible with naked eye, without any magnifications - bean halves, cracks in the seedcoat, missing parts or rubbings are considered macrodamage. Injuries which appeared only after 24-hour soaking of beans in water were considered microdamage.
Measurements were conducted on samples of 100 beans four times. This sample size was determined statistically on the basis of initial measurements at confidence level P = 0.99.

Two varieties of beans, Atut and Igołomska, commonly grown in this country, were subjected to testing. These two varieties differed substantially in the bean (seed) size, which became a decisive factor in the choice. The weight of 1,000 beans of Atut variety was 191 gram while that of Igołomska variety was 395 gram.

TEST RESULTS

The results for static loading of beans versus their moisture content are presented in Figure 1 while those for dynamic loading - in Figures 2 and 3.

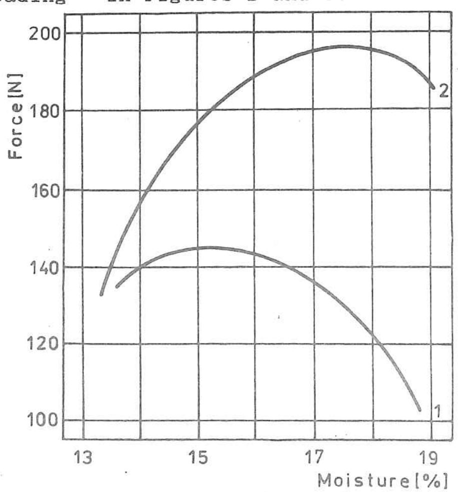

Fig.1. Force causing bean seed cracking versus their moisture content under static loading.
1 - Atut variety, 2 - Igołomska variety.

Under static loading the Igołomska variety beans showed higher resistance to cracking than those of Atut variety. The reverse situation in the resistance to damage exists under dynamic loading, i.e. beans of Atut variety exhibited higher resistance to dynamic loading than those of the other one.
Under static loading the relations between the value of force causing cracking of seeds and their moisture content took a form of a quadratic function of the formula:

$$F = aW^2 + bW + c \qquad (1)$$

where: F - value of force (N) causing the cracking
W - moisture content (%)
a, b, c, - coefficients

Under static loading the optimum ranges of moisture content for individual varieties differed and were: 14.5 - 16.0 % for Atut variety and 17.0 - 18.0 % for Igołomska variety. The values of maximum forces causing cracking of beans of those two varieties also differed and were: 148 N for Atut and 197 N for Igołomska.

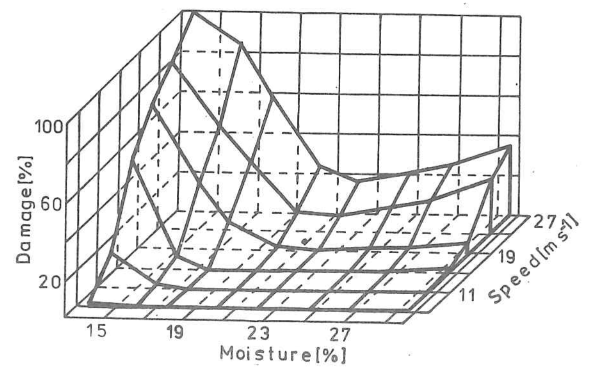

Fig.2. Relation between mehanical damage in Atut beans and their moisture content at various hitting speeds.

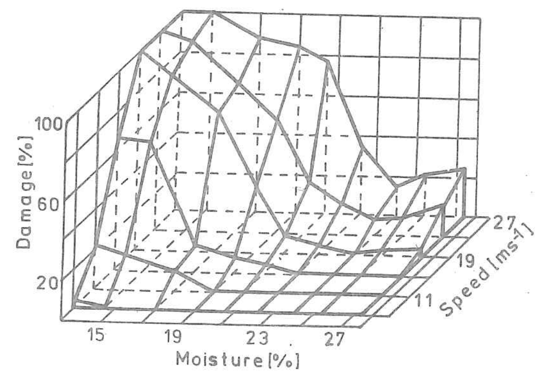

Fig. 3. Relation between mechanical damage in Igołomska beans and their moisture content at various hitting speeds.

Table No.1

Values of coefficients in Equation 1 describing the relation between bean cracking force and the moisture content in beans under static loading.

Variety	a	b	c	Correlation coefficient
Atut	-762.61	+118.49	-3.86	0.750
Igołomska	-908.41	+126.71	-3.62	0.848

In the conditions of dynamic loading the optimum ranges of moisture content were higher than those under static loading and reached approximate values of: 22.0 % for Atut variety and 24.0 % for Igołomska variety (ref to Fig. 2 and 3). The structure of damage in beans varied depending on their moisture content. At lower levels of moisture content the halves were a dominating form of damage while at higher moisture contents the cracking of seedcoat became more common. Such proportions were even more prominent at higher speeds of hitting, i.e. 15-27 ms^{-1}. At lower hitting speeds (7-11 ms^{-1}) the damage was mostly in the form of seedcoat cracking. Micro-damage took place in the forms of cracks of bean seedcoat and cotyledons.

CONCLUSIONS

1. Optimum ranges of moisture content, within which the beans (seeds) exhibited maximum esistance to mechanical damage, varied depending on the bean variety characteristics and on load type.
2. Under static loading the large bean variety exhibited higher resistance to damage than the small bean variety. Under dynamic loading on the other hand the small bean variety proved to be more resistant to damage than the large bean variety.
3. The optimum moisture-content ranges for beans under static load were lower (14.0-16.0 % for Atut and 17.0-18.0 % for Igołomska) than those found under dynamic loading (about 22.0 % for Atut and about 24.0 % for Igołomska).
4. While determining the optimum time for bean threshing the results of bean damage resistance obtained under dynamic loading should be taken into account.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

THE IMPROVEMENT OF DEVICES FOR AGRICULTURAL CROP IRRIGATION

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SUMMARY

Classification of the irrigation devices has been suggested according to new designs, especially those with flexible pipes on transportation reels , using mini- diffusers or mini-sprinklers.
There are two figures and two tables incorporated in this paper.

Key words: irrigation devices,classification,sprinkler.

1. INTRODUCTION

Irrigation by water atomization into mist or fine drops is very developed nowadays.It is used not only in bedewing of vegetables but for spraying of tall agricultural crops , in orchards and for watering of many other plants.Irrigation by spraying or raining is in fact a technical irrigation with constant water supply to the plants in the form of artificial rain.Pressurized water strikes against the fixed surface or bumper(side)of the sprinkler or nozzle and in such a way it is atomized into fine drops.

Fixed nozzle,produces a fine drop mist which is rather convenient for low crops of narrow spacing or for foliage plants for both leaf spraying and under -leaf watering. Mini-diffuser or mini-sprinkler operate as nozzles.

For swiveling nozzles which operate on the water kinetic energy,rotary sprinklers, mini sprinklers and other similar designs are being used.

Nowadays we differentiate between several systems or devices for irrigation by spraying which could be divided into following groups:

a) devices with mobile spray booms and their alternatives;
b) systems with flexible pipes installed in the plot;
c) devices with flexible pipes on transportation pipe reel ;
d) devices with pivot structure and sprinklers;
e) devices with frontal structure and sprinklers;
f) devices with micro-sprinklers.

This paper will deal in part only because of limited space with the devices incorporating the appropriate technical solutions and improvements.

2. DEVICES WITH MOBILE SPRAY BOOMS AND THEIR ALTERNATIVES

This is the old-time system and all other systems of irrigation by raining are based upon it.One or more spray booms are placed in each plot with the sprinklers made of light alloy or PVC material.The spray booms are manually transported and installed in the direction marked by arrows.(Fig.1).

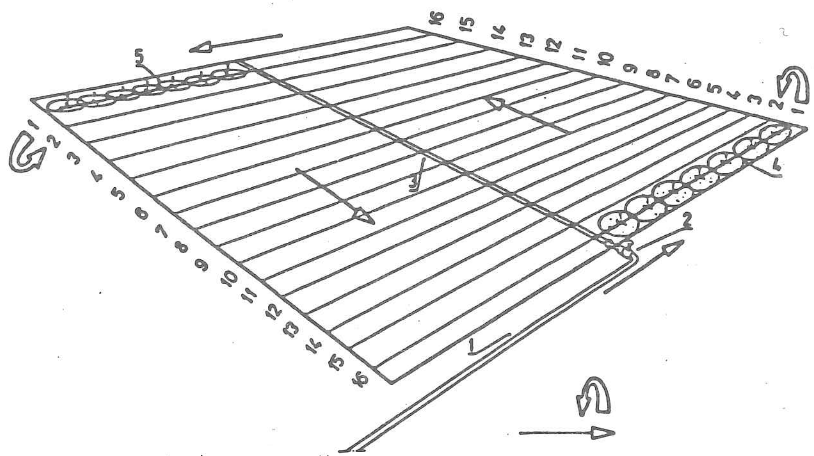

Fig 1. Devices for irrigation by spraying with mobile spray booms:
1-master pipeline ; 2 and 3 - secondary pipeline; 4 and 5-spray booms with sprinklers.

Water pressure is 3-4 b. Each plot is watered separately(partially). Water flow and water pressure are controlled by valves.Pipes of secondary pipeline are 12,18,24 or more meter long.The pipes may consist of the pipes which are 6 or m long, and pipe branches could be installed between them if required.It is possible to make various combinations of pipe lengths to match the size of the plot. Sprinkler spacing is as follows:

-for low crops: 6.6; 6.12; and 12.12 m;
-for tall crops:12.18; 18.18; 18.24; and 24.24 m

3. SYSTEMS WITH FLEXIBLE PIPES INSTALLED ACROSS THE PLOT

The predetermined plot is covered with flexible pipe network(fig.2) of small dia. (max. 32 mm) pipes and with pipe extensions located in correct places.Pipe extensions are made of stainless steel or galvanized steel.

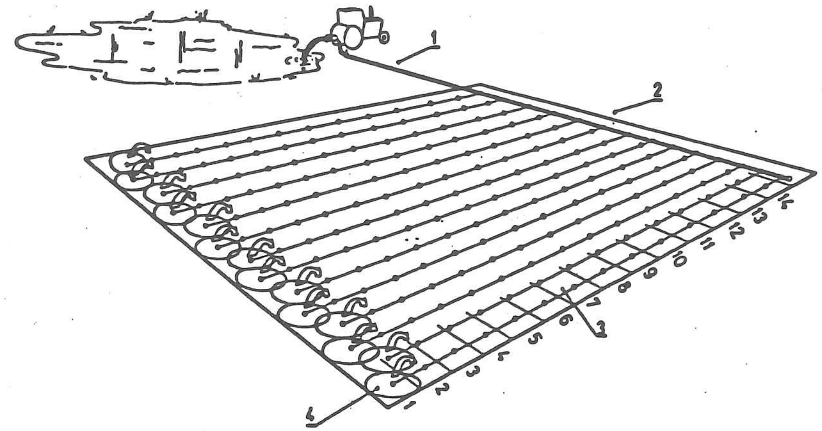

Fig.2 General view of the system for irrigation by spraying with flexible pipes.
1 and 2 - master and secondary pipeline with tractor pump set;
3-flexible pipes for water pressure of 6 b.;
4-sprinklers.

There are openings for sprinkler support mounting on the pipe extensions. On every spray boom (3) placed at the distance of 18 or 24 m ,there is an automatically operated valve.The valve is made of light alloy with double conical seat for better sealing.By means of similar automatically operated valves(with ball) the sprinklers are mounted onto the spray booms as indicated by arrows. For the pipe roll in and roll out some of which are even 60 m long,special tractor unit is designed which is attached to the lifting levers.The above described device is an improved model with spray booms and is intended for tall crop(maize) irrigation.

4. BRIEFLY ABOUT OTHER DEVICES FOR IRRIGATION BY RAINING

With stationary spray boom system,the booms remain in the plot during the whole watering season.No human labour is required for pipes removal,but more sprinklers on supports are required (17-70 sprinkler/ha),depending upon the length of the device.Sprinkler spacing is 6 m,12m,18m or 24m.The plot is gradually irrigated regardless of the irrigation starting point.The pipeline is under pressure of 3-4 b, when corresponding valves are opened.Flexible pipe dia. is 50 mm.

The devices with flexible (PVC) pipes on reel are designed for high outputs.They consist of mobile chassis,flexible pipes on reel,hydraulic motor (or turbine) and sliding piece with sprinkler or gun.Sprinkler pressure is 4-5 b,while pressure required for reel rotation is 5-10 b.Energy consumption costs are higher than the costs of the aforementioned devices. The range of the sprinkler-spray gun exceeds 45 m, and such devices are the right choice for solid and tough plants.Instantaneous pump stopping(by under-pressure or over-pressure) is achieved by the safety relief valve provided the water remains constantly in the pipes of the device.To keep uniformity of spraying , i.e. to assure the uniform sprinkler movement,there is a guidance attachment installed in the reel which acts on the valve for the flow of water to the turbine.

Table 1. contains data of the irrigation reel sets manufactured by famous European manufacturers,while table 2. contains basic parameters of the same devices in relation to the pressure and dia.of the nozzle.

TAB 1. BASIC DATA OF DEVICES WITH FLEXIBLE PIPES AND REEL[1)]

Pipe dia.: 50 - 63 - 70 - 75 - 82 - 90 - 100 - 110 and 125 mm ;
Pipe length: 230 - 400 m;
Distance between two pipe positions: 40 - 90 m;
Water flow: 10 - 80 m3/h ;
Water inlet pressure : 5 - 10 b;
Area sprayed in a single run: 1,3 - 3,5 ha[2)]

1 - after M.Nicouland ;
2 - max. spraying output is 1200 m3/ha,during a month of operation (each day: 20/24 h) the coverage is 5,5 - 17 ha.

TAB 2. SPRINKLER-SPRAY GUN OUTPUT AND ITS RANGE DEPENDANT UPON WATER PRESSURE AND NOZZLE DIA. (J.Dubalen)

Water pressure(b)	4,5		5		5,5		6		6,5	
	Water flow Q(m3/h) and range d (m)									
Ø nozzle (mm)	Q	d	Q	d	Q	d	Q	d	Q	d
24	43	46	45	48,5	47	50	49	51	-	-
22	36	45	38	46	40	48	42,5	50	44	52
20	29	43,5	30,5	45	31,5	47	33	49	34,5	51
18	22,5	41,5	24	43	26	44	27,5	45,5	28,5	46,5
17	19	39,5	20	41,5	21	43,5	22	45	23	45,5
16	-	37,5	17	40,5	18	42	19	43,5	20	44,5

There are three parameters ruling the selection of the type of the irrigation device with reel.They are the following:
- according to the graph of monthly water requirements(80-120 m);
- according to the rate of irrigation elaborated according to monthly plan
- according to the suitable distance in operation in an average plot.

The devices with pivot and frontal structure are used to cover huge land complex (exceeding 100 ha).

Devices with micro-sprinklers consist of the polyethylene pipes installed

on field surface ,to which micro-sprinklers with fixed nozzles (statojet) or rotary nozzles (circojet) are attached.There are various designs of micro-sprinklers.Installation of a micro-sprinkler requires a lot of labour which is a disadvantage of this device.Besides the above, such devices help weed growing.However, the devices with micro-sprinklers are rather simple and easy for access but very sensitive to impact,especially the rotary type impact.When used in watering of young fruit-trees,these sprinklers assist development of the root system.

Very convenient are the section sprinklers with deflector with which you can achieve the spraying angle of 240° or 300° .

The most frequently used irrigation nowadays is mist blowing.Among seven groups of raining devices, the devices with flexible pipes on reel are the prevailing devices,although the design of the device with flexible pipes in the plot is more simple and the devices with micro-sprinklers. This is the advantage of these two groups of devices over very expensive reel irrigators.It is anticipated that use of such devices will grow in future.

5. CONCLUSION

The improvements are first made in the devices for irrigation by spraying.New solutions have been adopted to avoid constant moving of the spray booms.Even more frequent in use are automatic devices and human labour is thus reduced considerably.The pipes are made of light and cheaper material.The devices with flexible pipes (with or without the reel) and the devices with micro-sprinklers are more and more in use today.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

VARIABILITY OF RAPESEED MODULUS OF ELASTICITY

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Quasi-static compression test was carried out for rapeseed variety Jet Neuf. The combination of five levels of moisture content (4, 7, 11, 14, 17%) and five levels of temperature (20, 30, 40, 50, 60°C) of seeds was applied for the experiment. Modulus of elasticity of a single seed was calculated according to Hertz theory from the linear part of the compression curve.

rapeseed; moisture content; temperature; modulus of elasticity

1. Introduction

New technologies of food production as well as new handling techniques on the modern farms cause the necessity of further investigation of physical properties of seeds. The changeability of these properties resulted from variety features, moisture content, growing conditions (agrotechnical factors, weather etc.), maturity, temperature and other, can play significant part in designing of new machines.

Some investigators studied the influence of various external factors on physical properties of seeds. Szot and Woźniak /7/ described the influence of differentiated soil conditions on the variability of the mechanical properties of spring wheat grain. The influence of agrotechnical factors on the variability of the basic mechanical properties of cereal grain were checked by Szot /5/ and Styk and Szot /4/. Fiscus et al. /1/ studied physical damage of grain caused by various handling techniques. Kustermann and Kutzbach /3/ presented dependence of corn Young's modulus on deformation velocity.

However only a few investigators check the effect of temperature on strength features of seeds. Herum et al. /2/ studied viscoelastic behavior of soybeans due to temperature and moisture content. Szot and Stępniewski /6/ reported the relation between seed temperature and damaging force, energy and deformation of rapeseed.

The aim of the present study was to calculate modulus of elasticity of rapeseed according to different moisture content and temperature of seeds.

2. Material and method

The investigations were carried out on Jet Neuf variety of rapeseed. Seeds were harvested and thrashed by hand in order to obtain material without initial failure of cover. Five moisture levels: 4, 7, 11, 14 and 17% w.b. were chosen as a representative for the whole handling process, from harvesting to storing. First level of moisture was obtained by drying air dry seeds in a laboratory dryer for two hours at 40°C. Air dry rape had 7% of moisture, and the next levels were gained by rewetting.

The range of temperature was within the limits from 20°C till 60°C (every 10°C). Seeds were heated, short before testing, in air-tight, glass bottle placed in hot water from the thermostat. The same water was used to heat the chamber (Fig. 1) where seeds were compressed, so the temperature of seeds as well as temperature inside the chamber were equal.

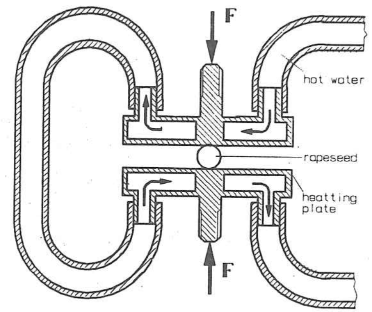

Fig. 1. Compression chamber

The static compression test of single seeds was carried out in a specially constructed thermal chamber fixed into the Instron testing machine. The chamber consisted of two parallel, heating plates and a wall around them. The deformation rate was 10 mm/min, and the compression curve in force-deformation coordinate system was registered by the computer connected with Instron.

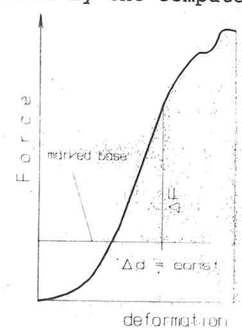

Fig. 2. The schema of interpretation of force-deformation curve

Modulus of elasticity was calculated from the linear part of the curve with a constant increase of deformation Fig. 2, according to the formula:

$$E=\frac{1.061(1-\mu^2)}{\pi}\sqrt{\frac{k^3}{R}}\sqrt{\frac{(\Delta F)^2}{(\Delta d)^3}}$$

where:
μ - Poisson's ratio
k - constant
R - radius of seed curvature [mm]
ΔF - force in the linear part of force-deformation curve [N]
Δd - deformation of the seed [mm]
The constant k was assumed as equal to 1.3514 and Poisson's ratio as 0.4.

3. Results

The results obtained showed both the influence of moisture content and temperature on rapeseed modulus of elasticity. Compression curves registered in force-deformation coordinate system (Fig. 2 and 3) described effects of moisture and temperature on damaging force and displacement of a single seed.

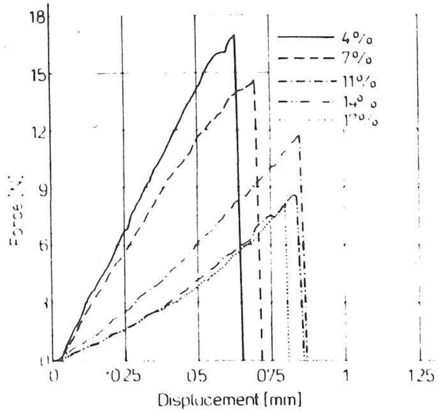

Fig. 3. Effects of moisture on damaging force and deformation of rapeseed at 20°C

With the increase of moisture content, force cause structural damage (cover break) decreased at the constant temperature, while displacement increased at the same time. The higher temperature of seeds the smallest force and displacement caused cover failure. The biggest damaging force occurred at 4% m.c. and 20°C and was in the range from 20.4 till 15.1 N, while deformation in this conditions was about 0.4 mm. The smallest damaging force was at 17% m.c. and 60°C, when this value was within the range from 9.3 till 5.1 N, and the corresponding

deformation was from 0.97 till 0.76 mm.

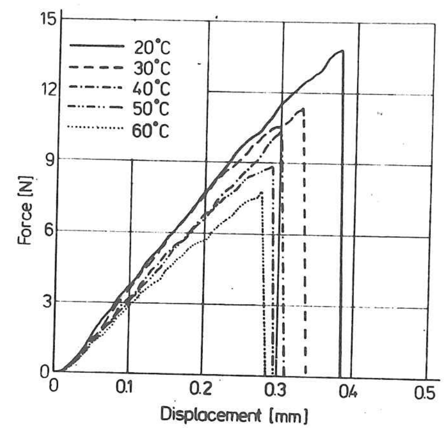

Fig. 4. Effects of temperature on damaging force and deformation of rapeseed at 7% m.c.

The change of the compression curve slop could represent, to some extend, the change of modulus of elasticity.

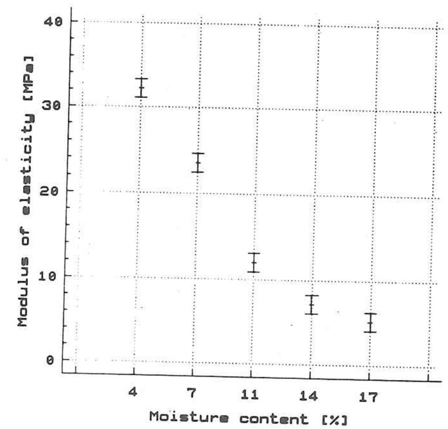

Fig. 5. Dependence of modulus of elasticity of rapeseed upon moisture content (20°C)

Fig. 5 represents changes of the values of modulus of elasticity of rapeseed at constant temperature 20°C and succeeding moisture content 4, 7, 11, 14, 17%. The point in the middle of the line represents mean value of the modulus of elasticity and the line, confidence intervals at level of confidence 0.95. Modulus of elasticity decreased from 32.2 till 5.3 MPa, but the drop was higher between 4 and 11% of moisture and with the further increase of moisture this drop is smaller.

Fig. 6 represents changes of the values of modulus of elasticity of rapeseed at constant moisture content 4% and succeeding temperature 20, 30, 40, 50 and 60°C (symbols like on the previous figure).

With the increase of temperature the value of modulus decrease and that tendency occurred at all moisture content. Only in a few cases modulus was greater between neighboring temperature, what could be caused by inaccuracy of measurement.

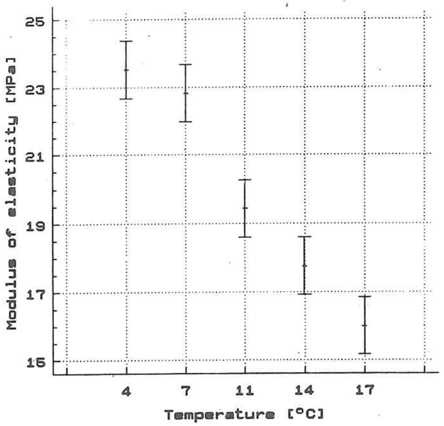

Fig. 6. Dependence of modulus of elasticity of rapeseed upon temperature (7% m.c.)

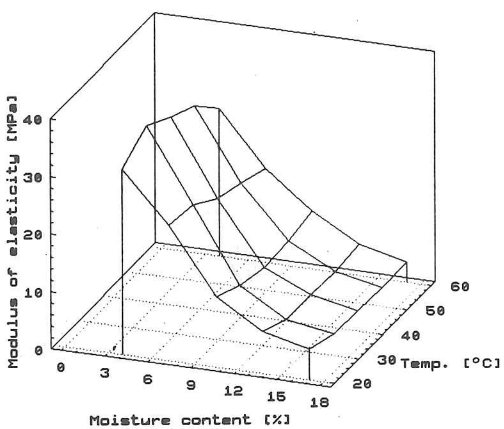

Fig. 7. The influence of moisture content and temperature on the modulus of elasticity of rapeseed

The surface pictured on the Fig. 7 showed changes of modulus of elasticity at the full range of moisture and temperature of seeds.

4. Conclusions

4.1. Both moisture content and temperature influenced modulus of elasticity of rapeseed. The value of modulus decreased with the increase of moisture content and temperature.

4.2. The highest modulus of elasticity was at 4% m.c. and 20°C and the mean value in this conditions was 32.2 MPa. The smallest modulus 3.4 MPa (mean value) was at 17% m.c. and 60°C.

4.3. Higher drop of modulus of elasticity was observed between 4 and 11% m.c. (from 32.2 till 12.2 MPa at 20°C) than between 11 and 17% m.c. (from 12.2 till 5.3 MPa at the same temperature).

4.4. Temperature influenced modulus stronger at low moisture level, where for 4% m.c. modulus decreased from 32.2 MPa at 20°C to 25.7 MPa at 60°C, while for 17% m.c. this decrease was from 5.3 MPa to 3.4 MPa.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

EFFECT OF HUMIDITY ON THE SEED-TO-EAR OR SEED-TO-PANICLE BINDING FORCE AND ENERGY VARIATIONS

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Seed-to-ear or seed-to-panicle binding force and energy examinations were carried out for the seed grasses (orchard grass, fescue grass, rye-grass and awnless brome grass). Direct method of force and energy determination was applied using INSTRON strength testing apparatus equipped with proper instrumentation. The examinations scope ranged over variable plants humidity and field desiccant application. It was found on the basis of the results obtained, that the binding force of a coccidian is variable within individual areas of the ear of the panicle. Coccidian-to-torus binding is univocally reduced by more then 50 % for all grass species in case of seeds humidity drop. Further reduction of the seeds binding is caused by Reglone desiccant application.

seed grasses; binding force and energy; humidity

1. Introduction

The grasses belong to the category of plants shedding their seeds easily. Therefore significant losses of sowable material are recorded irrespective of implemented harvesting method. This fact is resulted from atavistic features of this group of plants as well as from non-uniform seeds ripening. Therefore grass seeds harvesting technology shall be involved in through studying variations of physical properties and features determining the field conditions being closely connected with the level of the losses occured when harvesting /5/. The variability of coccidian-to-ear or coccidian-to-panicle binding force and energy being determined by humidity and field conditions are the most important features considered.

