Hungarian Agricultural Engineering

N° 12/1999

PERIODICAL OF

THE COMMITTEE OF AGRICULTURAL ENGINEERING OF

THE

HUNGARIAN ACADEMY OF SCIENCES

Gödöllő, 1999

Hungarian Agricultural Engineering

N⁰ 12/1999

PERIODICAL OF

THE COMMITTEE OF AGRICULTURAL ENGINEERING OF

THE

HUNGARIAN ACADEMY OF SCIENCES

Published by

Hungarian Institute of Agricultural Engineering
H-2100 Gödöllő, Tessedik S. u. 4.
Director: Dr. László Fenyvesi

St. István University, Gödöllő
H-2103 Gödöllő, Páter K. u. 1.
Faculty of Mechanical Engineering
Dean: Prof. Dr. Attila VAS

Gödöllő, 1999

HU ISSN 0864-7410

PREFACE

The Agricultural Engineering Board of the Hungarian Academy of Sciences which supervises the development of this branch organises annually a conference at Gödöllő, which is the central place of the Hungarian agricultural scientific activity.

During the sessions, research scientist, developing engineers, experts of institutions engaged in agricultural engineering development strong in numbers the organizer, the hungarian universities and other higher grades of education, the research institutions: Hungarian Institute of Agricultural Engineering at Gödöllő, Faculty of Mechanical Engineering of the St. István University at Gödöllő and foreign guests give account of their results obtained in the research work and development of agricultural machinery.

This yearly English-Language publication the “Hungarian Agricultural Engineering”, started at 1988, contains selected papers presented at the conference of 1999. We do hope that this publication will be found interesting to a big part of agricultural engineers.

Dr. Attila Vas
Dean

Faculty of Mechanical Engineering
St. István University

Dr. László Fenyvesi
Director

Hungarian Institute of Agricultural Engineering
Gödöllő

PART I.

ABSTRACT OF SELECTED PAPERS

RESULTS OF THE ANALYSIS AND DEVELOPMENT OF THE VIBRATION CUTTERHEAD

Dr. P. Szendrő - Dr. J. Nagy - Dr. E. Szabó
University of Agricultural Sciences, Gödöllő

According to the energetic analysis of field choppers it is clear that the most energy is consumed by the cutterhead. At the Institute of Farm Machinery in the Agricultural University of Gödöllő, the energetic problems of field choppers focusing especially on the chopping process is being examined already for decades. Our present technical and product development work has also been based on the experiences of the preliminary period.

In the frame of development the energy consumption o the cutterhead being used in field choppers is intended to lessen considerably by applying a novel cutterhead mechanism which realizes the sliding cut principle in a new way.

This study presents the questions of the research-development project no. FKFP 1171 MKM and the results of examinations purposing the determination of the energy balance of the cutterhead.

HIGH FREQUENCY AND MICROWAVE DIELECTRIC PROPERTIES OF BASIC FOOD MATERIAL

Dr. P. Sembery - G. Géczi - M. Kovács - M. Douba
University of Agricultural Sciences, Gödöllő

High frequency (RF) and microwave (MW) procedures successfully can be applied in the technological treatment for certain agricultural products and basic food materials. For example, here can be mentioned enzyme-inactivation of Soya bean, mustard seeds and wheat, pre-cooking of rice, blanching of peas and corn, etc. Developing the technology treatment for these products can not be done without suitable knowledge for main properties of electrophysic and science of heat.

Through our investigations we would like to study the dielectric properties for the above mentioned food and basic food materials. Measurement system of high frequency and microwave has been developed in RF and MW frequency range. Here will be introduced the most important results of these developments.

MAIN TRENDS OF THE MECHANIZATION IN MILKING

Prof. Dr. L. Tóth - Dr. L. Fogarasi - G. Horváth Ph.D. student
University of Agricultural Sciences, Gödöllő

By the investigations carried out in our department, a positive result can be obtained in the field of the milking development in order to increase the quality and efficiency with organising all the factors into a complex unit. The goal for the future is the plastic fitting the milking units to the udder configuration of the cow stocks (remembering that also the breeders are trying to create cow stocks where the animals would have uniform and symmetrical udder quarters). It is realized finally in the milking robots where the above described dissymmetrical solution of the milking units will be applied and nor other synchronisation (taking into consideration the individual parameters of the animals) during the mechanized process can be excluded. Using the regulator elements, continuous corrections can be realized in the milking process according to the detected parameters. Now the completed improvements include the most required technical solutions, of king units of better fitting (better than the existing solutions) to the present milking equipment considering that the application possibilities of the milking robots will be limited in the near future. Taking into consideration the above described facts as

- the length and diameter of the milking liner and
- the measure of the tubes etc.