2. Examinations methodlogy

The coccidian-to-ear or coccidian-to-panicle binding force and energy were determined by means of a measurement method designed for grain by Agricultural Physics Institute of Polish Academy of Sciences in Lublin by Physics Department of Agricultural College in Prague /1, 2, 3, 4/.
The examinations were carried out by means of INSTRON MODEL 1253 strength testing apparatus provided with proper gripping provisions to fit grass seeds sizes. The coccidian separation process was executed axially to maintain constant measurement conditions.
Orchard grass (Dactylis), fescue grass (Festuca), rye-grass (Lolium perenne) and brome grass (Bromus) were investigated. Similar examinations in proper repetition number were impractical for timothy grass (Phleum) due to undersized seeds and their specific chaff.
Thirty (30) ears or panicles were taken for every grass species at free fixed dates to consider various humidity levels (35 to 20%). The humidity level was greater for rye-grass only (50 to 35%) due to intensive seeds shedding occured for lower humidity levels of the material under examinations. Similar samples were taken simultaneously from a pilot field on the grass plantation after Reglone desiccant application.
The binding force measurements were performed in three areas of the ear (panicle)- i.e. lower, central and upper area - for orchard grass and brome grass and in the both areas of the rye-grass. Mentioned division into areas was accomplished after preliminary - methodical examinations (Fig. 1).

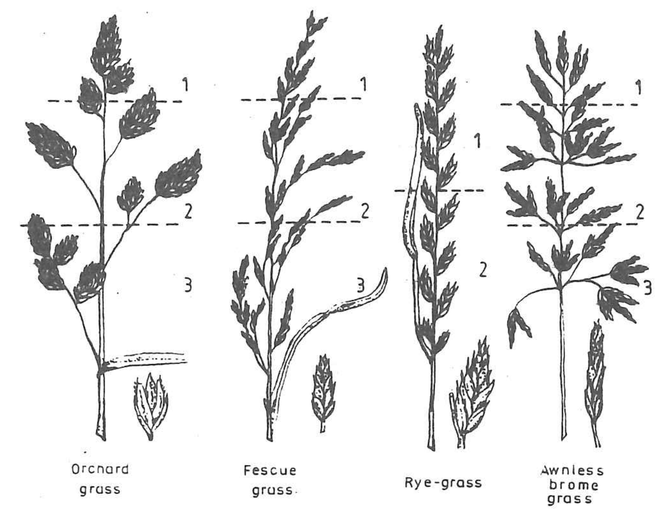

Fig. 1. Areas of the ears and panicles:
1-upper area, 2-central area, 3-lower area

Ten (10) seeds were measured for every area and 3300 total data were obtained for all humidity levels and grass species. The process of coccidian separation from the ear (panicle) being recorded by means of INSTRON recorder made it possible to determine the value of force required to separate the coccidian from the torus and to compute the value of energy (work) used to separate the torus and remove chaff from the seed completely (Fig. 2).

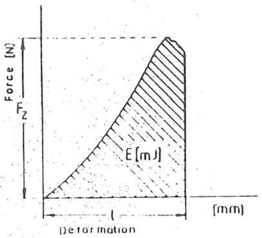

Fig. 2. Typical process of separating the grass coccidian from the ear or panicle

3. Results of examinations

Obtained results indicate that binding force is diversified for individual areas irrespective of humidity level i.e. of natural drying conditions in field ripening period (Fig. 3).

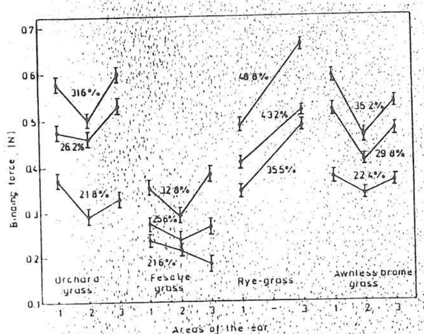

Fig. 3. Average value of grass coccidians binding force according to ear (panicle) areas and humidity - pilot field

The lowest binding force was found in the central coccidian area and greatest binding force in the lower part of the coccidian (for rye-grass) and in the upper area in case of brome grass. For the other grass species these trends are variable according to sampling dates.
The coccidian-to-torus binding force is univocally reduced in case of humidity level drop for all grass species with minimum values being even less than 0,2 N (fescue grass) and up to 0,4 N for the same grass at the first date of sampling.
More significant differences were found for the grass species having maximum binding force of the coccidians at the highest humidity level (orchard grass, rye-grass). At further humidity

drop the differences between individual areas of the ear become insignificant. This fact is confirmed by the results obtained for the sampling on the field after Reglone desiccant application (Fig. 4). The differences between individual areas are insignificant fcr the three grass species (orchard grass, fescue

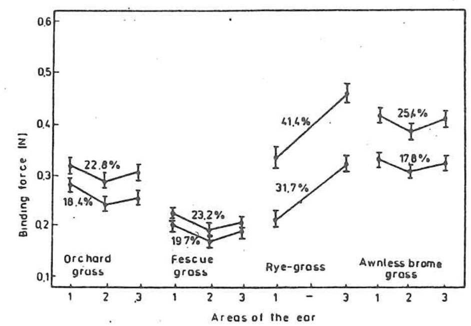

Fig. 4. Average values of grass coccidians binding forces according to ear (panicle) areas and humidity levels - a field after Reglone desiccant application

grass and broche grass). Diversification occured for rye-grass only, being probably caused by different ear morphology for this grass and certain similarity to morphology of grains resulting in easier separating the coccidian from the torus by means of later forces (breaking away).
Reglone desiccant application resulted in sudden reduction of forces required to separate the seeds from the ear for all grass species being made this way susceptible to seeds shedding even for humidity level greater than 20%.
Average values of seeds binding force for whole ears and panicles are ranged from 0,22 up to 0,58 N for natural field ripening conditions according to the grass species and humidity levels (Table 1): from 0,20 up to 0,40 for desiccant application at high humidity level (23 to 41%) and from 0,19 up to 0,32 at much lower humidity level (17 to 31%).
The energy values required to separate the seeds from ear are ranged widely from 0,041 up to 0,397 mJ according to experimental factors assumed. Maximum values are obtained for orchard grass and fescue grass and minimum values for brome grass and rye-grass.
Insignificant diversification resulted from humidity drop was found only for fescue grass. The differences for the other species are significant at individual humidity levels.
The force-energy correlation of seed-to-ear binding exists as shown in Table 2 and are undoubtedly conditioned by morphology features of the ears and panicles, as well as by chaff of the coccidians, their constitution and the humidity of the seeds. Therefore maximum correlation factors are referred to force-humidity relationship.

Table 1. Average values of the grass ear-to-coccidian binding force and energy

Grass species	Field type	Seeds humidity [%]	Average value of ear-to-coccidian binding force [N]	LSD α=0,05	Average value of ear-to-coccidian binding energy [mJ]	LSD α=0,05
Orchard grass	Pilot field	31,6	0,5589	0,0149	0,3969	0,0477
		26,2	0,4889		0,3155	
		21,8	0,3312		0,2406	
	Desiccant applied	22,8	0,3083		0,2442	
		18,4	0,2619		0,2145	
Fescue grass	Pilot field	32,8	0,3424	0,0113	0,3655	0,0525
		25,6	0,2555		0,3443	
		21,6	0,2216		0,3243	
	Desiccant applied	23,2	0,2080		0,2903	
		19,7	0,1921		0,2308	
Rye-grass	Pilot field	48,8	0,5825	0,0382	0,2138	0,0259
		43,2	0,4774		0,1533	
		35,5	0,4243		0,0568	
	Desiccant applied	41,4	0,4061		0,1273	
		31,7	0,2713		0,0416	
Awnless brome grass	Pilot field	35,2	0,5335	0,0185	0,1556	0,0223
		29,8	0,4698		0,0624	
		22,4	0,3641		0,0447	
	Desiccant applied	25,4	0,4096		0,1801	
		17,8	0,3214		0,0510	

Table 2. Values of correlations factors related to coccidians binding force and energy and seeds humidity ($r_{crit.}$ 0,1946)

Grass species	Correlation factors between:		
	Force-energy	Force-humidity	Energy-humidity
Orchard grass (Dactylis)	0,6459	0,9394	0,6996
Fescue grass (Festuca)	0,4444	0,9327	0,4398
Rye-grass (Lolium perenne)	0,7689	0,7841	0,8640
Awnless brome grass (Bromus)	0,4686	0,9251	0,4738

4. Summary

The examinations demonstrated that the implemented method is useful to determine values of ear-to-coccidian or panicle-to-coccidian binding force and energy for seed grasses and to evaluate variations of this feature according to humidity. It was found that coccidian binding force is diversified for individual areas of the ear or panicle. The lowest binding level occured in the central area of the coccidian and the highest binding level in the lowest area of the coccidian except of the brome grass (where the upper area is concerned).

At the seeds humidity drop the coccidian-to-torus binding becomes undoubtedly reduced by more then 50% for all grass species. The energy levels required to separate the coccidians from the ears are reduced simultaneously. Further reduction of seeds binding is resulted from Reglone desiccant application. Obtained results are indicative of their cognitive nature as well as of practical indication referring to harvesting date and desiccant application intended to avoid excessive seeds losses.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

METHOD OF DETERMINING THE BASIC GEOMETRY FEATURES FOR GRASS SEEDS

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A methodology was elaborated and the measurements of basic geometrical dimensions (tkickness, length, width) of grass seeds were accomplished. The examinations concerned five (5) grass species i.e. orchard grass (Dactylis), fescue grass (Festuca), rye-grass (Lolium perenne), timothy grass (Phleum) and awnless brome grass (Bromus).
On the basis of the results obtained the method was proved to be useful and significant diversification between individual species was found and through description of assumed dimensions of seed geometry were included.

seed grasses; geometry features of the seeds

1. Introduction

The seed size being an essential physical feature is of particular importance when evaluating the shapeliness and consumption quality as well as in process of seeds winnowing, drying and storing. Nevertheless serious methematical problems are resulted from seed size characteristics due to irregular shapes of the coccidians being characterized by significant shape variability /1/. Therefore at the grass coccidians description three basic dimensions were determined: thickness as the smallest dimension, length as the greatest dimension and the width as the intermediate dimension /2, 3/.
The seeds of the grasses being harvested on the congeneric plantations form highly differentiated population. For some species, i.e. orchard grass and brome grass the differences between single seeds are noticeable and for other species (e.g. timothy grass) are quite unnoticeable /4/. To provide better selection of grass seeds separating sieves installed in the combine-harvester and in winnowing equipment, the geometry features of the seeds were determined immediately after the harvesting.

2. Methodology and results of the examination

After preliminary winnowing the seeds were mixed and proper samples were taken providing representative quality for whole batch from the plantation. Then the length, width and thickness of individual coccidians were measured within 0,01 mm by means of clock indicator provide with a specialy designed adapter

(Fig. 1) basing upon 300-repetitions-principle for every grass species.
For timothy grass only two dimensions (length and thickness) were determined due to lack of difference between thickness and width. The geometry features are highly diversified according to grass species. Their frequency distributions being approximated to Gaussian distribution provide precise representation for individual size fractions within total population. The lengths of the coccidians are ranged from 1,1 up to 11,0 mm for all species (Fig. 2).
Timothy grass is characterized by the shortest seeds. The frequency distribution of this feature is ranged over a very narrow interval of 1 mm. Owing to such uniformity, this grass species completely differs from the others. On the other hand brome grass

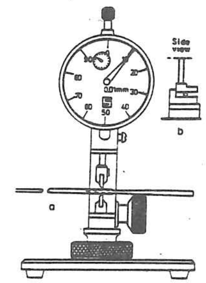

Fig. 1. The diagram of the meter designed for geometry features measurement of the grass coccidians (b) and blade diameter (a)

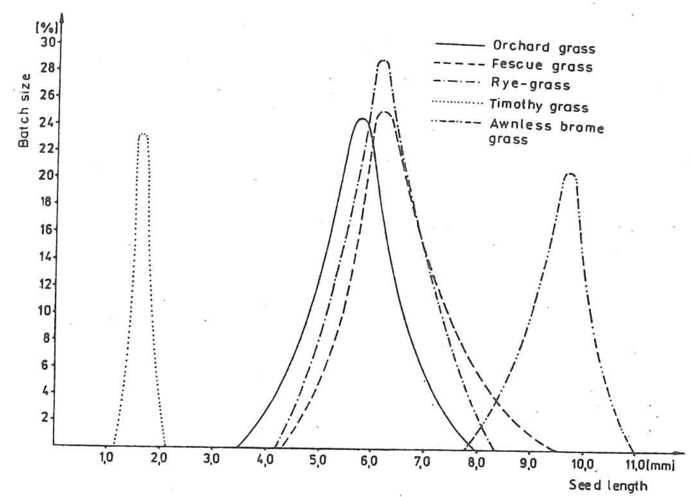

Fig. 2. Frequency distribution of the grass seed length

is characterized by the longest seeds with the seeds length ranged over 7,8 mm up to 11,0 mm. The other three species (orchard grass, fescue grass and rye-grass) have approximately equal length of the seeds with the average value being about 6,0 mm. Percentage contribution of the largest dimensional fractions

is significantly different for individual species.
The thickness of the grass seeds is ranged from 0,22 up to 1,35 mm with the orchard grass seeds being the smallest and the rye-grass seeds being the largest ones, The tolerance between the limit values (minimum - maximum) are not greater than 0,95 mm. The seeds width being ranged from 0,31 up to 2,20 mm is characterized by significant scatter value reaching 1,20 mm for fescue grass and 1,50 mm for frome grass. The contribution of individual seed thickness width fractions are diversified according to the grass species. Their typical configurations are shown in Fig. 3-4 as relationships between the both dimensions. Only for timothy grass the seed thickness has been related with the seed length /Fig. 5/.

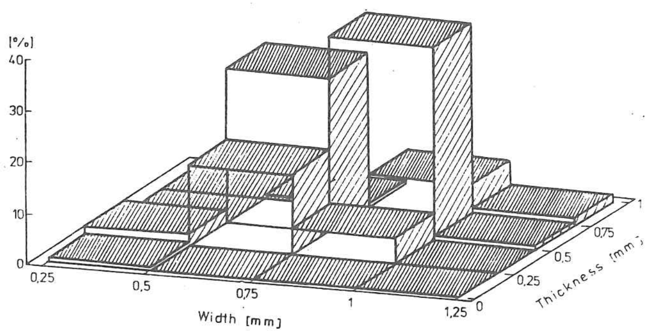

Fig. 3. Bar chart representing thickness-width relationship for orchard grass seeds within dimensional ranges every 0,25 mm

Finally it was found that geometrical features of the seeds are highly diversified according to grass species. The average lengths of the coccidians are ranged from 1,58 mm (timothy grass) up to 9,72 mm (brome grass), while the thickness is ranged from 0,60 mm (orchard grass) up to 0,88 mm (rye-grass) and width from 0,76 mm (orchard grass) up to 1,56 mm (brome grass).
Owing to determining the geometrical features of the grass seeds with such precision irrespective of extremely fine dimensions of the seeds under examinations, it was possible to obtain complete seed size data required to design many processing stages from the grass harvesting throughout winnowing and further seed processing including sowing.

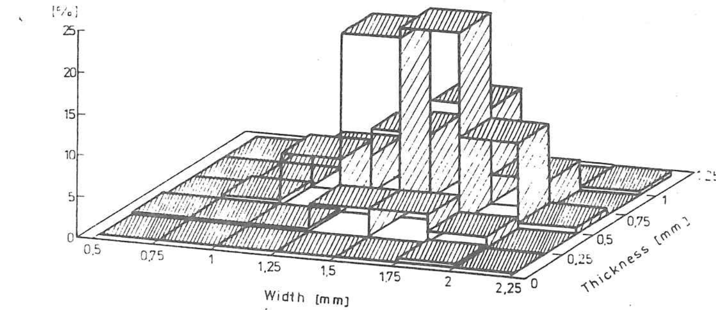

Fig. 4. Bar chart representing thickness-width relationship for awnless brome grass seeds within dimensional ranges every 0,25 mm

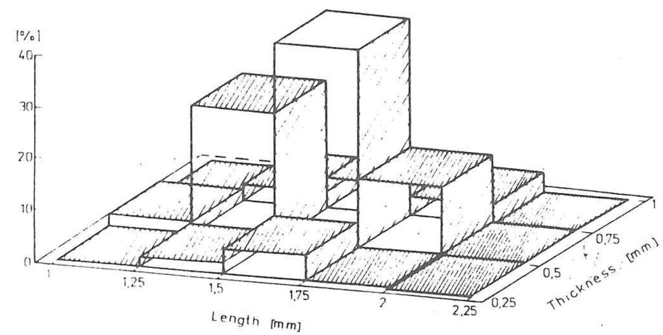

Fig. 5. Bar chart representing length-thickness relationspih for timothy grass seeds within dimensional ranges every 0,25 mm

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

RÜBENBAU IN DER TSCHECHOSLOWAKEI

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Der Rübenanbau im Westeuropa steht auf einem hohen Niveau, vor allem im Deutschland und im Frankreich. Unsere Ergebnisse liegen im Vergleich weit zurück. Der Hektarertrag lieg in den letzten Jahren im Durchschnitt bei ca 350 dt./ha. Dabei wurde Zuckergehalt von ca 15 Prozent erreicht. Im internationalen Wettbewerb wären wir nicht konkurrenzfähig. In der Tschechoslowakei gibt es 64 Zuckerfabriken mit durchschnittlicher Verarbeitungskapazität von nur 1430 t./Tag /Vergleich Offstein - 1300 t./Tag/. Die derzeitige Zuckerrübenanbaufläche liegt bei ungefähr 190 000 ha , davon 130 000 in Böhmen und 60 000 ha in der Slovakei. Sie weist eine sinkende Tendenz auf.

1. DER AKTUELLE ZUSTAND

Vor dem Krieg gehörte die Tschechoslowakei zu den führenden zuckerrübenanbauenden Ländern Europas. Die Veränderungen des politischen Systems nach dem zweiten Weltkrieg brachten eine Wende des Rücktritts. Initiative und Unternehmungsgeist der Menschen waren nicht mehr gefragt, eine betriebliche Weiterentwicklung wurde damit nicht mehr gewährleistet. In der Industrie fand eine Umorientierung statt. Der gesamten Leichtindustrie und speziell auch der Ernährungsindustrie wurden Zügel angelegt, die Investitionen wurden in die Schwerindustrie /Stahlbau/ umgeleitet. Die Zuckerproduktion unterlag fortan dem staatlichen Monopol. Investitionen waren nicht mehr möglich.
Den landwirtschaftlichen Betrieben wurde der Zuckerrübenanbau einerseits vorgeschrieben, andererseits hatten die Landwirte nicht die Möglichkeit, notwendige Produktionsmittel des modernen Rübenanbau einzusetzen. Pflanzenschutzmittel und qualitativ hochwertige Saatgut standen nicht ausreichend zur

Verfügung. Auch das Niveau der landtechnischen Maschinen ließ zu wünschen übrig. Die Tatsache, daß die landwirtschaftlichen Betriebe ähnlich wie im Ost-Deutschland, nur mit Angestellten geführt wurden, läßt ein eigenvrantwortliches Handeln vermissen.Die Sicherheit des einzelnen steht im Vordergrund. Eine gute Arbeit wurde nicht ohne weiteres belohnt bzw. eine schlechte Arbeit wurde nicht ohne weiteres bestraft, wenn politische Interessen übergeordnet waren. Eine Verbesserung des Systems kann somit nur auf gesellschaftlichem Wege erfolgen. Fachliche Probleme sind eher zweitrangig. Doch zurück zum Rübenbau.

2. ANBAUVERHÄLTNISSE

In Böhmen und Mähren /tschechische Republik/liegen zwei Drittel der Zuckerrübenflächen /130 000 ha/. In diesem Gebiet werden 54 Zuckerfabriken von 450 Betrieben beliefert. Die durchschnittliche Betriebsfläche liegt bei fast 300 ha. Im Laufe der letzten Jahre hat der Einsatz von einheimigem Saatgut den Anteil von 90 Prozent überschritten.Dabei stammen 80 Prozent von eigener Züchtung. Auf rund 40 Prozent der Fläche schätze ich heute den vereinzelungslosen Anbau. Dabei geht man bei der Saatgutablage von 16 bis 20 cm aus. Der Reihenabstand beträgt 45 cm. In der Saattechnik wurde den pneumatischen Sämaschinen Vorzug gegeben. Hierbei wurde sehr intensiv mit westlichen Firmen zusammengearbeitet.Die bessere Versorgung mit Herbiziden erleichterte in den letzten Jahren die Entwicklung der Anbauverfahren.
Die geringe Schlagkraft wirkt sich besonders bei den Pflanzenschutzmaßnahmen infolge der Untermechanisierung sehr negativ aus. Es steht für die geforderten Spritzmaßnahmen keine ausreichende Technik zur Verfügung, um in der Kürze der Zeit die Fläche zu behandeln .

3. DÜNGUNG

Die Empfehlung der Düngungsmaßnahmen hat sich gut entwickelt. Seit mehr als 10 Jahren wird eine Art von Nmin-Methode eingesetzt, die neuerdings durch die EUF-Methode ersetzt wird. Wir haben dadurch erreicht, daß die Stickstoffgaben von 200 kg/ha auf 120 - 130 kg/ha reduziert werden konnten. Trotz dieser Maßnahme ist die Rübenqualität kaum gestiegen.Die Stickstoffgaben müssen noch weiter sinken, die erhebliche Reststickstoffmengen über die Jahre hinweg im Boden gespeichert wurden.Dies resultiert zum einen aus den trockenen Jahren, zum anderen aus der Zuführung hoher organischer Düngegaben. 85 Prozent der Zuckerrüben sind mit Stalldung , 15 Prozent mit der Gülle gedüngt. Ein weiterer Faktor dürfte auch die Verfestigung der Böden sein, wodurch die Verrottung der organischen Masse verzögert wird.Infolge dessen wird der Stickstoff nach mehrmahligen Pflügen und somit durch erhöhte Bodenaktivität vor der Vegetation der Zuckerrübe massiv freigesetzt.

4 . DIE ERNTE

Da in allen Betrieben auch die Rindviehhaltung vorherrscht, wird auch das Rübenblatt geerntet. Die Rübenernte

erfolgt meistens zweiphasig - mit sechsreihigem selbstfahrenden Kopflader und Hochlader. Dieses System erfordert, daß die LKWs parallel zum Hochlader bzw. Kopflader das Feld befahren und somit erheblich zur Bodenverfestigung beitragen. Die LKWs überschreiten dabei den zulässigen Bodendruck um das 3 - 4 fache. Die Rübenverluste /15 - 30 Prozent/ sind auf zu tiefe Köopfung und auf schlechte Rodearbeit zurückzuführen. Die vorherrschenden sowjetischen Rodelader ersetzen wir jetzt schrittweise durch eine verbesserte Technik /meistens durch die geschobenen Erntemaschinen z.B. KR-6 der Firma Klein/. Es wird auch zweckmäßig sein, die Bunkertechnik einzuführen z.B. Hollmer, um dadurch den LKW-Verkehr vom Feld zu verbannen.
Der Zuckerrübenpreis richtet sich nach dem Zuckergehalt. Es werden Früh- und Spätlieferprämien bezahlt. Obwohl der tschechoslowakische Rübenbau sich problematisch gestaltet, gibt es auch genug Beispiele von "Mammutbetrieben", die gute Ergebnisse erreichen. Ein solches Beispiel ist die LP Senice /Nordmähren/. Sie ernteten auf einer Fläche von 1400 ha in sehr trockenen Jahren 1989,1990 und 1991 450 - 500 dt/ha Zuckerrüben bei 17,94 bis 19,6 Prozent Polarisation. Es gibt einige Betriebe vor allem in Mähren die im mehrjährigen Durchschnitt über 500 dt/ha liegen.

Zum Schluß möchte ich unsere vordringlichsten Forderungen formulieren:

1. Es muß den Verantwortlichen klargemacht werden, daß im Wettbewerb mit der freien Marktwirtschaft viel strengere Maßstäbe angelegt werden, d.h. es müssen Ertrag und Zuckergehalt deutlich gesteigert und die Arbeitsproduktivität verbessert werden.

2. Wir müssen eine Organisation von Zuckerrübenanbauern gründen, die sich eigenverantwortlich um den Rübenbau kümmert. Vor allem auch deshalb, weil bei uns die Voraussetzungen gegeben sind, daß Zuckerrüben auch bei uns den besten Gewinn bringen können. Wir glauben, daß die Zuckerrübenbauernorganisation die Interessen der Landwirte gegenüber den Zuckerfabriken in günstigem Maße beeinflußt.

3. Die Zuckerindustrie muß praktisch neu aufgebaut werden. Riesige Investitionssummen werden nötig sein. Der Staat kann diese Mittel nicht aufbringen.

TRENDS IN AGRICULTURAL ENGINEERING
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LOAD CELL FOR MEASURING NORMAL AND SHEAR STRESSES OF WHEEL - - SOIL INTERACTION

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The strain gauge load cell was developed which allows an point-by-point measurement of the normal and shear stress of wheel-soil interaction and can be embedded into the surface of tires and wheels.

wheel-soil interaction; load cell; normal and shear stress

1. INTRODUCTION

The understanding of force interaction between wheels and soil has mostly been based on soil bin and field experiments |1-10| where the external forces, acting on the wheel, are measured. These experiments, however, do not yield an insight into the detailed process which takes place at the wheel-soil interface surface. Therefore for an analysis of the behaviour of a wheel, it is necessary to know the distribution of normal (radial) and shear (tangential) stresses in the interface surface |11-15|.

The aim of this paper is to describe the strain gauge load cell for normal and shear stress measurement at the wheel-soil interface surface. The load cell enables the simultaneous and independent measurements of both stress components.

2. THE DEVELOPMENT OF INTERFACE NORMAL AND SHEAR STRESSES

In the case of rigid wheels the relation between interface shear stresses and applied torque is straightforward: equilibrium requires that the integral of shear stresses over the contact area multiplied by the wheel radius be equal to the applied torque. In the case of pneumatic tires no such clear

relation exists since the line of action of the interface normal stresses generally bypasses the axle because of the deflection of the tire. Thus, the interface normal stresses enter into the equilibrium equations for the applied torque. Nevertheless, the major portion of the driving torque is transmitted to the soil in the form of interface shear stresses. In either case, equilibrium requirements set a condition only for the magnitude and position of the resultant of the interface stresses and in no way restrain the distribution of the shear stresses along the interface. An infinite variety of shear stress distributions exists that satisfy the requirement for equilibrium with the applied forces.

There are, however, other limitations on the interface shear stresses that have to be considered in the interaction between wheel and soil. The interface shear stresses may not exceed either the adhesive strength between the surface of the wheel and the soil or the shear strength of soil. In the design of running gears for off-road vehicles different types of traction devices, such as various patterns of treads, lugs or grousers, are employed to insure that in the development of traction the adhesion and friction between the surface of the wheel and soil should not be a restraint and as high interface stresses as the shear strength of the soil permits may be developed. Thus, for all practical purposes the only limitation on the interface shear stresses is the one imposed by the shear strength of the soil, which, in the Coulombian concept |16|, is directly related to normal stress as follows:

$$s = c + p_n \, tg \, \varphi \qquad (1)$$

Alternatively, the following expression way be used

$$s = (\psi + p_n) \, tg \, \varphi \qquad (2)$$

where $\psi = c \, cotg \, \varphi$

It is convenient to express the interface shear stress in a similar form as follows

$$t = (\psi + p_n) \, tg \, \delta \qquad (3)$$

where δ is defined as the angle of interface friction.

Figure 1 shows the definition of the angle δ in relation to the Mohr-Coulomb strength envelope and the mobilized interface shear stress, t_{mob}. The development of shear stresses at the interface is associated with slip, and mathematical formulations for the relationship between shear stress and slip have been proposed by various researchers. Of these, the most useful is the empirical one |17| proposed on the basis of analogy with the direct shear test. This relationship, proposed for tracked vehicles, is as follows

$$t_{mob} = t_{max} \, (1 - e^{-j/k}) \qquad (4)$$

Slip in this expression is defined as

$$j = (1 - v/v_t) \qquad (5)$$

where v is defined as the actual travel velocity and v_t is the theoretical travel velocity.

For compressible soils that are of primary interest in off-road locomotion, this equation properly describes the relationship between shear stress and slip. When this relation-

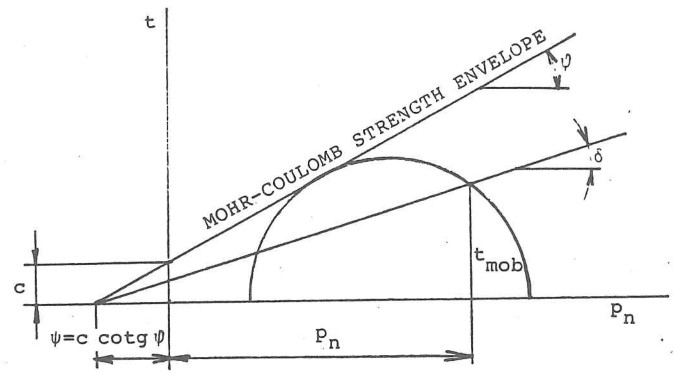

Fig. 1: Mohr circle, mobilized shear stress and interface friction angle.

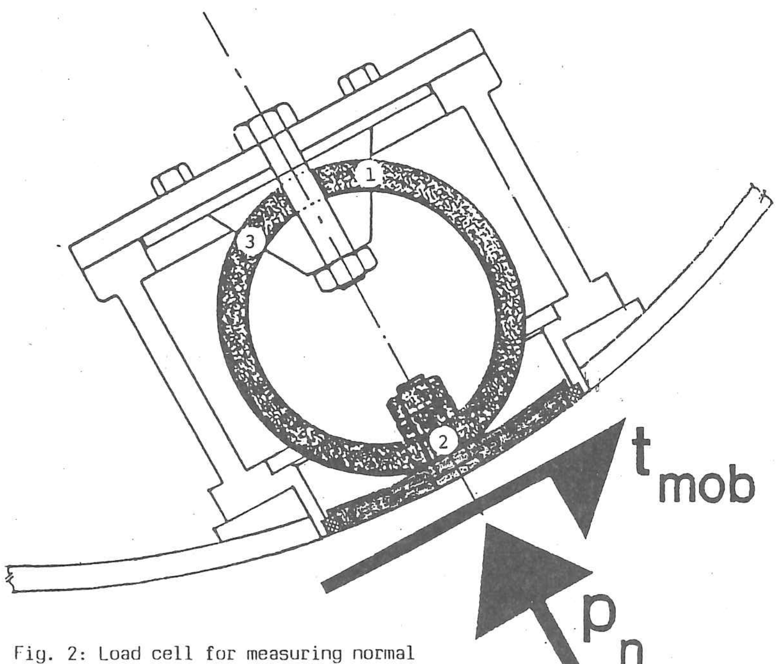

Fig. 2: Load cell for measuring normal and shear stresses.

ship is applied to the rigid wheel or pneumatic tires a constant, j_o, must be included in the slip term to account for the fact that a threshold perimetr shear exists, at which the movement of the wheel starts. Thus, Eq.(4) is modified as follows

$$t_{mob} = t_{max} \, (1 - e^{-(j+j_o)/k}) \qquad (6)$$

From Figure 1 the following relationship is seen to exist between the shear strength mobilized at the interface and the angle of interface friction

$$tg\,\delta = \frac{t_{mob}}{p_n + \psi} \qquad (7)$$

Combination of Eqs. (7) and (6) yields

$$tg\,\delta = \frac{t_{max}}{p_n + \psi} \, (1 - e^{-(j+j_o)/k}) \qquad (8)$$

3. LOAD CELL

The strain gauge load cell (see Fig.2) enables the simultaneous and independent measurements of normal and shear stresses at the wheel-soil interface surface. The rigid sensing plate is elastically sealed against wedging of soil particles in the slot between the sensing plate and body of the load cell. The pressure force effect P_n and shear force effect P_t of the interaction between wheel and soil are transmitted by the sensing plate to a steel ring to which the strain gauges are attached. The wiring and locations of strain gauges on the steel ring is made so that during the measurement of the force P_n, the effect of the simultaneously acting shear force P_t is completely eliminated and, vice versa, the measurement of the shear force P_t (i.e. the total force P_t from the shear stress t_{mob} on the sensing plate) is not affected by the simultaneously acting pressure p_n, i.e. by the resulting force P_n on the sensing plate.

During the measurement the pressure $p_n = P_n/F$ on the sensing plate, i.e. the force P_n of the wheel-soil interface transmitted by the active surface F of the sensing plate is determined. In a similar manner the shear stress $t_{mob} = P_t/F$ of the wheel-soil interface is evaluated. For evaluation of the measuring results calibration curves are utilized. Calibration of the load cell proved that during simultaneous measurements of both stress components their mutual separation achieved by the wiring and location of the strain gauges on the dynamometric steel ring is perfect and that there is no interaction between the results of measurements. In the calibration of both normal P_n and shear P_t forces, linear dependences were obtained on the recording milivoltmeter in the whole range of the measured stresses. The perfect heat treatment of the dynamometric steel ring of the load cell eliminated hysteresis effects and so the measured values gave very good reproducibilities.

The thickness of the dynamometric ring, i.e. its rigidity, was designed in such a way that even during measurements of maximum pressures p_n the radial deformation of the ring was not greater than $3 \cdot 10^{-3}$mm. The magnitude of deformation of the dynamometric ring, during the pressure measurement, substantially influences the accuracy of measurement. With an increasing deformation of the dynamometric element of the load cell, the measured pressure p_n decreases and the error of measurement increases. The sensing plate of the load cell is, after the deformation of the dynamometric element compressed only by a fraction of the pressure p_n. This effect is explained by formation of a local arch over the sensing plate. The pressure captured by the arch is not transmitted to the sensing plate.

4. THE PRINCIPLE OF SEPARATION OF FORCE COMPONENTS

The dynamometric ring of the load cell (see Fig.2), fixed in two points is loaded by the force components P_n and P_t. At every point of the ring's mean diameter bending moments are developed. In any two points which are symmetrical to the axis of symmetry of the circular part of the ring, force P_n induces a bending moment of equal size and sign whilst force P_t causes a bending moment of equal size but opposite sign.

If we designate the moments caused by the forces P_n and P_t as M_o^{Pn} and M_o^{Pt} respectively, the total moments given by superposition are:

$$M_{o,1-2} = M_o^{Pn} + M_o^{Pt} \qquad (9)$$

$$M_{o,2-3} = M_o^{Pn} + (-M_o^{Pt}) \qquad (10)$$

where M_{o1-2} and M_{o2-3} represent the bending moments between points 1-2 and 2-3 respectively (see Fig.2). By adding or subtracting Eqs. (9) and (10) we obtain expressions for determining the moments caused by the individual forces:

$$M_o^{Pn} = (M_{o,1-2} + M_{o,2-3})/2 \qquad (11)$$

$$M_o^{Pt} = (M_{o,1-2} - M_{o,2-3})/2 \qquad (12)$$

A certain system of wiring of the strain gauges with the Wheatstone bridges allows the simultaneous and independent recording of the normal P_n and shear P_t forces.

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DRUCKMESSDOSE FÜR DIE MESSUNG DER NORMAL- UND SCHERSPANNUNG ZWISCHEN RAD UND BODEN

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Das Coulomb'sche Konzept der Entstehung von Normal- und Scherspannungen zwischen einem Rad und dem Boden ermöglicht es den Spannungszustand an der Trennfläche "Rad-Boden" mit Hilfe von Drücken und einer mobilisierten Scherspannung festzuhalten. Zu ihrer Messung wird eine Meßdose des Normal-(Radial-)drucks und der Scherspannung vorgestellt. Beide Komponenten des Spannungszustands wirken hierbei gleichzeitig ein und die Meßdose mißt sie simultan und voneinander unabhängig. Beschrieben wird die Konstruktion der Meßdose und das Prinzip der Trennung der gleichzeitig einwirkenden Spannungskomponenten. Es wird empfohlen die Deformationscharakteristik der Meßdose max. 3.10^{-3}mm im Bereich des maximal gemessenen Normaldrucks zu wählen.

TRENDS IN AGRICULTURAL ENGINEERING
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DEFINITION DER SCHADSTOFEABLEITUNG AUS LEM SYSTEM

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SUMMARY

The balance which solves the questions of impact on environment, on its main parts, should represent the part of new intensifying, production and town-planning solutions, of modern ways of management and lanscape creation. The submitted proposal determins the basic procedure, defines the regularity, harmful substances, matters withdrawal from the system. The given procedure could be applied on broader scale in the technique of environment and within the systems in broader dimensions, in the coverage of the total characteristic of the system of the global character, in ecological systems, in the biosphere in general. Starting from the more simple general procedure - it is more demanding - laborious to elaborate in objective way the methodologies of observation of the given - resulting state, production and input into the individual system, output from one system into the other, secondary change of the harmful substance within the system, its bond with other substances etc. It is necessary to determine the time periods - cycles - according to their character in order to define the outlet of harmful substances from the system. The balance of production, of inlet of harmful substance and resulting state, of reminder of harmful substance in the system will be done for these periods.

system; outlet of harmful substances; definition-regularity

1. ENLEITUNG

Einer der Grundprobleme des modernen, intensive Wirtschaftens, das auch in der Landwirtschaftsproduktion am hohen Niveau der Systembelastung gegründet ist, ist eine sachliche Definition der Schadstoffeableitung. Grundlegende Bindung ist durch Industrialisierung der Landschaft, Intensitätserhöhung in der Landwirtschaftsproduktion, Konzentrationserhöhung der gehaltenen Tiere im Rahmen der Grossfarmen gegeben. Diese grundlegenden Faktore schaffen unerträgliche Bedingungen, die die Umwelt degradieren.

Ein Bestandteil der Intensivierungsprogramme sollte Verhinderung der negativen Einwirkungen auf die Umwelt und ihre Bestandteile sein. Wir schlagen vor, dass man für die Definition der Wirksamkeit von angenommenen Massnahmen, Festlegung der Ablaufdynamik, Schadstoffortgangs im System die Modellfunktion, die Gesetzmässigkeit der Schadstoffableitung aus dem System, benutzt.

2. GRUNDLEGENDE DEFINITION, GESETZMÄSSIGKEIT DER SCHADSTOFFEABLEITUNG AUS DEM SYSTEM

$$A_S = \frac{X_A}{X_Z} = \frac{X_Z - X_R}{X_Z} = 1 - \frac{X_R}{X_Z}$$

A_S - Ableitung der Schadstoffe aus dem System

X_A - Menge der abgeleiteten Schadstoffe aus dem System

X_Z - Menge des zugeleiteten Schadstoffes in das System, bzw. Menge des produzierten Schadstoffes im Rahmen des Systems

X_R - Rest des Schadstoffes im gegebenen System

3. NAHERE ERLÄUTERUNG DER DEFINITION, DER GESETZMÄSSIGKEIT DER SCHADSTOFFEABLEITUNG AUS DEM SYSTEM.

Unter dem Termin System versteht man biologisches, technisches und anderes Funktionsganze /Organismus und seine Bestandteile, Pflanze, der Bodensystem, Wasserstrom - Einheit, der See udgl., Wald und seine Bestandteile, Atmosphäre und ihre Komponenten, technische Einrichtungen - Produktionseinheit - Produktionshalle, Industrieeinheit, Verkehrsnetz, vor allem seine exponierte Siedlungs- und Stadtetappen udgl./. Im Rahmen des Systems ist es möglich auf Grund des genauen und für einzelne Systemstypen methodisch präzisierten methodischen Fortgangs das Niveau, Bewegung des studierten Schadstoffes, seine Tendenz - Trend und Dynamik zu bestimmen.

Allgemein kann man den durchgehenden, Schluss- oder "End"- stand des Schadstoffes im untersuchten System ausdrüsken. Auf Grund der angegebenen Gesetzmässigkeit kann man gegenseitiges Durchdringen der Stoffe von einen in das andere System, in gegenseitiger Funktionsabhängigkeit, die gesamte Ablaufsdynamik, Gestaltung und Ableitung der Produktion, Zuleitung und Verbleiben des Schadstoffes im System festlegen.

Vom Gesichtspunkt der allgemeinen Definition ist ein wichtiger, ökologisch bedingter Faktor die Variable X_R, d.h. Wert des Schadstoffrestes, der einen dauerhaften, bzw. überdauernden Charakter im System hat. Nach der Schadstoffart und ihrer Dynamik ändert sich auch ihr Niveau. Praktische Bedeutung hat so ein X_R, das keine Degradationswirkungen im System, im allgemeinen Sinne des Wortes, hat.

Bei der Wertbestimmung der einzelenen Funktionsbestandteile, die durch Gesetzmassigkeit - Abhängigkeit definiert wird, muss man charakteristische Zyklen, Rhytmen wählen,die für den anegegebenen System üblich sind, bzw. diese können in Zeitdimension nach Bedarf verengt werden, bzw. die üblichen oder längere können gebraucht werden /z.B. Jahr, Vegetationsperiode, Wuchsphase, Biozyklus im allgemeinen, usw./.

Bilanziert werden die Mengen des zugeführten bzw. produzierten Schadstoffes im System - ins System /X_Z/, Menge des Schadstoffrestes /X_R/ im Rahmen des Systems.

Selbständige Funktionsbedeutung hat die Menge des abgeleiteten Schadstoffes /X_A/. In den gegenzeitigen Bindungen zwischen den einzelnen Bestandteilen der Umwelt, des Systems, hat seinen Charakter nach einen Einfluss auf Bestimmung, Bilanz /X_Z/ des untergeordneten - übergeordneten, bzw. funktionsabhängigen Systems, für den untersuchten Schadstoff.

Genauere mathematische Ausarbeitung der gegenseitigen Bindungen, Durchdringung /Vermischung/ der einzelnen Bestandteile, aus dem und in den System /übergeordnetem- untergeordnetem, Funktionsverbindungen/ kann die Schadstoffebewegung, die im Rahmen des breiteren bio-ökologischen, atmos-

phärischen, technischen, "Natur"-ganzen System beobachtet wurde, im breiteren Masstab definieren.

4. ZUSAMMENFASSUNG

Die Bilanzbalanze, die die Fragen der Wirkung auf die Umwelt, auf ihre Grundelemente löst, sollte ein Bestandteil neuer urbanistischen, Intensivierungs- und Produktionslösungen, moderner Wirtschaftens- und Landschaftsgestaltungsmethoden werden. Der vorgelegte Vorschlag bestimmt den grundlegenden Verlauf, definiert die Gesetzmässigkeit, die Schadstoffabführung aus dem System. Wir vermuten breitere Durchsetzung des erwähnten Verfahrens in der Umwelttechnik und im Rahmen der Systeme in breiteren Dimensionen und möchten die Gesamtcharakteristik des Systems des globalen Charakters, in ökologischen Systemen, in der biosphäre im Allgemeineren zu erfassen. Falls wir dabei vom einfacheren allgemeinen Verfahren hervorgehen, ist es mehr anspruchsvoll - mühevoller die Beobachtungsmethodiken des Gegenenen - des Endzustandes, der Produktion und des Eintrittes in die einzelne Systeme, des Ausgangs von einem System in das andere, der sekundären Schadstoffveränderung im Rahmen des Systems, seine Bindung mit anderen Stoffen u.dlg. sachlich auszuarbeiten. Um die Schadstoffabführung aus dem System definieren zu können ist es notwendig Zeitabschnitte - Zykle, für die die Produktionsbilanz, Schadstoffzufuhr und Endstand durchgeführt wird, nach ihrem Charakter zu bestimmen.

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CONTROL OF FINAL DRYING PROCESS OF HAY IN HIGH LAYER

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Abstract. High quality hay production in barn and tower stores with the fan necessitates automation of farm operations. As major factors controlling the drying process temperature of the material stored, its moisture content, relative humidity of the drying air together with the temperature of the material were tested. Most suitable seemed to be the moisture content of the material, continuously detected as bioimpedance. This enabled conversion of the drying algorithm directly to changes in the moisture content of the material.

Keywords. Hay; drying; automation; fan; bioimpedance; temperature control; relative air humidity.

1. INTRODUCTION

Today's serious energy problems and forecasts of the future development in fuel and energy balance have forced farm enterprises to adopt technology with minimum, or rather optimum, energy requirements. The drawback of the drying technology utilizing natural ambient air introduced by the fan is that it is greatly dependent on weather conditions. When freshly cut forage (moisture content of 40 per cent is recommended) is loaded into barns under unfavourable weather conditions with permanently higher relative air humidity, hay may readily heat. Heating of hay to a temperature above 40° reduces markedly the nutritive value, aggravates the risk of mould development and aflatoxin production. Moreover, the risk of spontaneous ignition becomes greater. The understanding of biochemical processes associated with the physical conditions during final drying is essential for its success. There are still some opportunities for keeping the biological value of the material and energy saving. The need to find a satisfactory solution is still more urgent as the current trend is towards the construction of large-scale hay barns. It is clear that the control of the hay drying process cannot depend upon subjective judgments of the operator. Only objective assessment based on the profound knowledge of physical quantities may guarantee the success of the drying process in the barn. An important factor in increasing the quality and effectiveness of the drying process is automation which may be also essential to low-energy drying. The application of management systems based on electronic and microelectronic elements with a high degree of integrity allows to develop complex algorithms that are, however, simple to understand and easy to operate. In such computer-aided management system the human factor becomes only a supervisor of the operation and the output.

2. PATTERNS OF TEMPERATURE AND MOISTURE CONTENT IN FRESHLY CUT FORAGE AFTER LOADING INTO BARNS

The process of hay drying was described and analyzed by a number of authors. For example, Rees (1974) showed the relationship between ryegrass (*Lolium*) and the range of temperatures 20-50° C, as follows:

$$x-x_e = a.exp/-k_1. /+b.exp/-k_2. /, \qquad (1)$$

Where: $a=X_o-b-X_e$

$k_1=0.01249.exp/0.0703.t/$

$k_2=0.00190.exp/0.0585.t/$

$b=0.00415.x_o+0.032296.t$

whereas t (°C), X (kg/kg) and (min.).

The moisture content of the grass mixture was defined by Lamond (1985, 1986):

$$u=exp(-b.(-ln(1-MR))^m. \qquad (2)$$

$$u=exp-\sqrt{t}/a \qquad (3)$$

$$u=(X-X_e)/(X_o-X_e), \qquad (4)$$

Where: a, b, m are tabled values.

Measurements in the barn were made of

- the temperature of the material and the ambient air
- the moisture content of the material (bioimpedance) and the ambient air
- the time of switching the fan on

The pattern of these two quantities within two days of hay loading is given in Fig. 1.

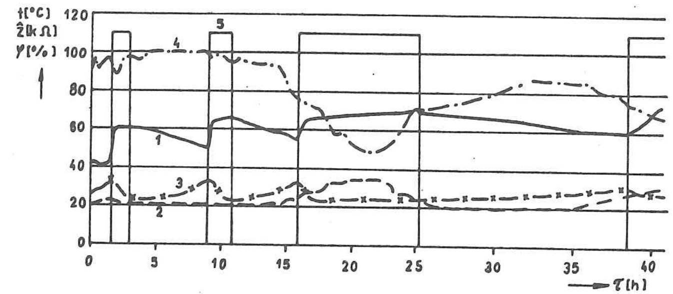


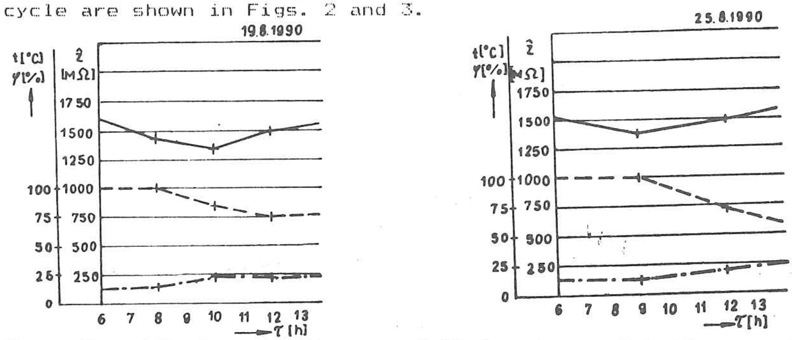
Fig. 1. Graphic Diagram of Drying Process of Hay in Barn 1-Bioimpedance of Hay (kOhm), 2-Temperature of Atmospheric Air (°C), 3-Temperature of Hay (°C), 4-Relative Humidity of Atmospheric Air (%), 5-Fan ON/OFF

The values recorded revealed an increase in the temperature of freshly loaded hay up to the value of 35°C due to heating. At that time the fan was automatically switched on. Thereafter, the material was gradually cooled and dry matter simultaneously increased (rise in bioimpedance). This was due to the removal of the liberated moisture vapour at a temperature higher than that of the ambient air (overheating caused a slight rise in temperature), even at a higher instantaneous sorption capacity of the drying air.

This process was repeated once more after 5 hours. Now, worth mentioning is the increase in the dry matter of hay expressed as bioimpedance - during the course of two ventilation cycles at night it increased by 25 kOhm. During another interval of fan operation the high temperature of hay, owing to spontaneous heating, rapidly decreased and in the end fell below the value of the temperature of the air blown into the barn. At that time intensive evaporation took place and the temperature of the material partly dropped. With increase in the dry matter of hay under given relative humidity the difference between the temperature of hay and the temperature of the air gradually decreased. This was confirmed during another interval of fan operation.
The graphs of the quantities studied suggest a relationship between the temperature of the material stored and its bio-impedance. It can be reported that they produce a mirror image. The measurement of bioimpedance utilized two stainless electrodes inserted into hay at a predetermined spacing. The range of measurement was 0 to 100 kOhm.

3. BIOIMPEDANCE AND SORPTION BEHAVIOUR OF HAY-LAYER

To verify the suitability of the method of measuring hay bioimpedance as a functional quantity of the moisture content, a number of measurements was performed. Again, two stainless electrodes 1 m long were inserted into the material at a 1-m spacing. The range of measurement was 0 to 1.999 MOhm, the input was 9 V (from a battery). The examples of the patterns of hay bioimpedance measured at one day cycle are shown in Figs. 2 and 3.



Figs. 2 and 3. Graphic Diagram of Bioimpedance, Relative Humidity and Temperature of Atmospheric Air

The graphs showing in addition to the values of bioimpedance $\hat{z}$ the pattern of relative humidity φ and temperature t reveal a link between $\hat{z}$ and φ. Their patterns are confirmed also by the sorption behaviour of hay, as reported by a number of authors (Tuncer, 1968 et al.). With a decrease in relative humidity, the moisture content of the material, characterized by the same amount of moisture, decreases, bioimpedance increases and *vice versa*.

4. CONCLUSION

The measurements performed in the field showed that there was a close relationship between the moisture content of hay and its bioimpedance. So far, the process of hay drying in barn and tower stores has been controlled predominantly by the temperature of the material loaded (Fig.1). or sometimes by the relative humidity of the drying air. When the preset limit values of these quantities are reached, a signal is produced to switch on or off the fan. This procedure is suitable predominantly with respect to fire prevention though occational unpredictable local rises in temperature cannot be excluded. With respect to the hay drying process itself and hay quality (nutritive value) it would be best to control ventilation by changes in the moisture content of the material layer. As demonstrated in Figs. 1, 2 and 3, bioimpedance comprises not only the moisture content of the material but also its temperature and the relative humidity of the drying air. From this reason , it is an advantage to transform the algorithm of hay drying to the algorithm of the moisture content of the material expressed e.g. by the bioimpedance.

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FORSCHUNGSSCHWERPUNKTE ZUR WEITERENTWICKLUNG DER LANDMASCHINEN FÜR DIE PFLANZENPRODUKTION

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FARM MACHINERY RESEARCH NEEDS

Summary

Most of the significant opportunities can be assigned from R&D the next major thrust areas: 1. Tractor modelling (structural and power transmission loads, dynamic stability and handling, alternative tractor design concepts), 2. Machinery-soil interaction (traction and compaction, potential of controlled traffic, design and development of low compaction tractive vehicles), 3. Machinery management (contemporary electronics and control systems, data comunications methods and standards), 4. Specialty crops and rural development research (fruit, vegetable and other specialty crops, low-cost equipment for processing and packaging), 5. Forage harvesting and processing (commodity quality, improvement, produce of "value-added" products from the forage, reduce energy requirements of the equipment and improve forage marketability), 6. Grain harvesting (threshing and separation process, human factors and improved hierarchical automatic controllers).

Key words: tractor, machinery-soil interaction, forage and grain harvesting, electronics and control systems

1. STAND UND ENTWICKLUNGSTENDENZEN DER LANDWIRTSCHAFT UND LANDMASCHINENINDUSTRIE

Die Landtechnik wurde im letzten Jahrzehnt systematisch entwickelt und ohne größere Sprünge vervollkommnet. Der bessere Umweltschutz erscheint in den neunziger Jahren als eine Herausforderung für jede Gesellschaft, für die Landwirtschaft und für den Landmaschinenbau und auch als wichtiges Argument auf dem Verkaufsmarkt.

Die Bildung des gemeinsamen europäischen Marktes mit 350 Mio. Verbrauchern in Europa beeinflußt die Schlagrichtungen in europäischen und amerikanischen Forschungen. Die Kaufkraft der EWG-Bewohner wird Mitte und Ende der neunziger Jahre noch größer werden. Diese Tatsache versteht man als Chance für noch schärfere Konkurrenz, die auch die Landwirtschaft und der Landmaschinenbau berücksichtigen müssen.

Die Landwirtschaft bedarf des technischen Fortschritt, um konkurrenzfähig zu bleiben, das erweckte Bewußtsein der Bevölkerung über den Umweltschutz zufriedenzustellen und um den immer strengeren Vorschriften über die Umweltverunreinigung nachzukommen. Die Landmaschinenindustrie muß die Aufgaben, die ihr die Landwirte stellen akzeptieren und nach neuen entsprechenden Lösungen suchen.

Die Landwirtschaft und die Wirtschaftszweige, die ihr in der Nahrungsproduktion voran- oder nachgehen müssen darauf bestehen, die bestehenden Reserven für die weitere Rationalisierung der Produktion auszunützen. Das bedeutet die Erniedrigung der hohen Produktionskosten.