APPLICABLE SLURRY TREATMENT METHODS ON LARGE-SCALE PIG HUSBANDRY

Dr. L. Fenyvesi - L. Mátyás
Hungarian Institute of Agricultural Engineering
Gy. Mészáros, FVM - MoARD
Prof. G. Hörnig, ATB Potsdam-Bornim

Nowadays the state of the housing system, manure/slurry removal and handling of pig farms, apart from some reconstructions, reflects a near 30 years of situation. Those pig farms have the most serious problems where the housing system is literless and where could not minimize the amount of surplus technologic water that gives the most part of the slurry because most of the pig farms do not dispose over arable land of their own for utilizing their slurry production. Because turning to bedding system, that has meaningful advantages zootechnically, in most of the cases are impossible, we have to calculate the presence of slurry for years. Taking info consideration the present economic situation we have to find the not expensive but effective solutions in order to reduce the volume of slurry and the environmental load.

STUDY OF THE RELATIONS OF DYNAMIC DRAW BAR PULL FORCE AND ENGINE LOAD BY MATHEMATICAL MODEL

Dr. A. Vas - Z. Lajber
University of Agricultural Sciences, Gödöllő

In the agriculture, the tractors are one of the biggest fuel consumers, hence the good efficiency of tractor engines is very important. During the operations of the tractors, the engine load dynamically changing, and this reduce the efficiency. In this study we examine the reasons and possible solutions of this changes.

DYNAMIC METHOD FOR QUICK AND NON-DESTRUCTIVE MEASUREMENT OF THE SURFACE FIRMNESS OF FRUITS AND VEGETABLES

J. Felföldi - T. Ignát
University of Horticulture and Food Industry

The firmness measurement of produces – fruits, vegetables, some foods – is very important for quality assessment, for describing the ripening and generally for the decision support in processing, storage or marketing. The methods – both the widely used traditional methods and the new methods as well – can be separated into two different groups:

a) compression methods, based on the slow compression of the produce and on the analysis of the stress/deformation relation

b) dynamic methods, based on impact (or vibration) of the produces and on the analysis of the force, acceleration or deformation changes after the excitation.

The dynamic methods offer some advantages related to the traditional methods. The most important advantages are that the dynamic methods are mostly non-destructive and very quick, providing with the possibility of the on-line individual testing of the produces (Chen, 1998). Therefore the research work of our department was concentrated – in addition to the traditional compressive destructive and non-destructive methods – on the dynamic methods as well.

The aim of the work is to develop and analyse a non-destructive impact testing method for quick and objective characterisation of the surface firmness of wide range of fruits and vegetables.

RESPONSE OF BIO-SYSTEMS ON WHITE NOISE EXITATION

P. Szendrő - G. Vincze - A. Szász
University of Agricultural Sciences, Gödöllő

The pink- (1/f -) noise is one of the most common behaviour of the bio-systems [4]. Our present paper is devoted to clarify the stochastic answer given to the white-noise excitation of bio-systems. It is shown that the white-noise powered bio-system generates also pink-noise spectrum. It is used that the living objects in general has cyclic symmetry in infinite degrees of freedom, and their dynamism covered by stationer random stochastic processes.

MODELLING OF COLOR CHANGING DURING STORAGE

A. Szepes Ph.D. student
Department of Physics-Control, UHFI

The storage is very important part of trade. The quality of the fruits and vegetables changes during the shelf-life. These changes can be positive or negative. The process is positive after the harvest until reaching the total ripeness. After this time the harvest will be negative. The state of crop in the process of ripening is determined by a numerical system [1].

The fruits and vegetables are stored before selling on the market. On this place the appearance of the fruits and vegetables is very important factor. Especially the color tested during the experiments, because the customers decide on the basis of the color. This external parameter is of great importance.

EFFECT OF SOIL DEFORMATION ON THE ENERGY BALANCE OF TRACTORS

P. Kiss
University of Agricultural Sciences, Gödöllő

In our paper we analyzed the relationship between a tractor's energy balance and the soil deformation taking place under its tires. The goal of this research was the development of a mathematical model to determine the energy balance equation for a tractor. This equation consists of two parts, one describing the „vertical energy transfer" from the tire into the soil and the second part is he „horizontal energy transfer" which is expended to overcome various resistances. This model takes into account the soil deformation. Our analysis was based on data obtained via field testing a tractor at many different speeds and tire inflation pressures.

THE GRIPPLING STUMPLIFTING TECHNOLOGY

T. Major
Sopron University
J. Rákosi
KEFAG Ltd.

The new challanges of forest economy, a better awareness policy as far as nature conservation and protection is concerned require more efficient stumplifting technologies. Afforestation policies should focus on establishing new forest sites it means a brand new phylosophy: new forest on the premises of the old one reducing the level of the artificial intervention. This new concept resulted in a new approach which means that certain places stumplifting procedure has been cancelled. Another approach is to make the best to eliminate the side effects of spoiling natural environment with applying new stumplifting technologies and tchniques.

Removing stumps may be carried out in different ways. The grippling stumpliftinf technology seems to be very popular nowdays all over the world. The traditional way of stumplifting was based on mechanical procedure or hydraulic procedure where machines equipped with forklifts with pushing or pulling function could operate.

Meanwhile this sort of operation was carried out the base machine was in work throughout the whole process, and the lifting structure pulls or pushes the stumps before finally grippling and removing them. Meanwhile this function is carried out significant soil damages occur.

To meet the high demands of environmental friendly policies a new technology appeared, which can guarantee the needs of modern forest policy as well. Actually when this new technology is applied the base machine is stationary and a horizontal rotation of lifting structure is about to remove the stump. This method is a lot more environmental friendly and protects the quality of soil in a more efficient way with a better performance. Another advantage of this application that simultaneously soil preparation can be carried out as well.

There are several machines for the implementation of the new grappling stumlifting technology. In Hungary the French product the CASE POCLAIN stump remover is available (in the forests of Kiskunság Forest and Woodwork Ltd.)This machine was designed to remove stumps with the grippling technology, to pile them up either in rows or in bulk. Simultaneously it is applicable for clearing bushes, clearing away, clipping, soil loosening and soil preparation as well.

IS THE STRUCTURE OF THE WATER CONVERTIBLE IN PHYSICAL WAY?

P. Szendrő - J. Koltay - A. Szász - Gy. Vincze
University of Agricultural Sciences, Gödöllő

It will be proved that the structure of the water consists of two solid, a liquid and a gas structure components in the temperature interval of $0-60^0C$. The two solid components contain ice like clusters, and their proportions can be altered by means of electro-magnetic field. In this way the water can be structured. The pattern remains for a long time after the treatment as well, which cannot be described by the chemical equilibrium. Therefore we have worked out such a polarization model for the water, according to which the polarization process holds hysteresis. Hereby the permanent structure conversion can be explained. According to the Eötvös law, the structure alteration entails a change of the surface tension, which we could also demonstrate by a simple experiment. The work has been carried out in the frame of the research projects OTKA I/3–1522, the OTKA T-017717 and the OMFB 96-97-44-1054.

EXPLORATION OF TECHNICAL AND FERMENTATION-BIOLOGICAL RELATIONSHIPS OF WRAPPED SILAGE BALES (OTKA T 022420)

Dr. L. Fenyvesi - Dr. Z. Bellus
Hungarian Institute of Agricultural Engineering

Silage-making of alfalfa is a well-known preservation method. Ensuring of coarse fodder of good quality, containing low content of fermentable sugar and high content of protein, in winter and in the case of monodietic feeding is adversely effected by the preservation.

The special harvesting and wrapping machines that have been appeared recently on the market of the western countries have been created the conditions for the long-time preservation of the coarse fodder in good quality.

Balers, as the main machines of the technology, have come on to the market with bale-chamber and slicing unit in order to get more favourable compaction.

Against of the traditional harvesting technology of alfalfa and coarse fodder in home conditions, these new machines have been appeared in Hungary too.

For the solution of the fodder supplying problems of small and middle size farms wrapping machines with simpler construction are suitable while on large-scale farms the best solution is to use the press-in-bag technology.

To start the fermentation process and to preserve the nutrient content of the fodder as for as to reduce losses and to avoid the harmful post-fermentation applying of different kind of additives, pro-biotics and enzymes is necessary.

In our present research report we give an account of the result of the foil tests in laboratory conditions and of the bale wrapping examinations in operative ones.

TECHNICAL, TECHNOLOGICAL AND FEEDING EXAMINATION OF FODDER FERMENTED IN BAG

Prof. Dr. J. Csermely
Hungarian Institute of Agricultural Engineering
Prof. Dr. J. Schmidt
Pannon University of Agricultural Sciences (PATE-MTK)

The aim of three years lasting research theme that was started in 1998 are the technological establishing of the home adaptation of the new storage system, finding out the technical, technological and feeding connections and elaboration of the running costs.

Summarizing, conclusions

- The average filling capacity of 7-14 t/h can be rised by more than twice by means of better service and better organising of the transport.
- Owing to the crushing and the pneumatic transport the specific energy consumption of the filling is 2.3-2.7 kWh/t at wet corn grits.
- On the basis of the preservation and feeding experiences it can be stated that by the bagging storage technology can be produced silage of good quality and of favourable digestibility.
- Owing to the better harmony with harvesting and filling the loss of harvesting can be decreased.
- By means of the more favourable storage characteristics the quality of the fodder can be preserved in better way.
- Flexibility and universality of the technology ensure favourable management advantages.