Die Landwirte müssen sich dauernd weiterbilden und vervollkommnen. Dazu muß auch die Wissenschaft beitragen. Auch in den entwickelten Ländern ist man der Meinung, daß es zu lange dauert bis die wissenschaftlichen Ergebnisse in die Praxis übertragen werden und aus diesem Grund werden Fachvereine und Regierungsinstitutionen beauftragt, sich mehr in dieser Richtung zu engagieren.

In allen europäischen Ländern sind sich die Landwirte dessen bewußt geworden, daß derjenige, der seine Zukunft durch seine Tätigkeit in der Landwirtschaft sicherstellen will, nicht mehr sondern billiger produzieren soll. Aus diesem Grund wird überprüft, was die Landwirtschaft in der Tat benötigt. Entsprechen die Ergebnisse der wissenschaftlichen Forschung und das Angebot der Industrie dem Bedarf der Landwirtschaft?

Der Umweltschutz ist das Thema in allen Gesprächen über die Entwicklung und Anwendung der Landtechnik. Die Gefahr vor allgemeiner Umweltverschmutzung und Umweltstörung bekam während der letzten Jahre sehr große Bedeutung. Die Verantwortung für die Umweltverschmutzung muß sehr groß werden. An vielen Stellen werden diesbezüglich Befürchtungen ausgesprochen und darauf hingewiesen, daß Bedarf an einer Zusammenarbeit besteht, um dazu beizutragen, daß man in den Ländern von Ost- und Südeuropa den Einsatz von veralteten Technologien und die weitere Umweltverschmutzung verhindert, um dadurch einen Beitrag für sämtliche europäische und weltweite Bevölkerung zu leisten.

Der konkrete Beitrag der Landmaschinenindustrie liegt in der entsprechenden Maschinenentwicklung. Nur an einer Stelle, während der Agritechnica 1989 in Frankfurt wurden als Neuheiten folgende "ökologische" Maschinen dargestellt:

- Einrichtung zur Luftdruckeinstellung in den Reifen bei Traktoren und Anhängern zum Schutz des Bodens,
- Maschine zur Probeentnahme für chemische Analyse des Bodens,

- Einrichtung für direktes Saugen des Pflanzenschutzmittels aus dem Originalbehälter, ohne Rückstand der chemischen Mittel oder Umweltbelastung
- Injector für Flüssigmist (vermeidung der Luftverunreinigung)
- Satellitnavigation für genaue Dosierung von chemischen Mitteln auf einer bestimmten Parzelle
- Sammeleinrichtung für Kartoffelkäfer (keine chemische Belastung)
- Zahlreiche Maschinen zur Reduktion der Bodenbearbeitung zwecks der Bodenerhaltung und noch viele weitere Maschinen.

Auf der Agritechnica waren noch mehr solcher "umweltfreundlichen" Maschinen zu sehen.

2. NOTWENDIGE UND AUSSICHTSREICHE FORSCHUNGSGEBIETE

Aufgrund zahlreicher Literatur (vor allem /3/) und eigenen Schätzungen konnte man sechs Forschungsbereiche im Fach Pflanzenproduktionsmaschinen formulieren, in denen besonders günstige Effekte zu erwarten sind. Es sind:

1. Optimierung des Schleppers
2. Gegenseitige Wirkung des Bodens und der Maschinen
3. Einführung der Elektronik und Informatik in die Landtechnik
4. Entwicklung der technischen Einrichtungen für Sonderkulturen
5. Futterernte und Futterverarbeitung
6. Getreideernte

In diesen Bereichen sollten folgende Phänomene - Themen weitererforscht werden:

<u>Optimierung des Schleppers</u>

- Modell Boden/Pneumatik damit man die Zugfähigkeit voraussieht und damit die Reifen bewertet werden, ihre projektierten und erzielten Eigenschaften, wie Profilform, Karkassenkonstruktion, Zugfähigkeit.
- Modell der Inkorporierung der Reifen in das Modell des Fahrzeuges zwecks der Bewertung seiner Vibration während der Fahrt, seiner Stabilität und der Steuerungseigenschaften.
- Modell Schlepper/Geräte zur Bewertung der Eigenschaften der dynamischen Zuverlässigkeit, zur Kontrolle der Belastung der Geräte und zur Bestimmung der Zuverlässigkeit der Aufrechterhaltung der gewünschten Lage des Arbeitsgerätes.
- Modell Schlepper mit Anschlußmaschinen zur Bewertung von alternativen Motoren, Transmissionen und des optimalen Entwurfes einzelner Zugkomponenten, um die Zuverlässigkeitseigenschaften vorauszusehen.
- Modell des Bedienungspersonals, um die verbesserten Sicherheitsmechanismen und Steuerungsmechanismen der Landmaschinen zu entwickeln.

Man soll die relativen gegenseitigen Vor- und Nachteile der unterschiedlichen Arten der Bodenbearbeitung mit diversen Geräten, bei unterschiedlicher Kraftübertragung und Fahrzeugssteuerung feststellen. Außerdem soll man auch die Hauptmöglichenkeiten der Anwendung von konkurrenzfähigen alternativen Schlepper und Antriebsstoffen vergleichen, wie z.B. von klassischen Schleppern und Sonderschleppern, Brücken, Geräteträgern, System-Schleppern, Systemen mit Kabeln, Biodieselkraftstoff und dgl., zur Bestimmung des Grades ihrer Vorteile in der weiteren Zukunft.

Gegenseitige Wirkung des Bodens und der Maschinen

Der Prozeß des Bodenverdichtens könnte besser verstanden werden, wenn man folgende Studien vornähme:

- Bewertung der verschiedenen Meßmethoden für Bodenverdichtung einschließlich der Angaben über die Schichtdichte, Bodenspannungen und über die Eigenschaften des Wasserleitvermögens.
- Entwicklung des automatischen Probeentnahmegerätes zur Probeentnahme aus verschiedenen Bodenschichten bis zur Tiefe von 60 cm.
- Bestimmung der Wirkung der schweren Maschinen auf die Bodenverdichtung unter diversen Bodenverhältnissen.
- Messen der Verdichtungswirkung auf Entwässerungssysteme.
- Bestimmung und Entwicklung von Methoden und Verfahren zur Milderung der negativen Folgen hervorgerufen durch die Bodenverdichtung.
- Entwurf und Entwicklung von Zug- und Transportfahrzeugen, die geringe Bodenverdichtung verursachen.
- Bewertung und Entwicklung von unterschiedlichen Produktionsschemen, damit man möglichst besser die Idee der ständigen Fahrgassen ausnützt.
- Optimierung der Forderung an großer Zugkraft und geringer Bodenverdichtung.
- Zusammenhang zwischen den Arbeitsgeräten und dem Boden.

Mehrere Informationen über die Hauptmechanismen des Bodenverhaltens bei der Bearbeitung würden ermöglichen die Geräte derart zu bauen, daß sie die wirksame Bodenbearbeitung mit minimaler Zugkraft ermöglichen.

Einführung der Elektronik und Informatik in die Landtechnik

Die genauen Daten und Modelle über die Möglichkeiten, Leistungen, Zuverlässigkeit und Lebensdauer der zeitgemäßen Maschinen in einer Datenbank würden wesentlich die Wirtschaftlichkeit ihrer Anwendung verbessern. Man sollte relative Vorteile des mechanischen Schutzes gegen Unkraut in Bezug auf chemische Methoden deutlich klar machen und propagieren. Zudem sollte man auch mehr die Möglichkeiten der zeitgemäßen Elektronik und darauf beruhenden Kontrollsystemen benützen. Man sollte auch die Kommunikationsmethode Daten - Information entwickeln und entsprechende Standarde zur Unterstützung des Informationsaustausches zwischen dem Computer, der am Schlepper und/oder am Anschlußgerät gebaut wird, und dem Zentralsteuerpunkt. Die Vorteile solcher Datenverarbeitung und Datenausnützung werden dazu beitragen, daß die Produktionskosten gesenkt und neue Verkaufsmärkte für Maschinen eröffnet werden. Das gesamte Managementsystem msoll man mit den Daten in eine zweckbestimmte Reihe der agrotechnischen Operationen einbauen bzw.

in die neuen technologischen Karten der Ackerbauproduktion eintragen.

Entwicklung der technischen Vorrichtungen für Sonderkulturen

Billige Maschinen mit niedrigen Betriebskosten für den Anbau und Ente von Gemüse und Obst und von anderen Sonderkulturen sollten dem Unternehmen größeren Profit ermöglichen, insbesondere den kleinen Produzenten. Außerdem werden sie den Anbau einzelner Kulturen in bestimmten Gebieten fördern. Die Verbesserung der Maschinenkomponenten wie auch ihrer Anwendung in Sondermaschinen wird den Anbau von Kulturen, die verhältnismäßig weniger gepflanzt werden, fördern. Man benötigt dazu billigere Verarbeitungs- und Verpackungsmaschinen. Die Entwicklung in dieser Richtung würde den kleinen und mittelgroßen Produzenten in der Landwirtschaft helfen. Dadurch würde man die Mannigfaltigkeit einzelner Gebiete und die Belebung des Dorflebens erzielen und behalten.

Futterernte und -verarbeitung

Die Forschung im Bereich der Maschinen für Futterernte und Futterverarbeitung könnte zur Verbesserung ihrer Qualität, zur besseren Ausnutzung ihres "zusätzlichen potentiellen Wertes" und zu Energieersparnissen führen. Daher ist die Erforschung des Futters und der dazugehörigen Mechanisierung in großem Umfang notwendig.

Schnelle Trocknung am Felde: Die Forschungen sollten zu neuen Verfahren führen, so daß das Futter am gleichen Tag geerntet, getrocknet und gepreßt wird.

Verfahren für Saftabsonderung aus dem Pflanzengut für die Gewinnung des proteinreichen Produktes als Zusatzmittel für Tiere oder Menschen: Das feuchte Gut, abgesondert durch mechanische Verfahren oder silieren oder dehydrieren. Sehr nützlich wäre die Entwicklung der geeigneten Ausrüstung zum Einsatz dieser Verfahren in der Praxis.

Energiesparende Maschinen: Die Futtererntemaschinen zeigen den höchsten Energieaufwand in Bezug auf alle Maschinen am Feld. Die so hohen Energieaufwendungen könnten gesenkt werden, indem man neue Mähmaschinen mit wirksameren Transportvorrichtungen entwickelt.

Pressen: Pakete großer Dichte unter Anwendung wenig Energie.

Getreideernte

Die Verluste, die bei der Ernte mit dem Mähdrescher entstehen und sogar bis zu 10% ausmachen, müssen besser überprüft und gesenkt werden. Das verbesserte theoretische Verstehen des Ernteverfahrens - Mähen, Fördern, Dreschen, Separieren - würde der Verbesserung des Entwurfes eines Mähdreschers helfen. Viele Aufgaben die heute einem Mähdrescherfahrer anvertraut werden, stellen die Grundlage für die Überprüfung der Möglichkeiten und Rechtfertigung der Arbeit des Menschen dar und seines Einflusses auf das Ernteverfahren. Gleichzeitig bieten sie die Möglichkeit für die Entwicklung und den Einbau automatischer Kontrollgeräte und Steuergeräte in den Mähdrescher.

Es soll hier auch betont werden, daß die Ergebnisse dieser Studien und Forschungen auch in anderen Maschinenbauindustriezweigen angewandt werden konnten. Gleichzeitig kann man hervorheben, daß die Politik, die die Entwicklung der Landmaschinen unterstützt auch die Erhaltung des Bodens als wichtigstes Produktionsgut, sowie auch der Naturquellen ermöglicht und dadurch auch die Erfüllung der Lebensbedürfnisse der Bevölkerung in ruralen Gebieten.

Wie wichtig diese Forschungs- und Entwicklungsvorhaben sind kann man einer Studie [3] entnehmen, in der angegeben wurde: "...aufgrund der Vervollkommnung der Landmaschinen die Steigerung der Arbeitsproduktivität in der Pflanzenproduktion in den USA sogar um 50% erwarten kann. Die vervollkommneten Maschinen für Luzerneernte werden die Steigerung des Ertrages an der Biomasse und am produzierten Protein bis 30% ermöglichen. Dank der geringeren Bodenverdichtung die erwartet wird, prognostiziert man die Steigerung des Ertrages um 30-50% nach dreijähriger Übergangszeit." Unserer Meinung nach klingt das sehr optimistisch, aber auch nur die Hälfte von diesen Werten zu erreichen wäre ein riesengroßer Erfolg.

3. ZUSAMMENFASSUNG

Die Hauptrichtungen in der Forschung und Entwicklung der Landmaschinen sollten
- für die Ökologie angepaßte Mechanisierung
- Energie und die Automatisierung in der Landtechnik
- Senkung der Fahrgänge und Bodenverdichtung
- effektivere Bodenbearbeitung, Futter- und Kornproduktion
- Anwendung der Elektronik und Robottechnik in der Landtechnik

werden. Es besteht der Bedarf zur Initierung und Durchführung von international koordinerten Forschungs- und Entwicklungsprogrammen in der Landtechnik.

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B E L G R A D E U N I V E R S I T Y
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WIRKUNG DER ZUSATZREINIGUNG DER ZUCKERRUBEN

S u m m a r y

Examination of one of the technical solutions for additional cleaning of sugar beet out of soil was done. The main working components of the machine are like specijal rolls which make up the so called "rolen-rost".
Examination results point out the following:

- of all the factors affecting the separation degree of soil, the most important is momentary soil moisture.
- higher percentage of momentary soil moisture decerases the degree of soil separation (and vice versa),
- mean value of separated soil during the examination was about 59,07% of total soil mass,
- the results of these examinations can be used as the basis for better machine design and economic effects.

Key words: sugar beet, uncleanliness, additional cleaning, rotary cleaners.

Einleitung

Im Rahmen der Gesamtmechanisierung der Zuckerrübenernte in Jugoslawien bedeutende Stelle haben die Erdanteile an Rüben. In der letzten Jahren das Problem ist bei der Zuckerindustrie sehr akut geworden und nimmt ständig mehr Aufmerksamkeit auf.

Das Problem wird leider einfach dirch die Abzüge "gelösst", so dass die abgezogene Mass nicht bezahlt und nicht für die Transportunkosten gerechnet wird. Die "Papierlösungen" bringen nicht dazu, das Problem zu lösen und die Erdmass wird geladen, transportiert und die Fabrik gebracht.

Die Probleme, die durch die hohe Erdanreile entstehen, sind zahlreich und verschiedenartig (3). Sie sind umso schwieriger je mehr Niederschläge in der Erntezeit fallen.

In Jugoslawien auf etwa 150.000 Hektar werden über 6 Mill. Tonnen Zuckerrüben erzeugt. Dazu sind noch 1,0 - 1,2 Mill. Tonen Erde, bzw. über 50.000 Tonnen pro Fabrik zu rechnen. Einige Fabrike müssten in extrem nassen Jahr die Unkosten von über 100.000 Tonnen Erde (d.H. etwa 4.000 Züge je 25 Tonnen) tragen. Die weitere Unkosten entstehen durch die Beseitigung der Erde aus der Fabrik.

Mit der Rübe werden die beste Bodenteile vom Acken weggenommen (2). Jahr für Jahr man fragt sich öfter, ob es möglich ist, durch die Bodenbearbeitung und - düngung die Bodenfläche biologisch in einer kurzen Zeit zu veredeln.

Besondere Schwierigkeiten bringen die Köpf - und grüne Teile. Wegen der ausgesprochen schlechten Wirkung ist man überzeugt, auch diese Teile zusätzlich wie die Erde zu reinigen. Man macht das nicht nur weil die organische (grüne) Teile wegen der unregelrechten Maschinenanwendung an der Rübeentstehen. Deswegen ist irgendeine Zusatzreinigung ungerechtfertigt.

Material und Arbeitsmethode

Die Arbeitsmethodologie ist in grösstem Umfang den konkteren Arbeitsbedingungen und der technischen Arbeitsmittel bei der Zuckerrübenernte angepasst.

Der Annahme-kasten der Reinigungsmaschine wurde mit der Zuckerrübe durch die entsprechende Schaufel einer Baumaschinen vollgefüllt. Von diesem Kasten gelangt die Rübe auf spezial Reinigungswalzen Typs "Rollen-Rost" und danach wird in der Transportmittel geworfen. Auf diese Weise werden die Transportmittel gleichmässig voll gemacht.

Zugleich wird die Köpfqualität geschätzt und die Daten später für die Ausrechnung der gesamten Beimischungen verwendet.

Die abgetrennte Erde (bzw. Beimischung) wird mittels eines zweiten Transportbandes auf den Boden gelegt. Die Probe für die Feststellung der Feuchtigkeit werden regelmässig vom Band genommen.

Von jedem LKW wird die Chiffre und entsprechende Daten für die EDV festgestellt. Durch das zweimalige Wiegen wird brutto und netto Masse und damit auch Beimischungmasse bekannt.

Untersuchungsergebnisse und - besprechung

Während der Untersuchungen die mittlere Wert der Momentalfeuchtigkeit der beigemischte Erde war um 33% (P_v = 33,26) im Vergleich zu apsolute Trockenerde. Man ging davon ab, dass die Erdfeutigkeit der grösste Einfluss auf den Reinigungsgrad hat. Alle andere Einflüsse, vereizelt und zusammen, haben kleinere Wirkung. Die Tab. 1 zeigt die Ergebnisse der Messungen von 16 Wiederholungen mit insgesamt 427 Tonnen Brutomasse der Zuckerrübe.

Tab. 1.

		Mittl. Wert	min.	max.
Momentfeutigkeit der Erde (P_v)	%	33,26	23,34	63,58
Gesamtmasse, brutto (G_b)	t	26,72	24,46	29,13
Gesamtmasse, netto (G_n)	t	22,65	18,81	24,87
Nichtgetrennte Beimischungen (G_{pn})	t	4,14	2,17	9,53
Getrennte Beimischungen (G_{pi})	t	1,30	0,23	3,14
Abgetrennte Beimischung (P_{iz})	%	59,07	20,73	88,27

G_b = Brutto-Masse (Zuckerrübenwurzel + organische Beimischung + unorganische Beimischung), festegestellt in der Fabrik

G_n = Netto-Masse der Zuckerrübenwurzel im LKW (G_b - organische und unorganische Beimischung), festgestellt in der Fabrik

G_{pn} = Beimischung-Masse (organische und unorganische) im LKW, festestellt in der Fabrik

G_{pi} = Masse der unorganische Beimischung, abgetrennt an der Maschine für die zusätzliche Reinigung (festgestellt bei der Reinigungsmaschine)

P_{iz} = Prozent der abgetrennten Beimischung im Bezug auf die gesamte unorganische Beimischung.

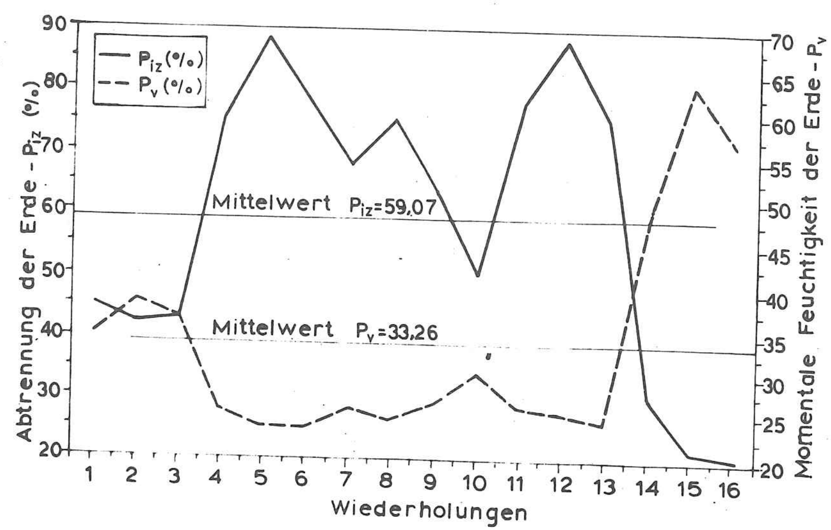
Da die Reinigungsamaschinen für die Trennung der unorganischen Beimischungen (also Erde) bestimmt ist, die Effektivität ihrer Arbeit wurde durch den Grad der Erdetrennung (P_{pz}) im Bezug auf die Gesamtmasse bekannt gemacht.

Die Daten über die gesamte Erde (G_{pzu}) bekommt man auf Grund der bekannte Wert auf der Maschine abgetrennte Erde (G_{pi}), der Masse der gesamten Beimischung (organisch und unorganisch) in der Zuckerfabrik (G_{pn}) und Schätzung der organischen Beimischung (P_{op}):

$$G_{pzu} = G_{pi} + G_n \times P_{op} / 100 \quad \text{(Tonnen)}$$

Die Daten der Massenverteilung verschiedenen Grösse waren die Grundlage für die Berechnung der relativen Anteile dieser Grösse, wo die Berechnungsgrundlage die Nettomasse der Zuckerrübe (G_n) war.

Bild 1. - Die Wert der momentale Feutigkeit der Erde (P_v) und Prozent der Abtrennung (P_{iz})



Die mittlere Wert der Feutigkeit der abgetrennte Erde während der Untersuchung war um 33,24% und der mittlere Grad der Abtrennung der Erde lag bei 59,07%.

Bild 1. zeigt die Wertänderung des Abtrennunggrades der Erde je nach Wiederholung im Bezug auf die Gesamtmasse der Erde (gleichzeitig wird die momentale Feutigkeit der Erde gezeigt).

Es ist sehr klar, dass die grosse Abhängigkeit zwischen momentale Feutigkeit der Erde (P_v) und den Abtrennunggrad (P_{iz}) besteht. Die Abhängigkeit zwischen P_v und P_{iz} ist negativ und sehr gross (R_{xy} = - 0,9119).

Das bedeutet, dass man mit der Erhöhung der momentale Feuchtigkeit der Erde immer kleinenen Abtrennunggrad erwarten kann.

Zusammenfassung

Es wurde eine technische Lösung für die zusätzliche Abtrennung der Erde von der Zuckerrübe untersucht. Die Hauptreinigungselemente waren in der Form eines Bandes mit Rollen des Typs Rollenrost.

Die Ergebnisse der Untersuchungen zeigen unzweideutig folgend:

- von allen Faktoren, die auf den Trennunggrad beeinflussen, die grösste Bedeutung hat die momentale Feutigkeit der Erde,

- höhere Prozente der momentalen Feutigkeit vermindern den Antrennunggrad (sowie ungekehrt),

- mittlere Wert der Abtrennung der Erde bei der Untersuchung lag um 59,07% von gesamter Wert der Erdmasse,

- die Ergebnisse dieser Untersuchung kann man als gute Grundlage für die Verbesserung der Konstruktuon der Maschinen sowie für die Berechnung der wirtschaftlichen Effekte bei der Maschinen für die zusätzliche Reinigung der Zuckerrübe verwenden.

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B E L G R A D E U N I V E R S I T Y
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POSSIBLE SOLUTIONS TO THE PROBLEM OF LARGE AMOUNTS OF LIQUID MANURE

Introduction

Liquid manure on farms having a great number of livestock (swine, first of all) can be assessed from two opposite viewpoints at the same time (5):

- as a large mass of properties which can be a source of great environmental pollution (water, soil, air), and
- as an important organic fertilizer valuable as a substitute for mineral fertilizers having positive effects on total soil conditions.

The immediate aim of the investigation is to out solutions to decrease environmental pollution of farms having a large number of livestock and the most possible utilization of liquid manure as a natural organic fertilizer.

S u m m a r y

Inappropriate location of large farms makes great problems: large quantities of liquid manure on the farms and environmental pollution.

Decreased application of natural organic fertilizers, general conditions of arable land are getting wors from year to year.

The solution of the problem of large amounts of liquid manure should concurrently include the problem of small organic mass content (humus) in arable land.

Deficiency of storage capacities is the cause of using natural liquid manure on a small scale. It is used only in the vicinity of the farms.

Compost making on the basis of natural liquid manure and wheat straw is an expensive procedure. Its application is justified because of high value of its essential nutrieents and organic and biological value of compost.

The separation of liquid manure gains its significance with the application of adequate separators and with lesser energy consumption.

Key words: natural liquid manure, compost, separation, storage place dislocation, environmental pollution.

The Existing Situation

In the last few decades in East Europian countries there has been a trend towards constructing large farms especially those for mest production (swine, cattle, poultry). The main reason and justification for this was a desire for better cost-effective investments and better labour force engagement.

Among a number of mistakes of such conceptions was a disparity between the number of livestock and available arable land. The most serious consequences of the fact were the following:

- large quantities of liquid manure which could not be used as organic manure in the immediate vicinity, and
- great concentration of livestock and liquid manure caused big and almost often unsolvable problem of environmental pollution.

In the construction of large farms there often occours another mistake with negative outcomes obvious later on. This mistake refers to the incomplete construction of farms, i.e. to topic of liquid manure. The background of the fault is an incomplete definition of all liquid manure treatments particularly its keeping, cultivation, and use. Another aspect of this error is the fact that storage capacities for liquid manure are incomplete at least in two respects:

- small storage capacity for the minimum period of four (six) months, and
- inadequate storage places in regard to the possibility of liquid manure cultivation in particular to the possibility of the keeping controlled.

There is another phenomenon relating to the problem of large farms and amounts of liquid manure. Over the same span of3 - 4 decades natural organic fertilizers were stted to be constantly less applied, whereas chemicals (mineral fertilizers, pesticides, herbicides) were in use more and more. Such a practice results in many negative consequences like: soil structure spoilage, reduction of soil bilogical activity, increase of energy consumption for soil cultivation, increase of pollution degree, etc.

The existing situation can be summerized as follows:

1. There is a strong necessity of the soil for natural organic fertilizers.
2. The availability of large liquid manure amounts on the farms with a great number of livestock.

Possible Solutions

Working out the problem of large liquid manure quantities has been done for several years under different conditions. They refer to the farm location in relation to settlements and availability ofarable land, on-farm conditions concerning buildings for liquid manure, equipment, trained personnel, etc.

In addition to the solutions for large liquid manure quantities, the immediate objective of the inestigation was necessity for making as large quantities of organic fertilizers as possible in the form most suitable to the soil. These forms are (in order of significance):

(a) solid manure compost, respectively,
(b) solid stage from natural liquid manure,
(c) natural liquid manure,
(d) liquid stage from natural liquid manure.

Each solution had to fit in the economy of total treatments. Considering the complexity of all treatments, total expenses and final effects of the manure, the sequence of the solutions would be:

(a) natural liquid manure,
(b) compost with natural liquid manure,
(c) separation of natural liquid manure by using both stages:
(c_1) solid stage as compost,
(c_2) liquid stage.

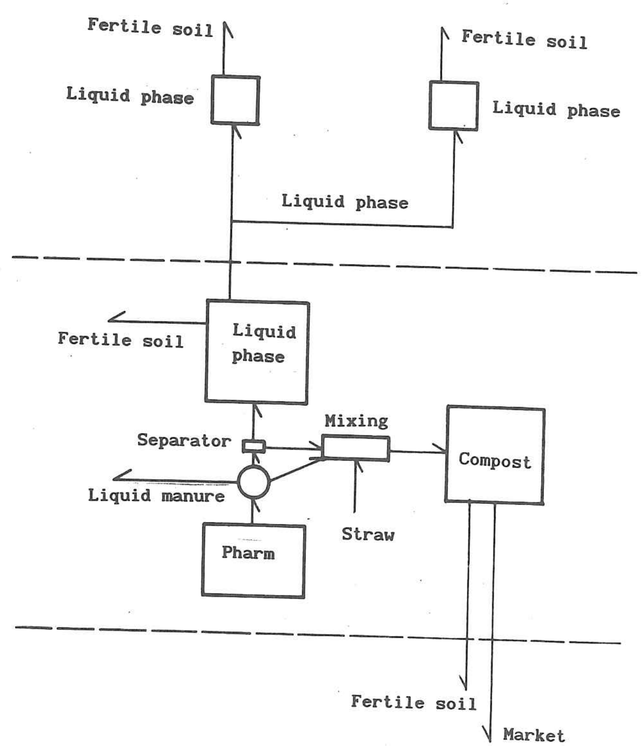

Fig. 1 - Relationship between natural liquid manure with 1 and 5% of dry matter and straw (l/kg) in 10 min. interval of contact

(a) Natural Liquid Manure

The simplest treatment which understands preserving of the total natural liquid manure mass in the best condition to the very moment of application as a fertilizer (4).

In this application there are two important conditions providing the profitability of the treatment:

- dry matter content as much as possible, e.g. 4-5% in natural liquid manure of swine,

- sufficient size of arable areas in the immediate vicinity of the farms.

In conditions of widespread practice this treatment is difficult to realize. The main reason is a small capacity of the existing storage places but also the fact that most often they do not meat the essential reauirements. Another thing is the fact that dry matter content in natural liquid manure is almost without exception very low so that the effects of natural liquid manure application are minimal.

Navertheless, the use of natural liquid manure remains the most acceptable solution, first of all in arable areas nearest to the farm.

(b) Compost = Natural Liquid Manure + Straw

The solution of the problem of large liquid manure amounts on the basis of compost is based on two essential facts:

1. - insufficiency of appropriate storage capacities for natural liquid manure and impossibility to construct them subsequently,

2. - great needs for solid organic natural fertilizers in those arable areas where organic matter content (humus) desreased to a half (or even less than half).

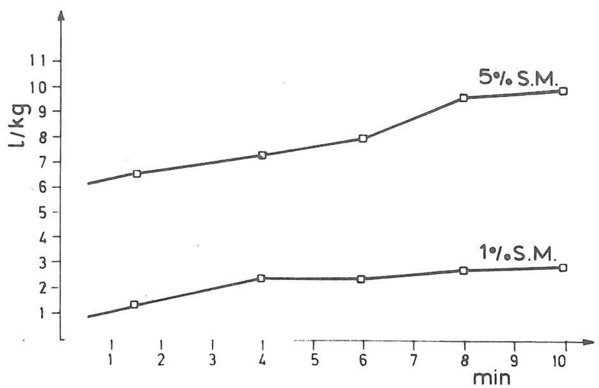

Fig 2 - Buildings and treatment at the swine farm and treatments of liquid manure inculding dislocation of storage place for liquid stage

The whole treatment of solving the problem of large liquid manure quantities by composting is a very expensive procedure. The cost of straw participates most in total expenses. It is for this reason that the total use of straw should be as low as possible. The essential way to achive this is high dry matter content in natural liquid manure with chopping of straw and sufficient time for both basal masses to contact.

Compost making and cultivating is done in a usual way (3). Compost cultivation finishes fairly early, 30 - 35 days, so that there would be favourable room for its cultivation. When compost is ready it is immediately

taken to the place where it is going to be used or it is put in prisms up to 3 m high.

The advantages of compost are determined according to:

- the value of essential nutrients in relation to their quality and value in mineral fertilizers, and

- organic and biological value.

If its essential value on the basis of nitrogen, phosphorus, and potassium content doubles because of its organic and biological value then all expenses (including values of both masses) are certainly made up for. Compost quality has a high market value, first of all in intensive crop production in market gardening and horticulture. That is why large quantities of compost are placed at the markets long distances from the farms.

(c) Separation of Liquid Manure

Previous ways of liquid manure separation regardless numerous trials and use of several types of separators were unsuccessful. The main reasons were large energy consumption, expensive separators, and their susceptibility to damage. In recent years better solutions for separators have been in use so that there are several justifications for this treatment:

(c_1) The obtained solid stage from natural liquid manure has value equal to solid organic fertilizer and as a base for making good-quality compost. Such a product can be placed at the markets long distances from the farm.

(c_2) Liquid stage after the separation (that is to say, after separating solid portions from natural liquid manure) remains organic fertilizer of high nitrogen, phosphorus, and potassium content. This mass is easy to handle with pumps and pipelines so that different ways of storage and use are possible.

Dislocation of storage place is always advisable because of large amounts of liquid manure. Only a small part of storage capacity is built on the farm then. The rest is divided into 2 - 3 places suitable to arable land areas.

Filling storage capacities out of the farms. which can be at larger distences (2 - 5 km) is regularly done with pipes, those used in irrigation systems. Similarly, pumps are used although it is much more convenient to use the so cold mud pumps.

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TRENDS IN AGRICULTURAL ENGINEERING
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MEASURING THE ACTUAL CUTTING WIDTH OF A COMBINE BY MEANS OF AN ULTRASONIC DISTANCE SENSOR

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An ultrasonic distance sensor was tested to measure continuously the effective cutting width of a combine. The sensor that was used, is a micro-processor based unit, commercialy available for industrial applications. By adapting software parameters, the sensor could well be adapted to the specific requirements in this application. In a crop, where plain crop edges are formed, the absolute accuracy of the sensor is 0.12 m, which equals the row spacing. The error on the accumulated width measurement over a 22 m wide and 100 m long field strip was below 0.37 m.

1. INTRODUCTION

A combine harvester may either be equipped with a row-crop header or a regular cutterbar. In the first case, the actual cutting width is the product of the row spacing and the number of rows harvested. It is a discrete variable which equals the full width of the header for most of the time. In the second case, the actual cutting width is a continuous variable and is always less than or equal to the full cutterbar width.

The continuous measurement of the yield during the harvesting operation is based on the following equation:

$$Y = \frac{Q}{V\,W} \qquad \text{(eq. 1)}$$

with: Y: yield (kg/m²); Q: flowrate of grain (kg/s); V: machine travel speed (m/s); W: cutting width of the machine. Most authors reporting on yield mapping work /1//2//3/ measure Q and V, but assume a constant width W. Since the actual cutting width may deviate from the full width by more than 10%, this introduces errors of the same magnitude. Continuous measurement of the actual cutting width can improve the accuracy of the yield estimate /4/.

Since operating a combine is a very demanding task, requiring simultaneous attention to many different aspects, there is a need for automating several functions /5/. An automatic pilot, taking over the steering function during normal operation could both improve the performance of the machine, and lower the mental load on the operator.

The objectives of the work reported in this paper were:
- the selection of a measurement principle for the actual cutting width of a combine
- testing the reliability and accuracy of the sensor
- use of the sensor in continuous yield measurements

2. EQUIPMENT

2.1. Requirements - Alternatives

The following requirements could be specified for the sensor:
- Measurement range: at least 1/4 th of the header width. It is very rare for the actual cutting width to be less than 3/4 th of the header width.
- The accuracy should be within ± 1 row spacing. For wheat or barley with a row spacing of around 0.12 m, this corresponds to 1.5 % to 3.5 %, depending on the full width of the header. This is considered as the minimum required accuracy in order to get an acceptable accuracy in the yield measurement.
- The sensor should be reliable.
- It should operate under rough conditions: dust, temperature variations, vibrations ...

An additional difficulty, inherent to this application, is the fact that there are no sharp and solid physical crop boundaries.

Several principles were considered. Mechanical switches were rejected for several reasons: limited measurement range, risk for jamming by straw stalks, no firm edge available ... An array of optical switches would be complex to build and very susceptible to dust. An ultrasonic transducer was retained as a promising solution to the problem. The measurement range, the robustness and the insensitivity to dirt were considered as the main advantages /6/.

2.2. The MultiRanger

A Milltronics MultiRanger(+) was used in this work. This is a multipurpose level monitoring system, consisting of a transducer, a micro-processor based processing unit and a calibrator. The transducer emits ultrasonic pulses. The echo, reflected by the target, is processed and the time difference between emission and reception is extracted. This time difference is converted into distance, material level, volume, or differential level, depending on the application. The measurement result is displayed and also available as an analogue output.

The unit that was used in this work has a measurement range between 0.3 m and 15.2 m, and an accuracy of 0.25% or 6 mm for distances less than 3 m. By means of the built-in calibrator, parameters can be entered, which makes it possible to adapt the system to specific requirements. Especialy following capabilities were interesting for our application:
- Several modes of measurement: in one of these, the output signal was directly proportional to the actual cutting width.
- Damping rate: the maximum rate of change of the width can be entered. This reduces the chance for meaningless outputs, even if the actual measurement was meaningless.
- Several failsafe modes: in one of these, the unit will output the last good measurement, in case no echo can be received.

(+) MultiRanger is a product of Milltronics, P.O. Box 4225, 730 The Kingsway, Peterborough, Ontario, Canada K9J-7B1. Product specifications are included for completeness only, and don't hold any recommendation by the authors.

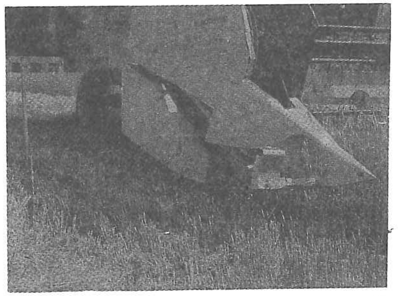

Fig 1: view of the transducer, mounted on the combine header

- Adjustable confidence threshold levels for long and short shots. It is possible to make the system deny low unwanted echoes, e.q. caused by stubbles, instead of the actual crop edge.
- Agitator discrimination: this allows suppresion of disturbances which might be caused by objects moving in front of the transducer for a short time, such as the fingers of the reel.

Several additional options exist, such as: automatic temperature compensation and differential measurement, using 2 transducers. These options were not available on the system that was tested here.

2.3. Mounting of the transducer

The transducer was mounted on the left crop divider, and aimed at the crop edge, such that the unused part of the cutterbar is measured (Fig. 1). Since the same component is used to emit ultrasonic pulses and to receive the echo, there is a minimum distance required between the transducer and the crop, called the dead zone. Therefore the transducer had to be mounted with an offset of at least 0.30 m. This offset, together with the fact that only one transducer was used, puts some restrictions on the way the field could be harvested: the combine always had to be driven clockwise around the field.

Aiming the transducer was somewhat critical. Since the beam of the sound pulses has a divergence angle of 12°, care should be taken to avoid false echos caused by nearby stubble. The smaller the actual cutting width, the more likely this is to occur.

2.4. Data acquisition

In addition to a digital display, the sensor also has a standard current output (selectable: 0-20mA / 4-20mA). This current output was converted to a voltage range of 0-5 V, and sampled by means of a analog input card in a personal computer.

3. THEORETICAL ACCURACY LIMITATIONS

There are several reasons for which the accuracy in the actual cutting width measurement is limited.

Error source I: Assume a simplified situation as it is shown in fig. 2. Line BB' represents the path of the right crop divider; line AA' is the trajectory of the right crop divider during the previous, adjacent pass. The distance between these lines is the actual cutting width W_a. The sensor however measures the distance d between the transducer and the crop edge, and calculates W_s. Since AA' could have been anywhere between the two adjacent rows, it follows that there is always an underestimation of the actual cutting width of between 0 and ΔR. Adding 0.5 ΔR or 0.06 m to the sensor output shifts this uncertainty range to -0.5 ΔR and +0.5 ΔR.

Error source II: There no sharp boundary between the crop and the harvested part of the field; but rather a transition zone. The sound pulse, emitted by the transducer, is reflected by the stalks and

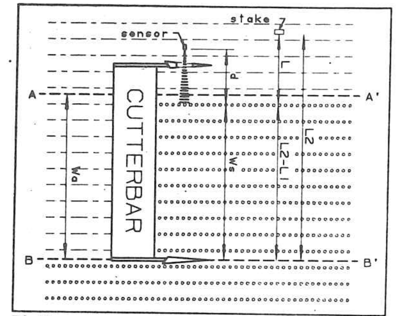

Fig 2: error source I

ears in this transition zone. Therefore, it can be expected that the reflected echo is in fact a multiple of echos, caused by different stalks. The first echo that crosses the trehold level is processed by the sensors software. It is likely that this echo is caused by one of the nearest stalks. Since the grain plants of a row are irregularly distributed over a narrow strip at both sides of their theoretical centerline and also because the earse may hang over, this will result in an overestimation of the actual cutting width. Sometimes, at least during stationary measurements, it was not the nearest, but the second nearest row that was detected. In that case, the sensor gives an underestimation.

Error source III: Temperature variations are another source of error. The distance is determined from the time it takes for the ultrasonic pulse to travel back and forth between the transducer and the target. The speed of sound in air is a function of temperature: for a deviation of ±10°C around 20°C the speed of sound changes with ±1.7%. Assuming an average distance of 0.6 m to be measured (dead zone included) this can introduce an error of ±0.01 m. Since this is significantely smaller then the other errors, this is acceptable. The 'Multiranger' system has the possibility for automatic temperature compensation, but this option was not used. Another possibility is to use the reference measurement, which is available each time the header is out of the crop, to calculate a correction factor.

4. RESULTS AND DISCUSSION

4.1. Preliminary tests

Preliminary tests were done under laboratory conditions, with the transducer aimed at a fibreboard. The results showed that, for a solid target, the sensor meets the accuracy specified by the manufacturer. In a second test series, a row of wheat stalks was used as the target. It was anticipated that, in this situation, the reflected pulse might be to weak to be detected. It turned out however, that one single wheat stalk could be detected, within the accuracy specifications, up to a distance of 5 m .

Next, stationary measurements were done in the field: The transducer was mounted on the header, but the combine was not travelling during these tests. The difference between the sensor reading and the reference measurement was mostly less than or equal to 0.003 m, with some outliers up to 0.007 m. These rather small errors can be attributed mainly to the second error source that was mentioned in section 3. During some of these measurements the sensor output varied over a range of 2 to 6 cm. Changing the threshold value often resulted in a more stable reading. The presence of several echos of approximately equal strength can explain this.

4.2. Accuracy tests under normal field operation

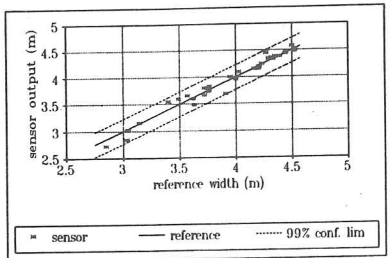

Fig 3: difference between reference width and sensor output for an instantaneous reading

It was not possible to determine the accuracy of the sensor precisely, since there was no possibility to make an exact reference measurement. However, two different tests were done which allow a good assessement of the accuracy during normal field operations.

In the first series of measurements, a stake with a reflector was positioned somewhere beside the crop edge, and the distance between the stake and the crop edge (L_1) was measured (fig. 2). When the combine passed the stake, an optical switch triggered the sampling of the ultrasonic sensor signal. Afterwards, the distance between the stake and the new crop edge (L_2) was measured again. The difference L_2-L_1 is called the reference width. Results are shown in fig. 3: the asterisks represent the observations, the solid line is the reference width. The average difference between the reference width and the sensor value ((L_2-L_1-W_s') was -0.003 m and the 99% confidence interval is -0.235 m - 0.229 m. Care should be taken in interpreting these values. The reference width (L_2-L_1) suffers from a similar uncertainty as the sensor reading (error source I, see section 3). This results in an overestimation of the confidence interval by ΔR at both sides, wich means that the accuracy interval for the sensor would be: -0.115 m - 0.109 m. This accuracy of 0.12 m approximately equals the spacing between the rows.

In the second test, the accumulated width signal from the sensor was compared with the reference measurement, for a grain strip of 100m by approx. 22m. The reference measurement was obtained by taking the difference of the distance between the crop edge and reference stakes, before and after harvesting the entire strip. The result is given in fig. 4: the solid line (bottom part of the graph) is the reference measurement, the dashed lines are width signals obtained by the sensor. The upper part of the graph shows the difference between the sum of the width signals and the reference

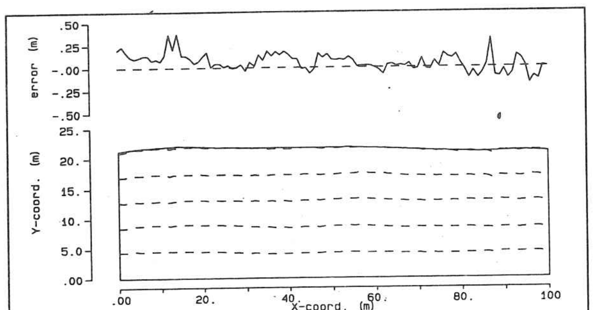

Fig 4: difference between reference width and sensor output for a block of 100m x 21m

measurement. The average error was 0.06 m and ranged between 0.18 m and 0.37 m. This corresponds well with the results of the previous experiment. However, here we find a slight under-estimation of the actual cutting width, were the previous experiment showed no bias.

4.3. Use of the sensor in continuous yield measurements

In the introduction, the usefulness of the actual cutting width measurement for the continuous estimation of the yield, was argued. To illustrate this, fig. 5 gives the yield signal for a trajectory in the field, mentioned in section 4.3. The yield is calculated twice, once using the measured actual cutting width (solid line), and once assuming a constant width of 4.24 m. From section 4.3, we know that the average cutting width was 4.24 m; without that knowledge we might have used the header width 4.57 m.

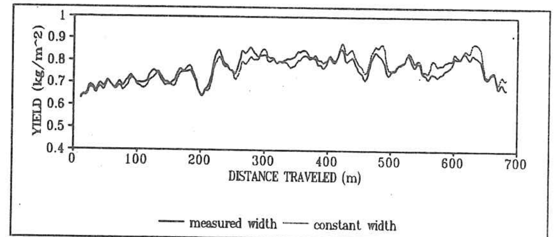

Fig 5: calculated yield signal, with and without using the actual cutting width signal

5. CONCLUSIONS

The results of this work lead to the following conclusions.

1. It is possible to measure continuously the actual cutting width of a combine by means of an ultrasonic distance sensor. The main condition is, that the crop is not lodged and that clear crop edges are formed.
2. Under normal field conditions the measurement accuracy was $\pm$0.12 m or one row spacing.
3. The sensor is robust and can withstand the rough conditions on a combine header. It is insensitive to dirt and dust.
4. Errors resulting from temperature variations are small.
5. The reliability of the sensor output is obtained by sophisticated signal processing, which can be adapted to specific conditions.
6. Measurements of the actual cutting width during the harvest of a 5 ha wheat field showed that on average 7% (0.35 m) of the cutterbar was not used.
7. Using this sensor, the accuracy of continuous yield measurements can be improved.

6. ACKNOWLEDGEMENT

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THE KINETICS OF TEXTURE DEVELOPMENT OF POTATOES IN PRECOOKED CHILLED FOODS DURING PROCESSING AND SUBSEQUENT STORAGE AND REHEATING

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The interruption of the cooking process with a refrigerated storage period was studied for its effects on the texture kinetics of potatoes. Three refrigerated storage periods (0h, 24h, and 96h) were investigated. A significant increase in firmness after storage of 24h or 96h compared to an uninterrupted cooking process was found.

texture kinetics; mathematical modelling; cook-chill; potatoes

1. INTRODUCTION

Precooked chilled foods to be stored at temperatures between 0°C and 3°C - for several days typically, to even several weeks in some cases - and that only need reheating before consumption respond to a growing need for convenience and time saving cooking. This cook-chill technique also finds important applications in the catering industry. Restaurants are now able to disconnect production and peak-consumption of their meals. The diversity in the assortment can be enlarged while at the same time the production can be efficiently organized /1/.

A conventional cooking process of a meal consists of one heating process immediatly followed by the consumption. With precooked chilled foods the cooking process is split up into a cooking process in the factory and one at the place of consumption. The manufacturer of precooked chilled foods has to instruct the consumer directions on how long and how his meal should be reheated to become tastefull with an optimal texture. Herefore it is necessary to predict the texture development during the cold storage and the subsequent reheating. The research reported in this paper relates to the effect on the texture kinetics of the interruption of the cooking process by a cold storage treatment. The texture development of a potato variety (Bintje) in a cook-chill process is described.

2. TEXTURE KINETICS DURING PROCESSING

Untill now considerable work on the kinetics of texture of vegetables, including potatoes, during cooking has been done /2/,/3/,/4/,/5/,/6/. However, there is little work on texture development when the processing is interrupted with a cold storage step. The biochemical mechanisms underlying the texture changes are not fully understood.

Kozempel /7/ developed a first order model for precooking and cooking independent of potato variety and valid in the temperature range of 75°C to 100°C.

$$\ln\frac{F}{F_o} = -k.t \qquad (1)$$

The temperature dependence of the rate constant k could be described by the Arrhenius equation.

$$k = k_o . e^{-\frac{E_a}{RT}} \qquad (2)$$

Kozempel /7/ did not find any significant effect of cooling after heating on the texture. Other authors found firming effects due to interruption of the cooking process and cooling. Wu and Chang /8/ investigated the influence of precooking at 40 to 70°C on the firmness of broccoli, asparagus letuce and large-stem mustard. Optimal firming temperatures - 50 to 60°C - coincided with optimum temperatures of pectin-metylesterase activity. Bartolome and Hoff /9/ also found a firming effect of precooking at 70°C on potatoes. They also postulated that pectin-methylesterase would generate more free carboxyl-groups wich would form Ca-bridges what leads to a firmer structure. Other authors made other hypotheses : Reeve /10/ said that starch retrogradation would be the reason. Changes in intercellular adhesion because of amylose diffusing into the cellwall were postulated by Linehan and Huges /11/.

3. MATERIALS AND METHODS

3.1. Materials

Potatoes of the variety Bintje harvested during October of 1991 were used. Experiments were performed after 6, 12, 15, and 17 weeks of storage at 4°C.

3.2. Sample preparation

One day before each experimental run potatoes were washed and placed at room temperature. The potato tubers were cut in thick slices of approximately 30 - 40 mm. Out of these slices, 20 mm diameter cilinders were cut and trimmed to a lenght of 10 mm with a two bladed knive.

3.3. Experimental design and procedure

After cutting, all the samples for one experimental run (R) were randomly allocated to a treatment. The cooking treatment factors considered in these experiments are cooking time (C) at 3 levels : 3, 6 and 12 minutes, temperature (T) at 4 levels : 75, 82, 90 and 100°C and refrigerated storage at 4°C for 96 hours, for 24 hours and for 0 hours (no interruption of the cooking process). This is further denoted by interruption (I).

In each experimental run 12 cooking batches were performed. In each cooking batch an other combination of cooking time and temperature was set. These 12 combinations were run in a random order. The potato samples were cooked in a wire basket divided in 3 compartments. Each interruption treatment was randomly assigned to a compartment. Each compartment contained two potato samples.

Distilled water was used for cooking to avoid interference of ions on the texture kinetics. Cooking time was measured from the time samples went into the water until they came out of the water. Cooked samples were immédiately placed in distilled water at 20°C. After 5 minutes of cooling the texture measurement was performed.

3.4. Texture measurements

The samples were compressed up to breakage in an uniaxial compression test. The constant deformation speed of the universal testing machine was set at 50 mm per minute. The rupture force was used as a measure of texture.

4. RESULTS

4.1. Analysis of variance

The purpose of the analysis of variance was to determine which experimental factors and which of their interactions had a significant effect on the texture measurement. Significant effects will be taken into account in the regression models that will be developed later on.

Normal distribution and constant variance conditions were tested. A transformation of the data was needed to achieve these conditions. Based on the results of Kozempel /7/ a logaritmic transformation looked appropriate.

Computation was done using SAS-procedures /12/. The results are shown in Table 1. The experimental run (R) is a block factor. Interactions of this block factor with the other experimental factors were used to test the significance of these factors. This is illustrated in colum 3 of Table 1. The arrows denote which error sources are used to test the significance of the experimental factors.

The temperature and the cooking time as well as their interaction (TC) have a significant effect on the breaking force. This result is in agreement with other authors. This model also shows that an interruption effect exists but the interactions are not significant, except TCI.

Table 1 : results of the analysis of variance

source of variance	DF	significance testing
R(experim. run)	3	
T(temperature)	3	**
C(cooking time)	2	**
TC	6	**
RT	9	
RC	6	
RTC	18	
I(interruption)	2	**
TI	6	
CI	4	
TCI	12	*
RI	6	
RTI	18	
RCI	12	
RTCI	36	

* : significant on a 95% level
**: significant on a 99% level
DF: degrees of freedom

4.2. Multiple comparison

To analyse the interruption effect in more detail a multiple comparison test between the three levels of interruption was done. It was seen from this test that there were differences - on a 99% significance level - in effect between no interruption and 1 day of interruption and between no interruption and 4 days of interruption. However, there was no difference between 1 and 4 days of interruption.

4.3. Regression models

To describe the experimental data, the following first order differential equation was used for the uninterrupted cooking process.

$$\frac{dF}{dt} = -k.F \qquad \text{with } F(t_o) = F_o \tag{3}$$

Integration of this equation gives:

$$\ln F = \ln F_o - k.t \tag{4}$$

To model the firming effect of the cooling step, the same first order kinetics can be used but the initial value F_o appears to be multiplied with a firming factor i. This firming factor is the same for 1 day interruption and for 4 days of interruption as is shown by the multiple comparison test.

$$\frac{dF}{dt} = -k.F \qquad \text{with } F(t_o) = F_o.i \tag{5}$$

Integration gives:

$$\ln F = \ln F_o + \ln i - k.t \tag{6}$$

Because the interaction effect of interruption with cooking time is not significant (see Table 1) we can say the interruption effect is the same for each cooking time and so the texture rate constant k is the same for the interrupted and the non-interrupted cooking process. The result of these regressions can be seen in Figures 1 and 2. The numerical values of k, F_o and i are found in Table 2.

Altough the interaction between interruption and temperature IT is not significant on a 95% level it is significant on a 90% level. Therefore it is possible that i is a function of temperature. In Figure 3, $\ln F(t_o)$ is plotted against temperature. In Figure 4, k is plotted in an Arrhenius plot. It is obvious that for the results of this experiment the Arrhenius law is not valid.

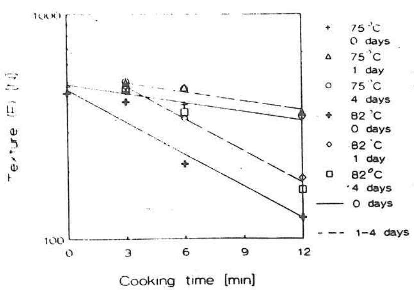

Figure 1 : Texture degradation during cooking (75 and 82°C)

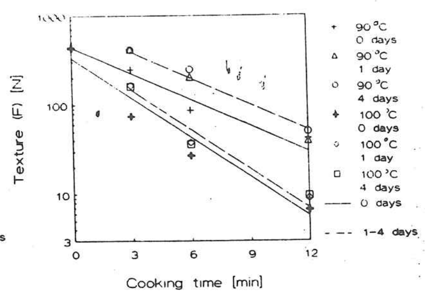

Figure 2 : Texture degradation during cooking (90 and 100°C)

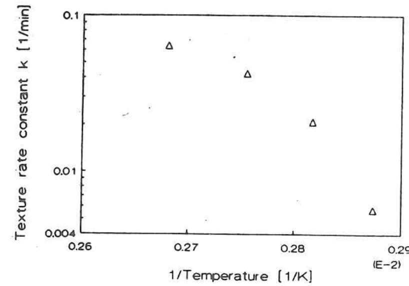

Figure 3 : Interruption effect on texture as a function of cooking temperature

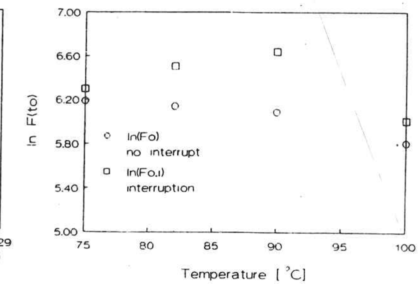

Figure 4 : Arrhenius plot of the texture rate constant k

Table 2 : Regression parameters

Temperature [°C]	k [min^{-1}]	F_o [N]	i
75	0.0057	487	1.12
82	0.021	463	1.44
90	0.042	441	1.74
100	0.064	333	1.22

5. DISCUSSION

Although the Arrhenius law seems not valid in these experiments it would not be appropriate to reject it. Because of a relative slow heat transfer, it takes some time for the samples to reach the cooking temperature. It also means that texture degradation is slowed down in the first minute of cooking. This would be more pronounced at higher temperatures which would explain the over estimation of the texture rate constant k by the Arrhenius model at high temperatures.

An other explanation would be that at some temperature there is a change in the mechanism of texture degradation. This would result in a twist on the Arrheniusplot. Pravisani *et al.* /13/ found an alteration of the mechanism at 67.5°C for starch gelatinization in potatoes. Also Suzuki *et al.* /14/ and Bakshi and Singh /15/ found this phenomenon during rice boiling at 110°C and 85°C respectively.

Apart from this it can not be denied that a firming effect due to the interruption exists. It seems that in some way a structure is built or rebuilt. According to Reeve /16/ structural changes in potatoes due to cooking involve starch gelatinization and separation of cells.

During gelatinization starch granules take up water and swell. Amylose chains are released from the granules. When these amylose chains are allowed to cool down - during the interruption period - retrogradation takes place. The amylose chains interact with each other and cristalize /17/. This results in a firmer structure.

At the same time another mechanism in the cell walls can take place. Pectin-methylesterase is activated by the first cooking process and starts to make free carboxyl ends by demethylation of the methylated uronic acids in the pectine. These free carboxyl ends can form Ca-bridges. So more bindings within the cell wall are created which results in a firmer structure. As can be seen in Figure 3 there seems to be an optimum temperature for the firming. This supports the pectin-methylesterase hypothesis. One can say that the effect is less at higher temperatures because of the deactivation of the enzymes.

Probably the firming effect found in these experiments is due to a combination of these two factors, starch retrogradation and the activity of pectin-methylesterase in the cell walls.

6. CONCLUSIONS

A firming effect exists following the interruption of the cooking process for a period of cold storage. The overall texture kinetics are not altered by this interruption which means that the texture change rate stays the same for uninterrupted and interrupted cooking processes. The firming effect can be modelled by an apparent initial texture which is the real initial texture multiplied by the firming factor *i*.

This firming effect seems temperature dependent but more experimental evidence is needed to draw definite conclusions. The texture change rate constant *k* does not follow the Arrhenius law in the temperature range 75 to 100°C.

7. SYMBOLS

E_a apparent activation energy [J/mol]
F breaking force [N]
F_o breaking force of the raw potatoes [N]
i firming factor [1]
k texture rate constant [1/min]
k_o texture rate constant at infinite temperature [1/min]
R universal gas constant [J/mol.K]
t time [min]
t_o initial time [min]
T temperature [K]

8. ACKNOWLEDGMENTS

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THE EFFECTS OF THE VELOCITY AND DIRECTION OF WIND UPON THE QUALITY OF FERTILIZING BY AGRICULTURAL AIRCRAFTS

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SUMMARY

The purpose of this paper is to determine the effects of the velocity and direction of the wind upon the quality of fertilizing as to the pollution of the enviroment, by agricultural aircrafts.
If the wind direction is perpendicular to the aircraft flight direction, then the swerving of the urea particles from the theoretical working width (30 m) occurs at higher wind velocity than 1 m/sec.The particles of KAN are more inert so that critical wind velocity is higher: 1,2 m/sec.
If the aircraft flight direction is congruent with the wind direction, then wind velocity exceeding 1,0 i.e. 1,2 m/sec.will not essentially effect the uniformity of the fertilize dosage over the working width, but will have a significant effect upon the pollution of the enviroment, especially if the fertilizer containes fine fractions(dust).

Key words: agricultural aircraft,velocity and direction of wind, fertilize dosage,pollution of the enviroment.

1. INTRODUCTION

The production of food is a strategic activity of man in his fight for survival and development.The exponential growth of population in the world and limited resources in the production of sufficient quantity of healthy food are major problems but they are also the challenge to the agronomists and agricultural science.The solution lies in the rational increase of agricultural crop yields which is greatly dependant on the application of organic manure and fertilizers.After Popović (1985),the increase in agricultural production results primarily from the use of fertilizers.The percentage of the effect ranges from 40 to 70 per cent(France,USA,Germany).

After Ratschow(1987)to reduce the production costs,besides stabilization or even the increase of yields, and taking into account at the same time more severe requirements of the enviroment protection,it is necessary to search for such technical and technological solutions which will make the application of fertilizers cheap and which will not cause the pollution of human enviroment.

High precision rate in application of the fertilizers is a great demand in wheat top dressing because of the application of small dosage of nitrogen fertilizers (100-150 kg/ha) with high content of the active matter and strong influence on yields.Therefore,the fertilizer distributors of uniform distribution of the fertilizer particles over the field,not only in the flight direction but also perpendicular to the direction of the machine or aircraft run during the operation of fertilizing should be used.

To apply solid fertilizers ground mechanization and agricultural aircrafts are being used.For top dressing of wheat,especially if the fertilizer particles are not even in size,the use of pneumatic fertilizer distributors is recommended.

The target of the research has been to determine the effects of velocity and wind direction upon the quality of fertilizing by agricultural aircrafts, i.e. upon the uniform distribution of the particles of fertilizer over the field, as well as upon the pollution of the enviroment.

2. MATERIAL AND METHOD OF WORK

The subject of the research is the agricultural aircraft PZL M 18 Dromader in the application of fertilizers.PZL M 18 is oneseat aircraft of metal structure with fixed undercarriage.It is a low-wing aircraft fitted with star piston engine.Wing span is 17,7m.Max.airspeed is 256 km/h,and min. 116 km/h.Working speed ranges from 170 to 200 km/h.Take-off runway is 190 m long.Landing length is 250 m.Aircraft payload is 1500 kg.Dosing unit operates on diffuser principle.

For sampling of the applied fertilize dosage(kg/ha) specially designed cardboard vessels are used.The specific feature of the vessel is in conjunction of two truncated pyramids (figure 1),the total height of which is 1070mm, max. width is 920 mm.The area of top vessel opening covers 0,25 m^2(0,5X0,5 m) and the bottom area covers 0,01 m^2(0,01X0,01 m).The bottom opening runs into the collecting box of"the catch" of fertilizer particles.Dimensions of box "b" (fig.1) are the following:130 X 130 X 35 mm

Bottom opening i.e. sampler basis "a"(fig.1) is of small area(0,01m^2), and the vessel itself is therefore not stable.It has to be fixed by 4 long metal wedges.

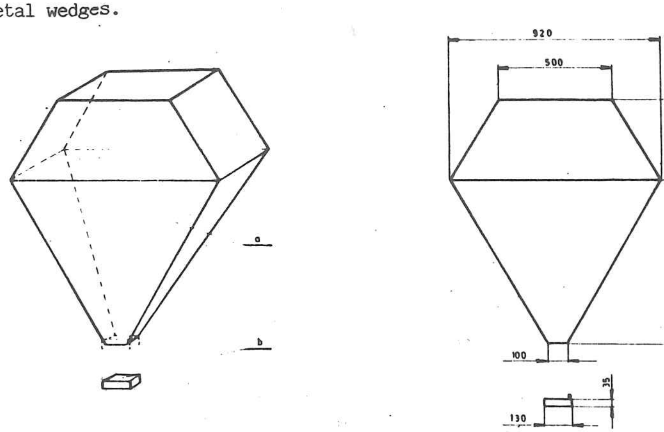

Fig.1 Shape and dimensions of fertilize dosage sampler
a-sampler
b-collector

For the "catch" of the applied fertilize dosage sample,30 vessels distributed over the area 30 m wide -perpendicular to the aircraft flight direction.The spacing of the vessels has been one meter.The vessels have been distributed in three rows(fig.2).The wind velocity has been measured by anemometer during the aircraft flight over thevessels collecting the fertilizer particles.The weather vane has been used for measuring of the wind direction and the wind` s eye in relation to the aircraft flight direction.

The flight altitude has been 25 m, and the flight speed has been approx. 170 km/h ; theoretical fertilizing width of the aircraft has been 30 m, while the working width has been 28 m.For every fertilize dosage, the tests have been made in three repetitions.

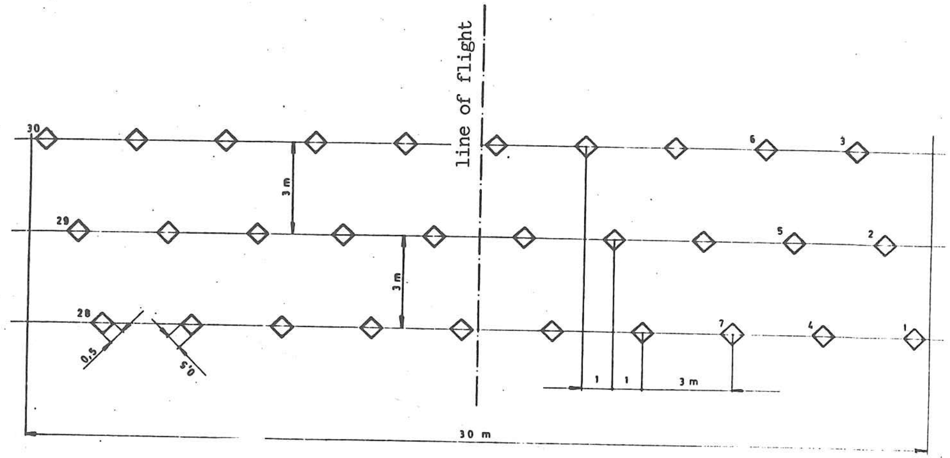

Fig.2 Arrangement of fertilize dosage sampling vessels over the aircraft working width.

3. THE RESULTS OF THE RESEARCH AND DISCUSSION

The Effect of the Wind Upon Swerving of Fertilizer Particles

It has been found out that the wind abeam even of low velocity,swerves the particles of the fertilizer beyond the theoretical working width which is 30 m.It is particularly obvious with urea fertilizer of low volume weight (728 kg/m3).This is shown in the diagram of fig.3 : at wind velocity of 2 m/sec. and direction which is perpendicular to the aircraft flight direction,the fertilize dosage applied to the aircraft working width varies considerably.Generally,it has been found out that at wind velocity exceeding 1 m/sec.,the direction of which (or its component) is perpendicular to the aircraft flight direction,the particles of the urea fertilizer have swerved beyond the theoretical fertilizing width (30 m).

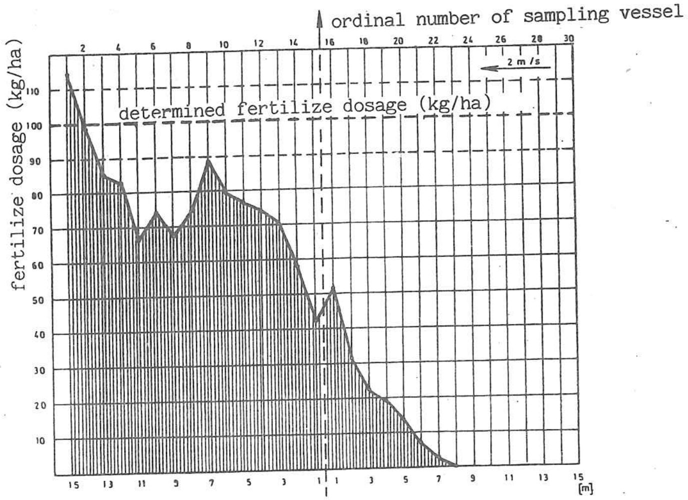

Fig.3 The diagram shows the distribution of the fertilize sosage over, the working width of PZL M 18 aircraft(fertilizer: urea ,fertilize dosage: 100 kg/ha,wind velocity: 2 m/sec.)

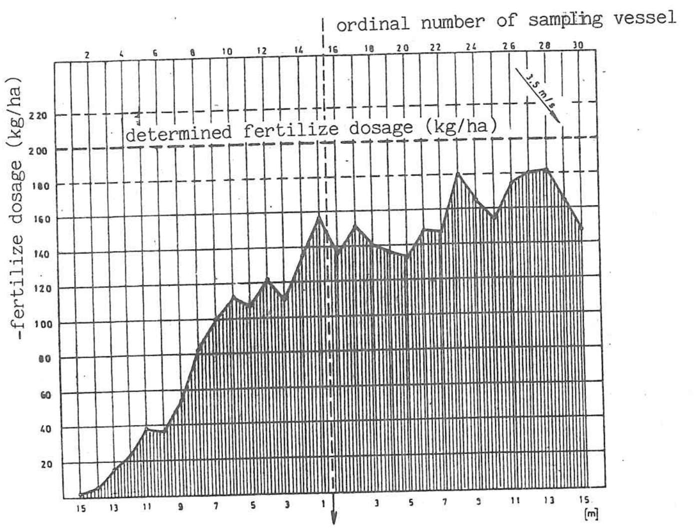

Fig.4 The diagram shows distribution of the fertilize dosage over the working width of PZL M 18 aircraft (fertilizer: KAN,fertilize dosage: 200 kg/ha,wind velocity: 3,5 m/sec.)

For KAN fertilizer it has been found out that at wind velocity exceeding 1,2 m/sec., and direction of wind(or its component) perpendicular to the aircraft flight direction,the fertilizer particles have swerved beyond the theoretical aircraft working width.This is indicated in diagram of gig.4: wind velocity has been 3,50 m/sec.The velocity of the component perpendicular to the aircraft flight direction has been 1,30 m/sec.At this velocity, the particles of fertilizer have swerved to the right.

When the aircraft flight direction coincides with the wind direction, as indicated in Fig.5 , no lateral swerve of the urea fertilizer particles has occurred. It results from the above that pilot should have at all times information on wind direction and velocity to be able to select the correct flight direction over the certain plot, or to cancel the flight untill the occurrence of favourable flight conditions to assure good quality of fertilizer application.

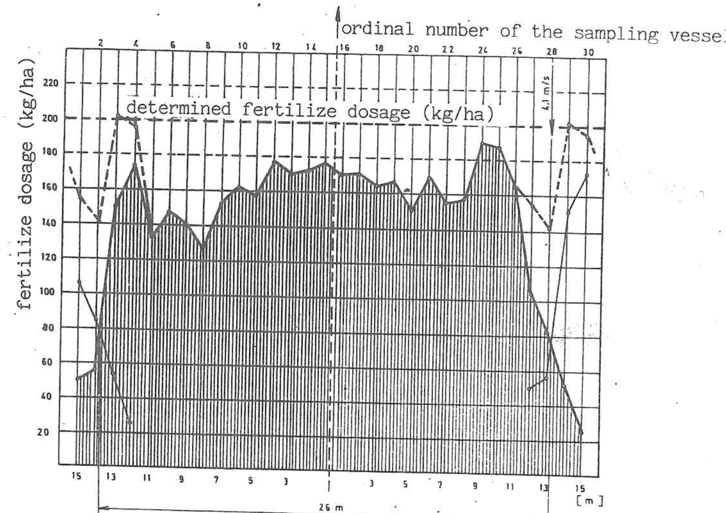

Fig.5 The diagram indicates fertilize dosage over working width of PZL M 18 (fertilizer: urea, fertilize dosage: 200 kg/ha ,wind velocity:4,1 m/sec.)

4. GRANULOMETRIC COMPOSITION OF THE UREA FERTILIZER BEFORE AND AFTER APPLICATION

The fertilizer will have expected efficiency if the specified dosage has been evenly distributed over the field.If during application,the fertilizer has been scattered without any control by the wind,it is twice a pity: the fertilizer is not applied to the required place and ithas polluted the enviroment.

At the wind velocity of 2 m/sec.,the direction of which is perpendicular to the direction of the aircraft flight,a certain amount of small granules of the urea does not fall to the predetermined,set spot,but has been swerved by the wind out of any control thus polluting the atmosphere in the first place. The data of Table 1 indicate the aforesaid clearly:in the fertilizer sample taken before application there have been granules smaller than 0,50 mm,while the sample taken after application of the fertilizer by PZL M 18 aircraft has contained no such granules.The share of granules ranging from 0,51 to 1,00 mm in dia. has also been reduced: before application the percentage has been 2,30 and after application it has been 0,31 per cent.

Table 1.Granulometric composition of the UREA fertilizer before and after the application

Granule dia(mm)	Before I(%)	Application II(%)	III (%)	Average(%)	After Applic. (%)
0,50	0,20	0,15	0,15	0,17	-
0,50 - 1,00	2,70	2,20	2,00	2,30	0,31
1,01 - 2,00	83,70	78,40	79,10	80,40	84,47
2,01 - 3,36	12,65	17,65	17,95	16,28	14,93
3,37 - 4,76	0,50	0,65	0,80	0,65	0,29
4,76	0,25	0,95	-	0,40	-

The prominent feature being the increase of the share of granules from 1,01 to 2,00 mm dia. while the share of the granules ranging from 2,01 to 3,36 and those ranging from 3,37 to 4,76 mm(table 1) has been reduced. The granules have been disintegrated because of the following:
a) friction of the granules during filling of the aircraft hopper with fertilizer, b) the impact of the granules during hopper filling, c) friction of the granules during hopper discharge, d) friction of the granules against metal surface of the tank and the diffuser, e) granule friction in the air from the moment of the discharge from the diffuser to the moment of its landing.

5. CONCLUSION

The velocity and the direction of the wind have the essential influence on the quality of fertilizing by agricultural aircrafts as well as upon the pollution of the enviroment.

The granules of large dia. and high volume weight are more inert and more resistant therefore, to the wind swerve.

At the velocity exceeding 1,0 m/sec and direction which is perpendicular to the direction of the aircraft flight , granules of the urea fertilizer have swerved beyond the theoretical fertilizing width(30 m).The critical velocity of the wind for the granules of KAN fertilizer is somewhat higher: 1,2 m/sec.,for the granule dia .is larger and the volume weight is higher (917 kg/m3) and they are therefore more inert.

If the wind direction coincides with aircraft flight direction,wind velocity has no essential influence upon the uniformity of applied fertilize dosage to the aircraft working width , but it causes the pollution of the enviroment,especially if the fertilizer contains fine granules(dust).

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

ENERGETICS ANALYSIS OF THE PLOUGH BODY

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The article brings an analysis of the relations for the setting up the specific draught of the plough. Based on the measurements of the triple furrow plough PH 1-434 and tractor Z 8011 unit with the power measurement on the middle share are setted up the experimental equation for the dependance of the plough resistence on the rate of motion, on the density, on the humidity, on the depth of the ploughing and on the steepness.

resistance of the plough; energetics of the ploughing; specific draught of the plough; share; plough resistance equation

1.Überblick der Problematik

Mit der Feststellung der Pflugwiderstände befasste sich eine Menge von Autoren, aber bisher stehen nur wenige systematische Messungen zur Verfügung, die übliche Betriebsbedingunge berücksichtigen. Die Grundbeziehung für Berechnung des Pflugwiderstandes wurde von Gorjačkin zusammengestellt:

$$R_o = f.G + r_{mo}.a.B + \varepsilon.v^2.a.B$$

Söhne /1/ vereinfachte die Beziehung für den Meßwiderstand folgend:

$$r_{mo} = r_{mel} + \varepsilon.v^2$$

Mit der Pflugwiderstandsberechnung befassten sich auch weitere Autoren. Voorhees und Walker /3/ berechneten den Pflugwiderstand mit Hilfe folgender

Gleichung:

$r_{mo} = 2.572.W + 106,503 + 0,2450.v^{2}$

Oskoui, Rackam und Witney /4/ rechneten den Pflugwiderstand mit Hilfe des Kegelindexes CI:

$r_{mo} = K_1.CI + K_2.\rho.\dot{v}^2.[1-\cos\theta].g^{-1}$

wobei $CI = 450,5.W^{-2} + 0,019.\rho.9,81$

Für die experimentelle Feststellung des Pflugwiderstandes existiert eine Menge von Methoden, die einfach folgend zu beschreiben sind:

1. Festlegung des Widerstandes der ganzen Garnitur /Schlepper und Pflug/ mir folgender Feststellung des Rollwiderstandes der Garnitur. Dieser Messvorgang ist zu ungenau.

2. Messung der Kraftverhältnisse in der Dreipunktanhängung des Traktors. Diese Messung ist bei Voraussetzung der richtigen Einstellung die genaueste. Sie ist aber nicht günstig für die langfristigen Messungen.

3. Messung des Pflugwiderstandes an einem Schar.

2. Messungsmethodik

Für die Messungen der Pflugwiderstände wurde der Dreifurchenpflug PH 1-434 /Hersteller Agrozet Roudnice/ angewandt. Die Angriffsbreite des Körpers beträgt 0.35m, Tiefe des Pflügen ist bis 0,27m. Es wurde der Streichbleichtyp PI benützt. Für die Messungen wurde das Anfaßende der Pflugeisen an neue Maße nachgebohrt.

Das mittlere Pflugeisen wurde in sechs Punkten festgehalten, so daß die horizontale Zugkraft des Pflugeisens abgetastet werden konnte.

Die Auswertung der Messungen wurde mit Hilfe des Aufnahmedynamometers und der Handabmessung der Pflügentiefe in Jahren 1988-1989 durchgeführt. In Jahre 1991 wurde für die Auswertung Meßrechenanlage MC 12A /BRD/ angewandt.

Die Pflugwiderstände wurden an Strecken von min 30m lang, an der Ebene oder am milden Abhang und an relativ homogenen Böden abgemessen. Das Grundstück wurde in einige Abschnitte verteilt. Von jedem Abschnitt wurden die Bodenproben abgenommen.

3. Analyse der Messungsresultate

Ziel der Messungen war die Präzisierung der energetischen Bilanz des angewandten Pfluges für die Bilanzrechnungen der Pflugforderungen unter verschiedenen Naturbedingungen.

3.1. Analyse der Geschwindigkeitsfaktors

Bei der Auswertung des Geschwindigkeitsfaktors an den spezifischen Widerstand wurde der Komplex mit relativ gleichen Bedingungen für die Abhängigkeit an der Form

$r_{mo} = K_1 + K_2.\rho.v^{K_3}$

bei Anwendung der nichtlinearen Regression angewandt. Die festgestellte Form

$r_{mo} = 41,18 + 1,75.\rho.v^{2,1}$ $R = 0,64$

ist gültig für diese Bedingungen: $v = 0,32$ bis $2,48\ m*s^{-1}$

$\rho = 1,38\ g*cm^{-3}$

$W = 15,9\ \%$

$H = 1,2\ \%$

$J = 38\ \%$

3.2. Analyse des anderen Faktors

Für die Feststellung der globalen Gleichung wurde auch die nichtlineare Regression angewandt. Mit der Ausnützung des dynamischen Gliedes aus der Geschwindigkeitsformel wurde folgende Gleichung gelegt:

$r_{mo} = K_1 + K_2.J + K_3.H + K_4.W + K_5.\rho + K_6.a +$
$+ 1.75.\rho.v^{2,1}$ [kPa]

wo J - Ton[%], H - Humus[%], W - Bodenfeuchtigkeit [%] a - Pflügentiefe [m], v - Geschwindigkeit [m/s], ρ -spezifische Bodenmasse

Statistische Ergebnisse sind in Tab.1. eingeführt:

Tab.1. Statistische Resultate

Koefizient	Grösse	Standardfehler	Beziehung
K_1	9,30	9,63	-0,97
K_2	0,60	0,09	6,57
K_3	-6,73	1,58	4,25
K_4	0,37	0,14	2,59
K_5	29,7	6,29	4,72
K_6	57,1	22,07	-2,58
$R^2 = 0,5273$ (Correlationskoefizient = 0,723)			
Anzahl der Messungen 290			

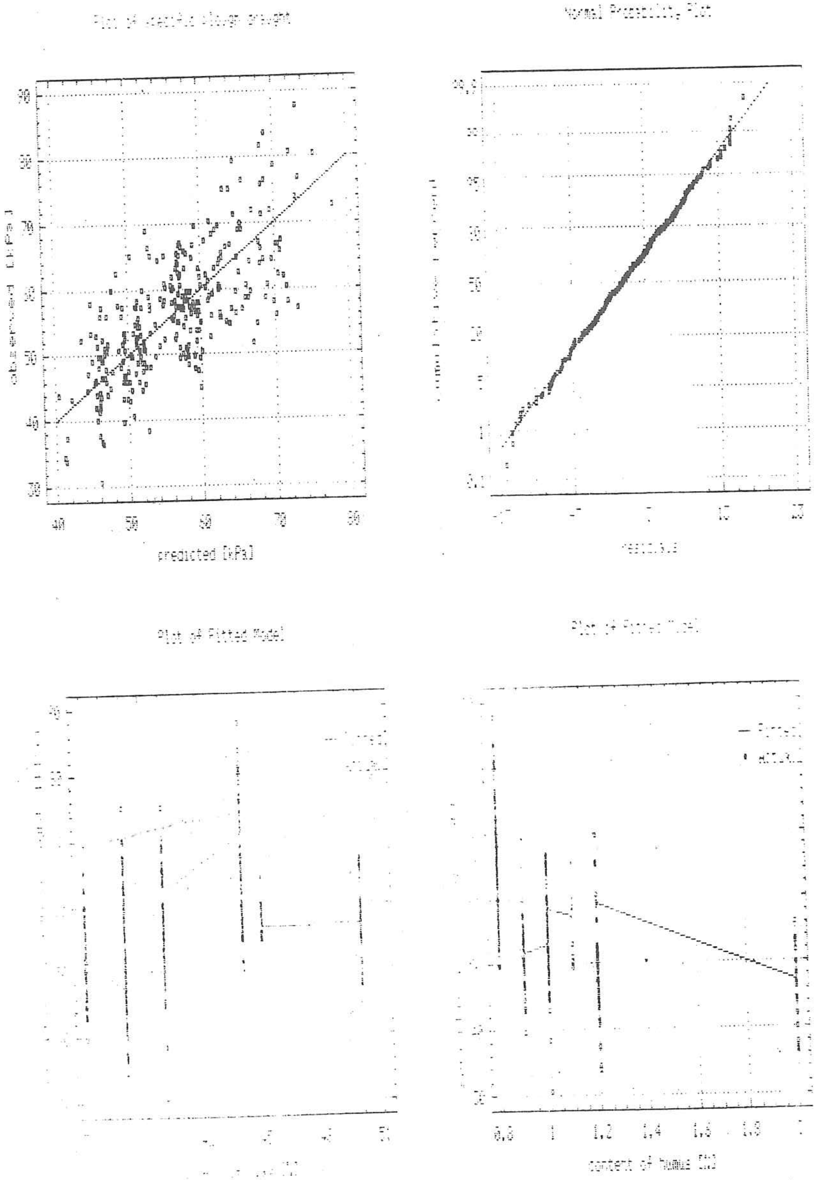

Bild 1. Abhängigkeit des vorausgesetzten und des wirklichen Widerstandes, Normalwahrscheinlichkeit, Abhängigkeit auf dem Ton- und Humusgehalt

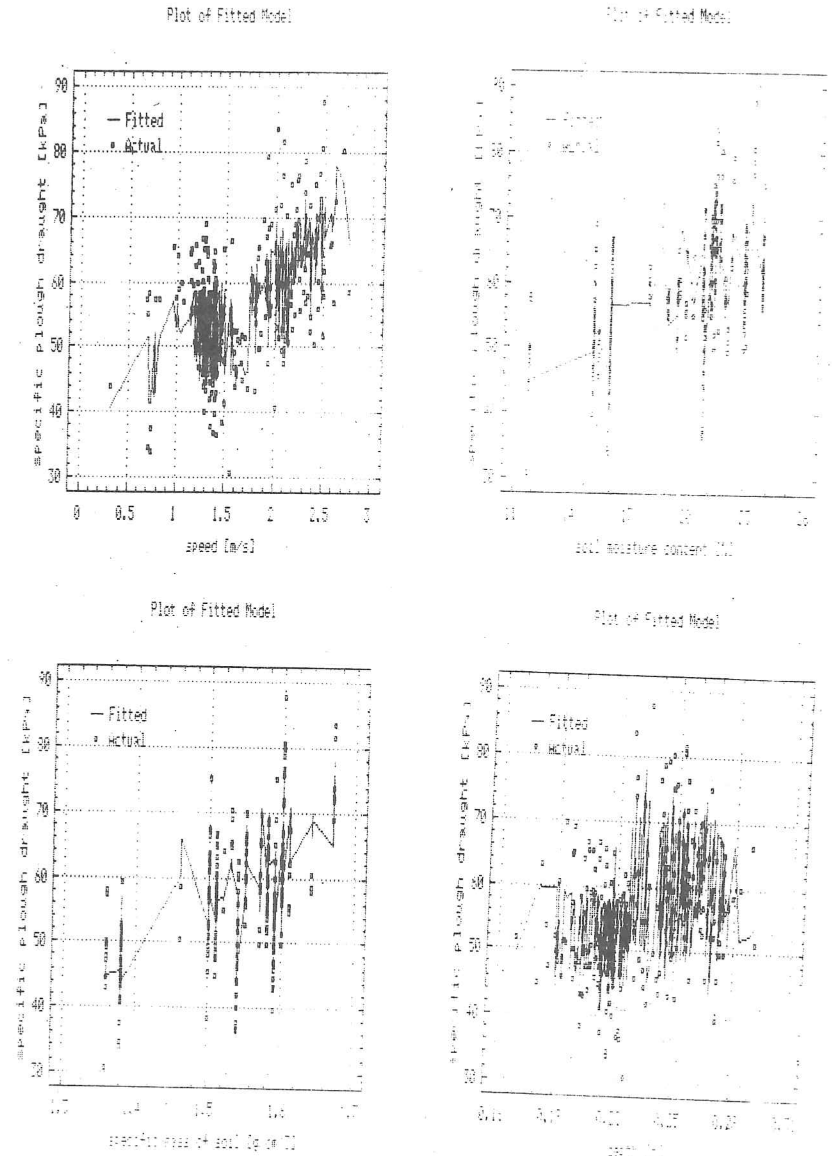

Bild 2. Abhängigkeit des spezifisches Meßwiderstandes auf der Geschwindigkeite, Feuchtigkeite, Dichte und Tiefesfaktor.

4. Auswertung der Resultate

Die Resultate sind auf dem Bild 1. und 2. abgebildet. Sie sind für die horizontale Zugkraft gültig. Für die Umrechnung an den gesamten Pflugwiderstand ist es nötig die gegebenen Widerstandergebnisse des Pfluges zu korrigieren. Die erzielten Resultate werden in nächsten Jahren weiter präzisiert und auch für dieVerwertung der Pflugeisenwiderstände und für weitere Konstruktionsverbesserungen des Pfluges ausgenützt werden.

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Verzeichnis der Kennzeichnungen:

a -Pflügentiefe [m]
B -Angriffsbreite des Pflüges [m]
CI -Kegelindex [kPa]
H -Humusgehalt des Boden [%]
J -Tongehalt des Boden [%]
K_{1-6} -Koeffizienten
R_o -Pflugwiderstand [kN]
r_{mo} -spezifischer Meßwiderstand des Pfluges [kPa]
v -Geschwindigkeit des Fahrbetriebes [m/s]
W -die Feuchtigkeit des Boden [%]
ε -Geschwindigkeitskoeffizient
ρ -spezifische Bodenmasse [g/cm³]
Θ -Neigungswinkel des hinteren Streichbrettteils [Grad]

TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

COMPARISON TESTS OF ECOLOGICAL SUITABLE PAINTS FOR PROSPECTIVE USE IN AGRICULTURE

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The aim of experiments carried out was to investigate protective properties of some paints on dependence of surface preparation. The paper presents test results (modified immersion test under Czechoslovak Standard 67 3087, MACHU and SCHIFFMAN test) of protection efficiency with synthetic, water diluted and inorganic paints. It has been proved, that in some case is possible replace organic paint by inorganic paint. This reason decreases ecological demages of live environment.

live environment; protection against corrosion; inorganic paint.

1. INTRODUCTION

Protection against corrosion in agriculture is a very important issue. Today, 80 % of construction surfaces is protected by organic coatings.

Now the choice of the paint materials is determined by it is influence on ecology atmosphere. Solvents in common paints are one of the compereds, that demage environment.

The function of solvent in paints has only a temperary charakter. After making of the paint solvents evaporate. About 100 000 tons of solvents are evaporated in ČSFR every year /2/. There do exist some ways to decrease quantity of evaporated solvents:
- paints with high content of dry matter
- powder paints
- water diluted paints.

Futher we refer to some experiments with water diluted paints. The test included paints based on acrylate dispersion (marked V ....), alkyd resins (marked S ....) and inorganic phosphate paint (further referred to as FAN). This paint consist of condensed phosphates Al, Zn and phosphoric acid /1/. It is properties are typical for inorganic matter:
- the paint is not combustible and is resistant to high tempe-

rature (about 600 ÷ 700 °C) and is non-toxic
- the paint nead not so clear surface as acrylate dispersion
- the coating does not decrease weldability and is suitable for top paint. On the other land, it has worse adhesion and it is porosity is higher.

2. THE METHOD OF EXPERIMENT

The protection efficienty of paints was tested on dependence of surface cleaning. One half of the specimens was cleaned by pickling, the second one had on the surface a layer of rust and was cleaned by brusting. Mass of non athesive rust (removed by brushing) was 48,5 ; mass of adhesive rust (removed by pickling) was 106,2 grams per square meter.

Further combination of the paints were tested:

number	ground paint	top paint	number	ground paint	top paint
1.	S 2000	S 2013	4.	V 2043	V 2045
2.	S 2000	V 2045	5.	FAN	S 2013
3.	V 2043	S 2013	6.	FAN	V 2045

Enironment in bildings of livestock is one of the most agresive in agricultural. It is effect was simulated convert MACHU-SCHIFFMAN test (under Czechoslovak Standard 67 3087). It is supposed, that the main corrosion factors in the organic matters in livestock are inorganic substances. Composition of tested solution was made under experimental data /3/. This solution was prepared by dissolving inorganic salts in destiled water. Composition of the tested solution brings table 1 below.

Table 1. Composition of the testing solution

ion	content [%]
NH_4^+	0,39
K^+	0,26
SO_4^{2-}	0,36
S^{2-}	0,23
Cl^-	0,30
urea	2,00
pH	8,80

One testing cycle consist of:
- 6 hours of immersion in the testing solution (temp. 40 °C)
- 2 hours of drying (40 °C)
- 16 hours of holding in the condensing chambre at the 35 °C, without SO_2.

The evaluation of the speciments is described in the next part of the paper. The following three parameters were watched:
- adhesion of paint coatings by cross-cut method (before and after experiment)
- determination degree of rust penetration through the coating
- undercoating corrosion.

Results of the experiments contain table 2 below:
a) clear surface (cleaning by pickling) /4/
b) surface of specimens with rust, cleaning by brushing.

Table 2 Results of experiments

a) clear surface

paint system	thickness [μm]	adhesion before test	adhesion after test	rust penetration [% area of specimen]	undercoating corrosion [% area of specimen]
1	2	3	4	5	6
S 2000 + S 2013	16 + 11	1/2-3	4	0[2]	3,3
S 2000 + V 2045	18 + 13	1/2-3	4	5	1,3
V 2043 + S 2013	10 + 12	1/2	1/2	0[3]	3,3
V 2043 + V 2045	11 + 11	1/4	1/2	5	8
FAN + S 2013	12 + 11	2-3	4	100[5]	100[4]
FAN + V 2045	13 + 12	2-3	4	10[6]	10

b) surface of specimens with rust

1	2	3	4	5	6
S 2000 + S 2013	45	1/1-2	4	0	5,3
S 2000 + V 2045	48	1/2-3	1/2-3	10[1]	1,3
V 2043 + S 2013	31	2	4	100[5]	6,7
V 2043 + V 2045	28	1/3	3	60[1]	10
FAN + S 2013	48	1/1	2	0	2,3
FAN + V 2045	55	1/1-2	3	60[1]	33

Notes:

1 - the area of deteriation of coating with penetration rust through the coating and blisters
2 - difference of colour stade of coating
3 - some points of corrosion in the area of specimen
4 - flating of the all coating system
5 - the area of deteriation of coating with blisters without seeing penetration rust through the coating
6 - flaking area of paint without rust on the base metal.

3. CONCLUSION

Protective efficiency of FAN with suitable top paint is better than acrylate dispersions and worse than alkyd paints. Very good properties of FAN were seen when the surface of specimen was cleaned by brushing after former corrosion. In some cases, it is possible to replace organic paints with FAN. This precaution decreases demages of the environment.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

On identification of biological materials via 'IR-response' method.

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An introductory information dealing with concept, principles and application potencial of the IR-response method is presented. The metod and measuring set-up are propounded for fast, physical identification of agricultural materials.
The principle of the method - an analysis of 'IR response' after pulse irradiation of the investigated material is briefly mentioned. The analysis have to be carried out both in time and frequency demains. Meassuring device is proposed to consist of laser, IR detectors, IR filters, sampling amplifer and computer with specific SW. Block diagram of the proposed device is discussed. Some features of SW systems are suggested in the next part of the paper.

1. Introduction

Simple, cheap, fast and reliable identification method of biological materials, both in agriculture and in many branches of industry is an objective of the significant effort of technicians and scientists.

For real-time monitoring currently used laboratory tests are unpractical, cumbersome, time-consuming and -first of all -expensive. Physical method, which is in principle fast, easy to perform and at least able to sort the materials into the pre-defined categories with sufficient reliability is in the center of users' interest.

Commonly used methods could be divided into several groups according to principles of operation which are exploited:

- conductrometric methods. Differences in conductivity of various materials are monitored. The method is simple, cheep and fast but unreliable and unaccurate in its origin (the sources of troubles are usually contacts).
- optical method, based on pattern recognition in visible light has been recently experimentally investigated. The method is relatively expensive; both hardware (CCD-camera, digitizer, computer) and software have to be complicated. On the other hand, the method is fast, handy, very promising and has wide application potencial in

future.

- optical methods, exploiting wider, mostly IR part of spectrum have recently been successfully investigated, too. The fundamental problem here is: How to define 'the best spectral window' which provides the maximum informational content. Another serious problem - the variability of biological materials is common for all methods, of course.

In spite of the above mentioned problems the method seems advantageous to me, nevertheless some important alternatious are to be adopted. This is an objective of presented paper, tackling with so called 'IR-response method'.

2. Theory

From the technical point of view, the IR-response method is (in principle) simple. The object under investigation is in time T=0 irradiated by a short pulse of light. The response of the material (mostly in IR-region) is measured as a function of time (for T≥0) and wavelength; irradiated energy being a parameter. The result, detected 'IR-response' is to be compared with 'pattern', stored in computer memory.

From the physical point of view the method is complicated. The detected signal in time T=0 (+dt) should be stated (with some degree of confidence) to be a reflection. For T>0 the situation is generally even more complicated (not only Planckian gray-body radiation!) and detected signal varies sensitively with the properties of studied materials. For some classical industrial materials the discrimination of wavelength would not be necessary. In such a case the technical solution is quite straighforward and some commercially produced instruments are available (for example - the tester of the quality of solder joints on printed circuit boards developed by Vanzetti - U.S.A). Unfortunately, this is not the case of biological materials. Here, the wavelength discrimination must be performed in order to enhance the information content and therefore to increase the probability of investigated material identification.

3. Suggested measuring set-up structure

Let us assume the classical reflectivity function of biological materials. (See fig.1., three curves for different biological objects are drawn there). The identification of the objects is more or less feasible in the near infrared region (700 - 2000 nm), nevertheless the one-to-one correspondence cannot be obtained even if the variational span is neglected.

Well, let us exercise our 'IR-response' method. The sample of material under investigation is to be irradiated by suitable impulse light source (in T=0) and then the decay signal on selected wavelength interval is to be monitored. The measurment is then repeated for another selected wavelength interval, or alternatively the parallel detection in different wavelength intervals ('channels') is to be performed. By this procedure , the 2-dimensional function (surface) is obtained. The 'surface' is characteristic for given material and the amplitude of it depends on iniciating light energy, of course. The graphic plot of such function is done in Fig.2. Let us stress again that the 'surface'-stimulated IR-response, could be physically very complicated entity, but for our purposes it is something like fingerprint of the material, irrespective of its nature, and therefore could be compared with library patterns.

For basic verification of the method and the set-up I propose 5 or 6 wavelength intervals, detected in T=0 (+dt0) and in 3 or 4 time instants in the range of 10^{-2} - 10^{-0} s. (I assume the light pulse has ended in T=0.) It is obvious that the increase of the number of wavelength intervals , choosen results in the better resolution, reliability and lower error rate of material identification, on the other hand some problems with selective filters in IR-region could arise.

4. Instrumentation

The discussed method is not too demanding on instruments and devices to be used. Almost any impulse laser with output power ≥0.5 W in the visible range of spectrum (preferencially in vincinity of IR-edge) could be used in principle, but some additional technical features are needed, (good ability of switching control e.g.).

Some examples: gas He-Ne laser - 632 nm; semiconductor GaAs laser - 905 nm. Semiconductor IR diodes could be used for sensing signals. Cooling is not expected. Filters (or optics, if it would be necessary) for IR could probably arise some problems, but many applications of similar devices could show us this approach is feasible. The conceptual scheme is in Fig.3.

5. Evaluation - identification

'IR-response' evaluation and identification is the key problem and the topical part of the work. The nature and structure of the signals have been described already in part II of this paper. The evaluation is always in fact a comparison of the detected response ('surface') with library patterns. The selection algorithm is to be constructed to gain maximum probability of good identification. (Some heurestic methods and/or cluster analysis approaches could be combined e.g.)

In the firs phase, the filling-up of the library is necessary. To obtain reliable patterns, the well-known materials in precisely defined conditions (humidity e.g.) is to be measured. Then the defined change of conditions is to be performed and the procedure is to be repeated again. By such a manner, the basic library could be formed and gradually improved and extended. The problem of identification is then reduced to purely SW-activity, when the optimal (or quasioptimal) methods of surface parameters identification are to be founded.

The first simulations are carried out on personal computers PC 286/16Mhz. As the problem from the mathematical point of view could be assumed as the classical problem of associative seeking with embedded self-learning mechanism, I assume the implementation of neuron or neuron-like nets should be advantageous, at least via SW-simulation of them.

This approach would lead in future to the 'tailoring' the set-ups to the users' needs.

6. Proposed features

Proposed instrument is devised to be able to discriminate basic sorts of biological materials in real time and with minimal expenses. The topical factor is the ability of the whole instrument (HW and SW) to improve itself gradually via self-learning process. A simple expert-system is to be an internal part of SW, which could help to the user to specify further the material under investigation by the sequence of questions and answers. Thus, an overview of another physical properties, humidity e.g., could be gained.

The whole principle of the sample - evaluation procedure is described in Fig.4.

7. Conclusion

Proposed set-up is now only in its initial phase. The very concept of device, the optimum choice of wavelengths and/or filters, lasers and another elements are to be done in near future.

Partially evaluated are the methods of identification and discrimination. The experiments with neuron-like nets are in the phase of simulation.

The testing of the first model of set-up is expected in 1-2 years.

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Set-up principle

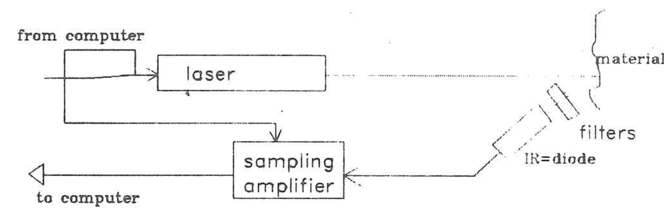

Fig.3.

Block diagram of evaluation procedure

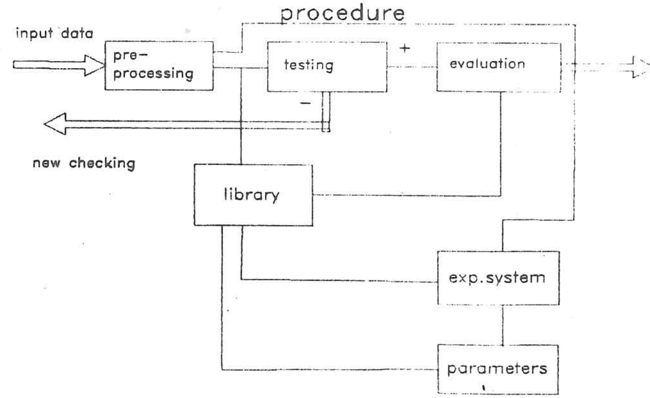

Fig. 4.

Examples of reflectivity curves
for various agricultural materials

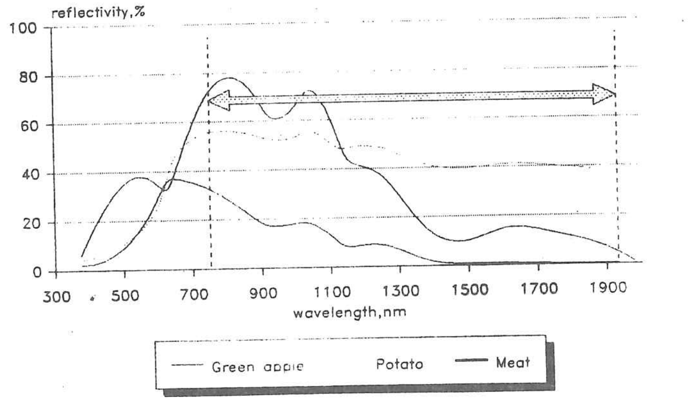

Fig. 1

An idealized example of time depending
IR–response

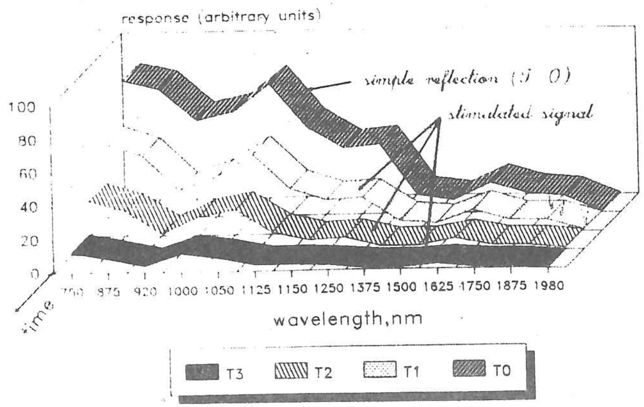

Fig. 2

TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

CREATING AND SOLVING ELEMENTARY EQUATIONS

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Article contains description of new method of creating and solving elementary equations. Method is based on processing physics units. Physical quantities are placed in space. During calculation are find solutions that have centroid in the centre of coordinate system.

computers; equation solving; calculating algorithm

New method for automated creation and solving of equations was developed. Aim of this method is to improve and to speed up development of expert system for engineering.

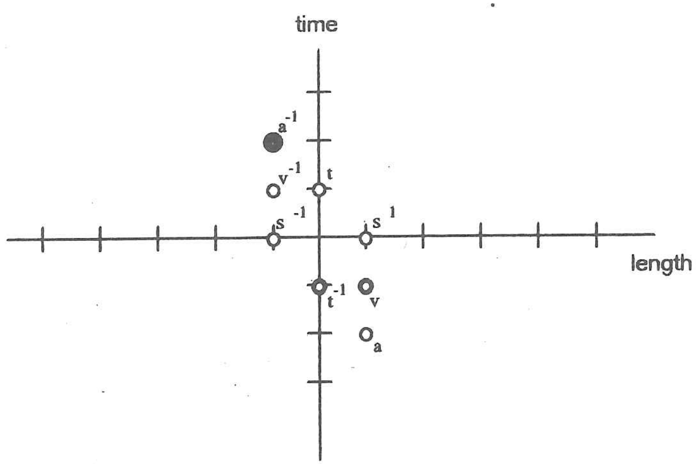
Method is based on several ideas. First idea is unit checking. If equation can be checked by unit compatibility, so equation can be constructed on this principle, too.

Another idea is to put in the space all physical quantities that can be measured or calculated. Space is seven dimensional because of seven SI units. Every axis is defined for one SI unit. Space is discreet because positions of other units are set according to their relation to SI units. Units fully describe related physical quantities.

Last idea is, that system of physical units can be described either in units or in related reverse units. For example when mass is defined, then is also automatically defined reverse unit 1/mass and this new unit can be used for calculations and definitions.

Suppose that we have already defined unit space and in this space there are placed defined units. In such space we will make active points that represent already known quantities and the point that represents the quantity that we want to calculate. Solution of problem is set of quantities when centroid of this set lies in the centre of coordinate system.

Let us consider very simple example. Suppose only two-dimensional space with length axis and time axis. In this two dimensional unit space we would like to solve simple problem: calculate acceleration when velocity and time are known.



In the unit space there is active point that represents reverse quantity to acceleration. Reverse quantity is active because in the equation there is acceleration on the left side and known quantities (velocity and length) are on the right side. When we write the equation with 1 on the left side (or constant on the left side), then transferred quantity is reverse on the right side. Then points that represent already known quantities (given, measured or calculated) are made active.

Solution is set of quantities that has centroid in the coordinate centre. During solving this method considers and checks all possible variations , quantity that we want to extract is always present in the checked set. When the set of quantities that fulfills centroid condition is found, then these quantities are multiplied by each other. This way

we can obtain equation. When several possibilities are found, then sets of quantities are added to each other. In this example the only valid answer is: a=v/t, because only set of v and t^{-1} outweighs a^{-1}.

This method was developed for expert system for engineering. This method can solve many problems with single function. Input side of this function is the list of known quantities plus quantity that we want to calculate. Numeric result together with relevant unit appears on the output side. When constant is passed to function, then result is multiplied by passed constant.

When this function is implemented in programme for solving complex engineering problems like machine design, then there is need to write only several additional functions for calculating that are not solvable with this method. Whole computing system is than more versatile, takes less memory and is easier to build.

TRENDS IN AGRICULTURAL ENGINEERING
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ARBEITSQUALITÄT VON AXIAL- UND TANGENTIALDRESCHWERKEN BEI DER ERNTE VON ACKERBOHNEN

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Combines with conventional tangential threshing cylinders and straw walkers and for several years combines with axial rotary threshers are used for grain harvesting. In the latter, threshing and final grain-straw separation are performed in one aggregate. While there is numerous information on the operational characteristics of tangential threshing cylinders and straw walkers, a similar level of information on rotary threshers is only slowly attained. Tests, in which both threshing systems were investigated under comparable laboratory conditions with fresh harvested beans (Vicia faba) are reported about here. Through these investigations the influence of the feedrate level and rotor speed on grain separation, grain losses and kernel damage was ascertained.
Combine harvester, beans, separation, kernel damage

EINLEITUNG

Seit Einführung des Mähdreschers wird von den Herstellern intensiv an einer Steigerung der Durchsatzleistung, an der Verbesserung der Arbeitsqualität und der Verminderung des Leistungsbedarfes gearbeitet. Dies wurde in erster Linie durch Vergrößerung und Optimierung der Bauelemente erzielt. Seit mehreren Jahren werden von verschiedenen Herstellern Mähdrescher mit Axialdreschwerken angeboten. Bei diesen Mähdreschern werden die Funktionen von Dreschwerk und Schüttler von einem Arbeitsorgan übernommen. Untersuchungen zeigten, daß Axialmähdrescher im Vergleich zum Tangentialmähdrescher ein günstigeres Verlustverhalten bei geringerem Körnerbruch aufweisen. Als Nachteile wurden stärkere Strohzerkleinerung und als deren Folge eine höhere Belastung der Reinigung sowie ein erhöhter Leistungsbedarf festgestellt [1-3].

Das Axialdreschwerk scheint besonders für die Ernte von Leguminosen geeignet zu sein, da diese gegen mechanische Beschädigungen empfindlich sind. Newberry et.al. [4] führten Vergleichsuntersuchungen mit Sojabohnen mit geringem Feuchtegehalt (U = 11,6 - 13,3%) durch. Es liegen aber bisher keine Untersuchungsergebnisse beider Dreschsysteme mit Körnerleguminosen unter europäischen Bedingungen mit höheren Feuchtegehalten vor.

Um die beiden Dresch- und Abscheidesysteme umfassend vergleichen zu können, werden beide Systeme am Institut für Agrartechnik der Universität Hohenheim unter gleichen Bedingungen untersucht [5]. Die Versuche werden im Labor mit frischem und eingelagertem Gut durchgeführt. Bei frischem Gut werden beide Systeme am gleichen Tag untersucht. In diesem Beitrag wird an ausgewählten Beispielen über den Einfluß des NKB-Durchsatzes und der Umfangsgeschwindigkeit auf das Betriebsverhalten der beiden Dresch- und Abscheidesysteme bei erntefrischen Ackerbohnen (Vicia faba) berichtet.

VERSUCHSAUFBAU UND -DURCHFÜHRUNG

Für die Untersuchungen wurden zwei Versuchsstände aufgebaut. Den Aufbau des untersuchten Axialdreschwerkes zeigt Bild 1a. Der Rotor hat eine Länge von 2,82 m und einen Durchmesser von 0,61 m. Das Gut wird dem Rotor über einen Schrägförderer axial zugeführt. Zur Ermittlung der Abscheidung des Dresch- und Trennbereiches wurde die Reinigungsanlage ausgebaut. Ein konventioneller Mähdrescher mit Tangentialdreschwerk und Hordenschüttler wurde in ähnlicher Weise für die Untersuchungen umgebaut, Bild 1b. Er hat eine Dreschtrommelbreite von 1,03 m und einen Trommeldurchmesser von 0,65 m. Der vierteilige Hordenschüttler hat eine Abscheidefläche von 3,5 m^2.

Bei den Versuchen wird das Versuchsgut gleichmäßig auf einem 25 m langen und 2 m breiten Förderband verteilt. Unterschiedliche Gutdurchsätze werden durch entsprechende Massenbelegung vorgegeben. Das durch den Dresch- und Trennbereich bzw. durch den Dreschkorb und Hordenschüttler abgeschiedene Gut wird getrennt aufgefangen.

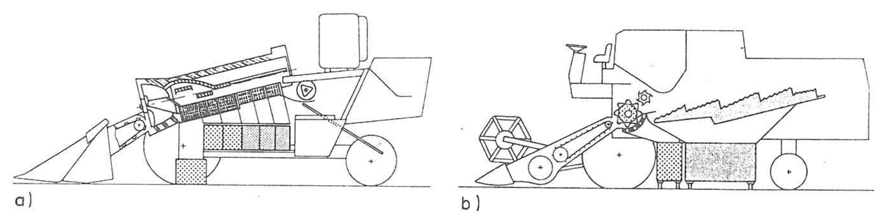


Bild 1: Aufbau der Versuchsstände a) Axialdreschwerk
b) Tangentialdreschwerk mit Hordenschüttler

VERSUCHSERGEBNISSE

Der Dreschspalt wurde beim Axialdreschwerk auf 50 mm im Einlauf und 24 mm im Auslauf des Dreschkorbes, beim Tangentialdreschwerk auf 24 mm im Einlauf und 10 mm im Auslauf eingestellt. Da im wesentlichen die Nichtkornbestandteile das Betriebsverhalten beeinflussen, wird der NKB-Durchsatz zur Beurteilung verwendet.

Das erntefrische Versuchsgut (Ackerbohnen, Sorte Herz-Freya) hatte je nach Versuchstag eine Kornfeuchte von 19 - 28% und eine Feuchte der NKB von 63-69%. Das Korn/NKB-Verhältnis betrug 1:2,2 bis 1:2,7. Im Untersuchungsjahr waren auch bei relativ niedrigen Kornfeuchten die Halmstengel bei der Ernte noch grün.

Einfluß des NKB-Durchsatzes

Beim Tangentialdreschwerk nimmt die Kornabscheidung durch den Dreschkorb mit zunehmendem NKB-Durchsatz mit Ausnahme kleiner Durchsätze von 67 auf 43% ab, Bild 2. Die Entkörnung erfolgt im wesentlichen durch Schlagbeanspruchung der mit hoher Frequenz auf die dünne Gutschicht einwirkenden Schlagleisten. Mit zunehmendem NKB-Durchsatz wird die NKB-Belegung im engen Dreschspalt höher, dadurch wird aber auch die durch die Schlagleisten übertragene Schlagenergie gedämpft. Der Ausdrusch ist vermindert und erfolgt später und die begrenzte Dreschkorblänge ermöglicht nur noch einem geringeren Teil der Körner den Durchtritt durch den Dreschkorb.

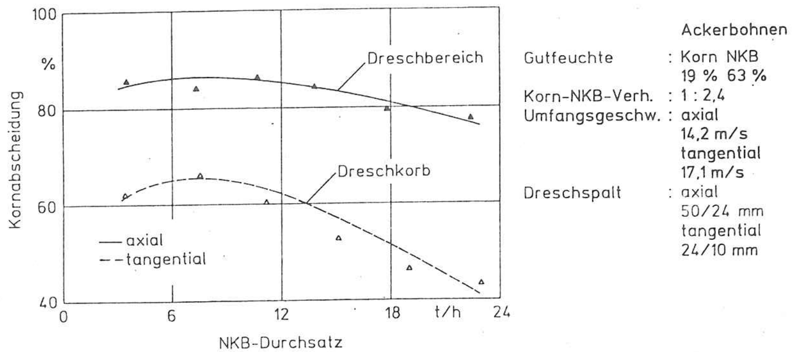


Bild 2: Einfluß des NKB-Durchsatzes auf die Kornabscheidung

Der Hordenschüttler hat die Aufgabe, die restlichen Körner (33-57%) abzuscheiden. Bei hohen NKB-Durchsätzen wird die NKB-Matte nicht mehr ausreichend aufgelockert und die Trennverluste nehmen zu, Bild 3. Die Zunahme der Trennverluste wird aber im wesentlichen durch die hohe Abnahme der Kornabscheidung durch den Dreschkorb verursacht, da der Wirkungsgrad des Hordenschüttlers sich nur um 5% von 98 auf 93% verringert.

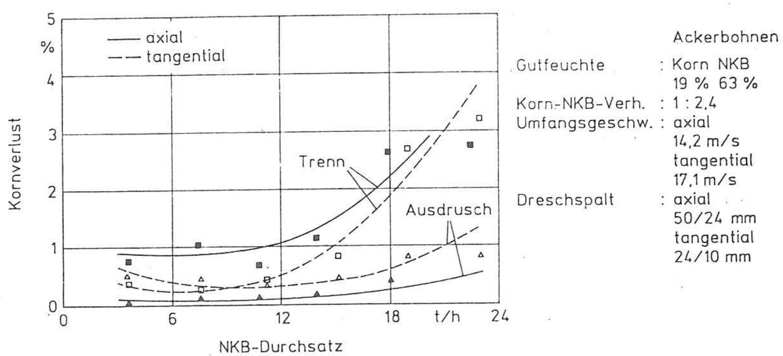


Bild 3: Einfluß des NKB-Durchsatzes auf die Kornverluste

Das untersuchte Axialdreschwerk hat im Bereich zwischen 4 und 11 t NKB/h ein Maximum der Kornabscheidung. Bei dem dargestellten Beispiel sind bereits 78 - 87% der Körner nach dem Dreschbereich abgeschieden. Beim Axialdreschsystem erfolgt die Entkörnung nach einer starken Schlagbeanspruchung und Beschleunigung im Einzugsbereich wegen der dämpfenden Wirkung der höheren NKB-Belegung im wesentlichen durch Reibung.

Im Trennbereich des Axialdreschsystems wird die Abscheidung der Körner durch hohe Fliehkräfte unterstützt. Bei kleinen Durchsätzen wird das Gut im relativ großen Ringspalt zwischen Rotor und Mantel nicht intensiv genug bearbeitet und die Verluste bleiben relativ hoch. Der Anstieg der Trennverluste bei höheren NKB-Durchsätzen wird durch die Abnahme des Wirkungsgrades des Trennbereiches durch zerschlagene Halmstengel verursacht, der Wirkungsgrad sinkt mit zunehmendem NKB-Durchstz um 11% von 94 auf 83%

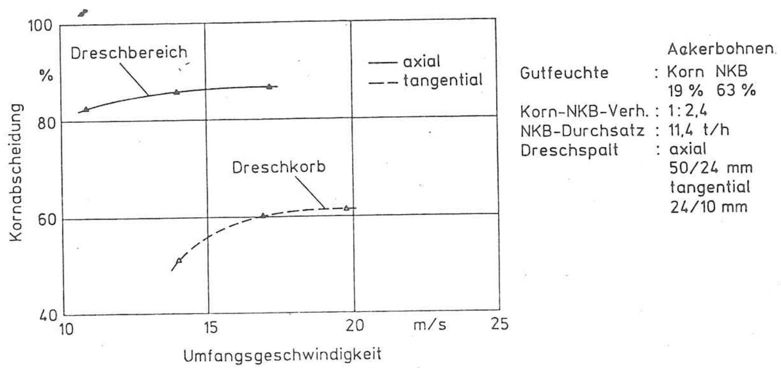
Der Einfluß des NKB-Durchsatzes auf die sehr niedrigen Kornbeschädigungen ist gering. Beim Axialdreschsystem sind die Kornbeschädigungen mit 0,2% gegenüber dem Tangentialdreschsystem mit Hordenschüttler mit 1% wesentlich niedriger. Beim Axialdreschwerk werden durch die hohe Kornabscheidung im Dreschbereich die Körner einer weiteren Schlagbeanspruchung entzogen. Außerdem wirkt sich die gegenüber dem Hordenschüttler intensivere Bearbeitung des Gutes im Trennbereich nicht so stark aus, da im Trennbereich der Spalt zwischen Rotor und Trennkorb 50 mm beträgt. Ursache für die höheren Kornbeschädigungen beim Tangentialdreschsystem ist vor allem die geringe Kornabscheidung des Dreschkorbes bei zunehmendem NKB-Durchsatz. Dadurch ist der Anteil der Körner, der den engen Dreschspalt vollständig passieren muß und erst vom Hordenschüttler abgeschieden wird, relativ groß.

Einfluß der Umfangsgeschwindigkeit

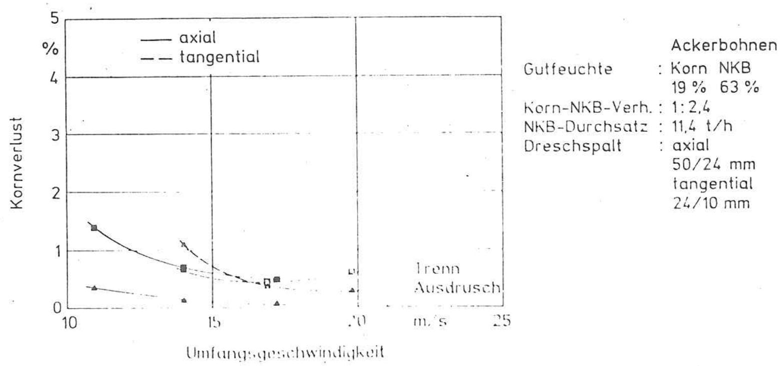
Zur Ermittlung des Einflusses der Umfangsgeschwindigkeit des Rotors bzw. der Trommel wurde diese beim Axialdreschwerk zwischen 11.2 und 17,2 m/s und beim Tangentialdreschwerk zwischen 14,2 und 19,8 m/s bei sonst konstanten Bedingungen variiert.

Sehr unterschiedlich zeigt sich die Kornabscheidung im Dreschbereich, Bild 4. Während das Tangentialdreschwerk auch bei höheren Umfangsgeschwindigkeiten der Trommel nur knapp über 60% abscheidet, liegt die Kornabscheidung im Dreschbereich des Axialdreschwerkes zwischen 84 und 88%. Das Tangentialdreschwerk zeigt bei der Kornabscheidung durch den Dreschkorb eine stärkere Abhängigkeit von der Umfangsgeschwindigkeit als das Axialdreschwerk.

Beim Axialdreschwerk werden die Verluste hauptsächlich von den Trennverlusten bestimmt, die mit zunehmender Umfangsgeschwindigkeit des Rotors stark zurückgehen, Bild 5. Die Ausdruschverluste sind relativ gering und gehen bei 17,2 m/s bis auf 0,1 % zurück. Ein anderes Verlustverhalten zeigt das Tangentialdreschwerk mit Hordenschüttler. Bei geringen Umfangsgeschwindigkeiten von rund 14 m/s sind die Ausdruschverluste höher als die Trennverluste, bei höheren Umfangsgeschwindigkeiten ist es umgekehrt. Die Gesamtverluste sind etwas höher als beim Axialdreschwerk.

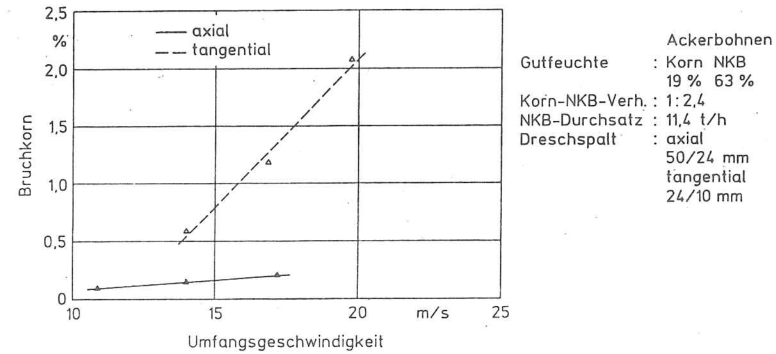


<u>Bild 4:</u> Einfluß der Umfangsgeschwindigkeit auf die Kornabscheidung



<u>Bild 5:</u> Einfluß der Umfangsgeschwindigkeit auf die Kornverluste.

Wie Bild 6 zeigt, hat bei einer Kornfeuchte von 19% die Umfangsgeschwindigkeit beim Axialdreschwerk nur einen geringen Einfluß auf die Kornbeschädigungen. Beim Tangentialdreschwerk steigen die Beschädigungen mit steigender Umfangsgeschwindigkeit linear an und erreichen Werte um 2%.



<u>Bild 6:</u> Einfluß der Umfangsgeschwindigkeit auf die Korn beschädigungen.

ZUSAMMENFASSUNG

- Das untersuchte Axialdreschwerk scheidet im Dreschbereich 20-30% mehr Körner ab als das Tangentialdreschwerk durch den Dreschkorb. Mit steigendem NKB-Durchsatz nimmt die Kornabscheidung beim Tangentialdreschwerk stärker ab als beim Axialdreschwerk.

- Die Körnerverluste sind beim Tangentialdreschwerk etwas höher. Sie werden hauptsächlich von den Trennverlusten bestimmt.

- Bei einer Kornfeuchte von 19% zeigen die Kornbeschädigungen keine Abhängigkeit vom NKB-Durchsatz. Mit zunehmender Umfangsgeschwindigkeit des Rotors bzw. der Dreschtrommel werden mehr Körner beschädigt. Der Einfluß ist beim Tangentialdreschwerk wesentlich größer.

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TRENDS IN AGRICULTURAL ENGINEERING
PRAGUE 15 - 18 SEPTEMBER 1992

DIREKTEINBRINGUNG VON GÜLLE AUF GRÜNLAND UND VERSUCHSEINRICHTUNGEN FÜR GRUNDLEGENDE UNTERSUCHUNGEN AN INJEKTOREN

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Environmental pressures to avoid possible aerial and water pollution from surface spreading of animal slurries are growing. Especially ammonia volatilization from surface spread slurry causes several negative environmental effects. Incorporation of slurry into the soil reduces ammonia volatilization, but is accompanied with problems on grassland. To avoid these problems new slurry injectors have been designed. The equipment to test such injectors under field conditions is described. The forces on the tines and ammonia volatilization can be measured.

slurry; injection; grassland; forces; ammonia volatilization

1. PROBLEMSTELLUNG

Die Landwirtschaft steht zunehmend unter dem Druck, eine umweltverträgliche Bewirtschaftung durchzuführen. Ein besonderes Problem ist vor allem das Ausbringen von Gülle. Als direkte Belästigung werden hauptsächlich die von der Flüssigmistausbringung ausgehenden unangenehmen Gerüche empfunden. Nitratauswaschungen in das Grundwasser resultieren aus überhöhten Güllegaben zum pflanzenbaulich falschen Zeitpunkt.

Die gasförmigen Stickstoffverluste in Form von Ammoniak (NH_3) rücken zunehmend in den Mittelpunkt Interesses. Nachgewiesen ist die Beteiligung von Ammoniak an den neuartigen Waldschäden ("Waldsterben"), während die Auswirkungen auf die Ozonschicht noch nicht hinreichend geklärt ist /1/. Der in Form von Ammoniak aus der Gülle entweichende Stickstoff unterliegt dem Ferntransport und wird vor allem durch Niederschläge wieder aus der Atmosphäre ausgewaschen und in den Boden eingetragen. Hierbei kommt es zu einer Bodenversauerung sowie zur unerwünschten Eutrophierung nährstoffarmer Ökosysteme (Heide, Hochmoor) und Oberflächengewässer /2/.

2. QUELLEN DER AMMONIAKEMISSION

Nach vorsichtigen Schätzungen werden im Gebiet der Bundesrepublik Deutschland jährlich 750 000 t NH_3 freigesetzt /3/. 90 % dieser Gesamtemission werden durch die Landwirtschaft, insbesondere die Tierhaltung, verursacht. Hohe Verluste treten im Stall und bei der Güllelagerung auf. Arbeiten an diesem Problembereich haben gezeigt, daß durch geeignete Stallsysteme /4/ und eine Abdeckung der Güllebehälter /5/ eine deutliche Emissionsreduktion möglich ist.

Durch diese Maßnahmen nimmt die Nährstoffkonzentration in der Gülle zu. Das führt zu einem erhöhten Emissionsdruck bei der Ausbringung, obwohl sie bereits jetzt die Hauptquelle der Ammoniakemission darstellt. Dies zeigt den starken Handlungsbedarf, die Emissionen bei der Ausbringung von Gülle nachhaltig zu senken.

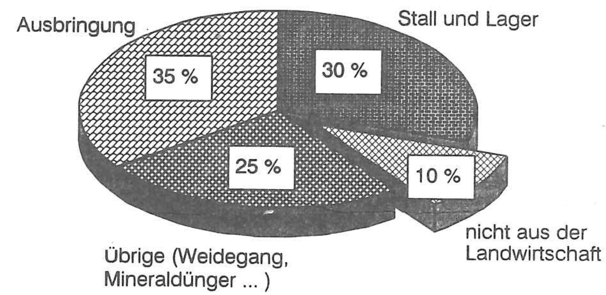

Bild 1: Hauptquellen der NH_3-Emission in Deutschland, Gesamtemission 750 000 t im Jahr.

3. MÖGLICHKEITEN ZUR REDUKTION DER EMISSIONEN BEI DER AUSBRINGUNG VON FLÜSSIGMIST

Bisherige Empfehlungen zur Reduktion der Ammoniakemissionen beschränken sich darauf, den Zeitpunkt der Gülleapplikation so zu wählen, daß aufgrund der momentanen Witterungsverhältnisse der Emissionsdruck vermindert wird. Dies stellt für die Landwirtschaft keine praktikable Lösung dar: so decken sich die Zeitpunkte für eine termingerechte Erledigung der Arbeiten nicht notwendigerweise mit den optimalen Witterungsverhältnissen für geringe Emissionsraten. Darüberhinaus sollte die Gülle als wertvoller wirtschaftseigener Mehrnährstoffdünger zum pflanzenbaulich optimalen Zeitpunkt verabreicht werden. Bei besonders wüchsigem Wetter besteht aber vor allem auf Grünland die Gefahr starker Freisetzung von flüchtigen Gülleinhaltsstoffen. Daher müssen technische Lösungen realisiert werden, die unabhängig von Witterungseinflüssen eine pflanzenwirksame und umweltgerechte Gülleausbringung ermöglichen.

3.1. Ackerland

Untersuchungen im Ackerbau /6/ zeigen, daß durch das sofortige Einarbeiten der Gülle in die Krume eine deutliche Emissionsreduktion möglich ist. Durch das Vermischen der Gülle mit dem Boden werden die flüchtigen Inhaltsstoffe durch die Bodenkolloide adsorbiert.

Die Einarbeitung kann mit konventionellen Bodenbearbeitungsgeräten in einem zweiten Arbeitsgang vorgenommen werden. Der Erfolg dieser Maßnahme richtet sich nach der Länge der Zeitspanne zwischen Ausbringung und Einarbeitung. Bereits nach fünf Stunden können bis zu 50 % des Ammoniumstickstoffes der Gülle in Form von NH_3 entwichen sein /7/. Eine sichere Emissionsreduktion wird daher mit Ackerinjektoren erreicht, die die Gülle unmittelbar bei der Ausbringung in die oberste Bodenschicht einarbeiten.

Ein verlustarmes Ausbringen von Gülle in wachsende Bestände ist beispielsweise mit Schleppschlauch- und Schleppfußverteilern möglich.

3.2. Grünland

Die größten Probleme treten bei der emissionsreduzierten Begüllung von Grünland auf. Der Flüssigmist bildet hier nach dem Ausbringen einen feinen Film auf der Pflanzenoberfläche, so daß starke Geruchs- und Ammoniakemissionen auftreten.

Zur Einarbeitung in den Boden ist ein Eingriff in die Grünlandnarbe unumgänglich. Die in den letzten Jahren entwickelten Grünlandinjektoren bringen die Gülle direkt in den Wurzelbereich der Pflanzen, wobei die Grasnarbe weitestgehend geschont wird.

3.3. Gülleinjektoren für Grünland

Um den Flüssigmist in die Grasnarbe einzubringen, wird diese mit einem scharfen senkrechten Schnitt etwa 7 bis 10 cm tief eingeschnitten. Als Schneidwerkzeuge werden üblicherweise Scheibenseche oder feststehende Messer eingesetzt. Aus diesem Schnitt muß ein Schlitz mit einem ausreichendem Volumen geschaffen werden, so daß die auszubringende Güllemenge vollständig aufgenommen werden kann. Hierzu werden die Schnittkanten auseinandergedrückt, so daß sich ein 2 bis 3 cm breiter und 5 bis 8 cm tiefer Hohlraum bildet. Dieses Verfahren, bei dem die Schlitze offen stehen bleiben, wird als Einfachinjektion bezeichnet.

Eine stärkere Reduktion der Emissionen wird mit der Flachinjektion erreicht. Dabei werden die Injektionsschlitze an der Bodenoberfläche wieder zugedrückt. Für dieses Schließen werden in der Regel V-förmig angestellte Scheiben eingesetzt.

Zur Verhinderung eines streifigen Grünlandaufwuchses durch ungenügende Querverteilung, sollte der Reihenabstand 20 cm bis maximal 30 cm betragen.

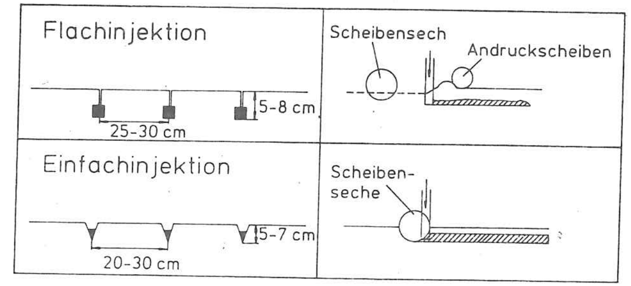

Bild 2: Verfahren der Gülleinjektion auf Grünland.

4. GRUNDLAGENUNTERSUCHUNGEN AN GRÜNLANDINJEKTOREN

Die oben beschriebenen neuentwickelten Gülleinjektoren für Grünland wurden bisher hinsichtlich der Auswirkung ihres konstruktiven Aufbaus auf Emissionshöhe und Zugkraftbedarf nicht untersucht. Forschungsarbeiten mit dieser Aufgabenstellung werden am Lehrstuhl für Grundlagen der Landtechnik der Universität Hohenheim durchgeführt.

4.1. Messanhänger zur Felduntersuchung von Injektoren

Die Versuchseinrichtung wird in der Heckhydraulik eines Ackerschleppers angebaut. In der Fahrerkabine sind die Geräte zur Meßdatenerfassung und -verarbeitung untergebracht. Mit dem Messanhänger kann jeweils ein einreihiger Grünlandinjektor untersucht werden.

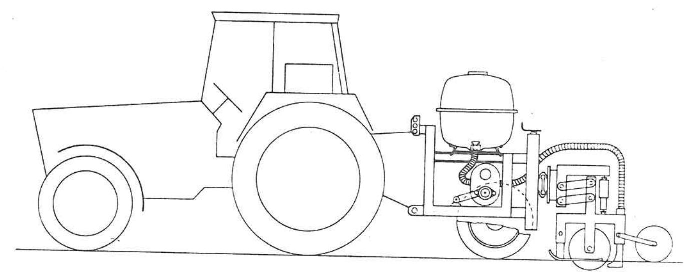

Bild 3: Versuchseinrichtung für die Untersuchungen an Gülleinjektoren für Grünland.

Im Versuch werden Fahrgeschwindigkeit, Gülleausbringmenge, Arbeitstiefe sowie die auftretenden Kräfte zwischen Injektor und Grünlandnarbe ermittelt.

Die Fahrgeschwindigkeit wird mit einem 5. Rad erfaßt, an dem ein inkrementaler Drehimpulsgeber je Radumdrehung 1000 digitale Signale abgibt.

Mit einem zweiten Drehimpulsgeber wird die Drehzahl der Güllepumpe gemessen. Bei der streng drehzahlproportionalen Fördermenge einer Drehkolbenpumpe läßt sich daraus die ausgebrachte Güllemenge errechnen.

Die Arbeitstiefe wird mit einem Ultraschallsensor, der ein abstandsproportionales Spannungssignal liefert, berührungslos gemessen.

Mit einer höhenverstellbaren und daher an alle Injektoren anpassbaren Kraftmeßeinrichtung aus zwei erweiterten Oktagonalelementen wird die zwischen Injektor und Messanhänger wirkende Zugkraft, die Normalkraft, sowie das von den Kräften bewirkte Moment ermittelt.

4.2. Windtunnelsystem zur Emissionsmessung im Feldeinsatz

Zur Erfassung der Ammoniakemission im Freiland muß die NH_3-Konzentration und die dazugehörige Luftmasse gemessen werden.

Die Ammoniakkonzentration kann mit unterschiedlichen Meßverfahren bestimmt werden: naßchemische Absorption in Säurefallen, Flüssig- und Festkörperelektrolytsensoren, Leitfähigkeitsmessung und Laser-Gasmeßsysteme. Aufgrund der geringen NH_3-Konzentrationen ergeben sich meßtechnische Probleme, so daß noch kein standardisiertes Meßverfahren zur kontinuierlichen Konzentrationsmessung zur Verfügung steht.

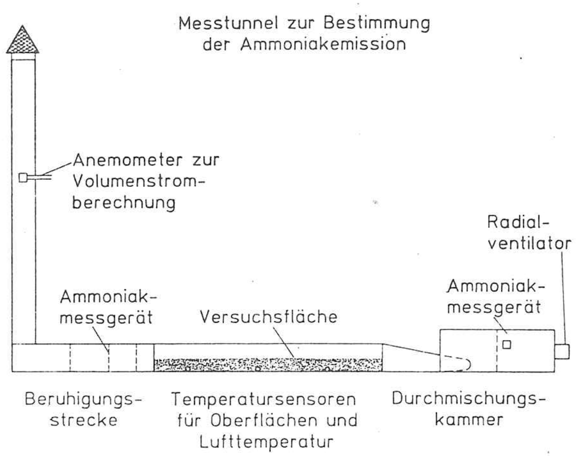

Bild 4: Windtunnelsystem zur Messung der Ammoniakemission bei der Gülleausbringung auf Grünland.

Die reproduzierbare Bestimmung der Luftmasse kann im Freiland nur mit Windtunneln vorgenommen werden. Der speziell für diese Aufgabe entwickelte Windtunnel saugt die Luft in 6 m Höhe an. Die in dieser Höhe gleichmäßigere Vorbelastung der Luft mit Ammoniak wird kontinuierlich erfaßt.

Die Luftgeschwindigkeit im Ansaugrohr wird mit einem Anemometer ständig gemessen. Um aus diesen Meßwerten den Luftmassenstrom berechnen zu können, wurde die Meßstrecke nach DIN 1952 kalibriert.

Die 50 cm breite Versuchsfläche wird auf einer Länge von 4 m gleichmäßig mit Luft überströmt. Das dabei aufgenommene Ammoniak wird nach einer Durchmischung als Konzentration bestimmt und zusammen mit dem Luftmassendurchsatz wird die emittierte NH_3-Menge berechnet.

Während des mehrtägigen Versuches werden Witterungsparameter kontinuierlich erfaßt und zusammen mit den Meßdaten des Windtunnelsystems in einem mobilen Labor weiterverarbeitet und auf Diskette gespeichert.

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