In the case of corn, harvesting capacity can be increased, its duration can be decreased and considerable energy and drying cost can be saved.

INDUSTRIAL DEVICE FOR STIMULATING SEEDS

P. Szendrő - J. Koltay - Gy. Vincze - A. Szász - K. Hentz
University of Agricultural Sciences, Gödöllő

The study describes the industrial version of the so-called vectorpotential device, constructed in the frame of the research projects OTKA T-017717, OMFB 96-97-44-1054 and the OTKA TO 30764. It discusses the effect mechanism, which results the raise of germination capacity and germination rate in several seeds. It introduces the functional parts of the prototype device. The final part of the study contains the results of a small plot research.

PIG FATTENING ON STRAWED SLOPING FLOOR IN HUNGARY ON THE BASIS OF GERMAN EXPERIENCES

L. Mátyás - Dr. L. Fenyvesi
Hungarian Institute of Agricultural Engineering
H. Sonnenberg
FAL, Braunschweig
E. Tugyi
Újlengyel
J. Preiner
Lajta-Hanság Joint-Stock Co. (Rt)

Littering makes better the comfort feeling of pigs, the production results and at the same time considerably decreases the amount of the environmental loading of the slurry. Man power demand of litter housing can be considerably decreased by the so called small littering sloping floor system that has been developed in the German co-institutes. Spreading of straw litter is done by pigs themselves while the manure is delivered on the floor with 5-7 % slope without man power intervention towards the opposite side of the front wall of pens. Domestic adaptation of the system has been realized on a middle-scale private pig farm. Litter demand hardly reached the 0.3 kg amount per day for one fattening place. The average daily gain was 670 g while the feed conversion was below 2.8 kg/kg. Manpower demand, as for bedding and manuring out, was negligible just as the unpleasant smell effect. Favourable experiences of on another large-scale pig farm with 1,300 sows could open new vistas for large-scale pig husbandry too.

A COMPUTER AIDED FREQUENCY ANALYSIS OF A WIND TURBINE

G. Horvath Ph.D. student
Prof. Dr. L. Tóth D.Sc. of the Hungarian Academy of Sciences
G. Tóth Ph.D. student
University of Agricultural Sciences, Gödöllő

The work presents a methodology developed for the structural and dynamic analysis of wind turbine blade and tower. The methodology is based on a numerical algorithm. An on site wind measurement data have been used as inlet boundary condition for a dynamic system analysis. A numerical computation and visualization software has been used for describing the structure's vibrations. The blade's natural frequencies and stress distribution were obtained from a finite element modeler. To convert the blade loads to material strain, results from a fluid flow analysis were assigned to the structural analysis creating a multiphysics application.

A basis for this algorithm is a comparison between different vibrations. A new method was developed for defining the critical frequencies. The continental wind conditions differ from the coastal area in the manner of dynamics. With computer-aided design methods the design procedures and design variables can be defined depending on the wind characteristics. As such the designer can select geometrical or operational characteristics. This model should give guidelines for wind turbine load measurement.

DISK TILLAGE - THE DISK TILLAGE EFFECTS ON THE PHYSICAL CONDITION OF SOILS

M. Birkás
University of Agricultural Sciences, Gödöllő

Disks can be used for either primary or secondary tillage. Advantages of disking are wide-ranging, although it can be accepted that disks are potentially soil compactors and extreme care needs to be taken in there use in wet and previously compacted soils. Examining arable soils an upward tendency can be stated in the ratio of soils compacted below 16 and 18 cm that is below the depth of disk tillage used commonly in 1990s in Hungary.

SOME DESIGN QUESTIONS OF VERTICAL SCREW CONVEYORS

Dr. J. Benkő
University of Agricultural Sciences, Gödöllő

Vertical screw conveyors are hardly mentioned in the home technical literature They are very rarely applied in practice in spite of their many advantages. The probable reason of it that designing vertical screw conveyors requires much experience and theoretical knowledge. This presentation deals with the explanation and calculation of two important parameters of the design, namely the critical angular velocity and the conveying speed.

FUZZY LOGIC APPLICATION IN THE ARABLE SITE DETERMINATION OF AGRICULTURAL CROPS

Cs. Fogarassy - Cs. Gyuricza - K. Kocsis
University of Agricultural Sciences, Gödöllő

Originally the „Fuzzy Logic" has emerged as a profitable tool for the controlling of subway systems and complex industrial processes, as well as for household and entertainment electronics, diagnosis systems and other experts systems. Although Fuzzy Logic was invented in the United States the rapid growth of this technology has started from Japan and has now again reached the USA and Europe also.

Fuzzy Logic is still booming in Japan, the number of letters patent applied for increases exponentially. The main part deals with rather simple application of Fuzzy Control. Fuzzy has become a key-word for marketing too.

In Japan Fuzzy-research is widely supported with a huge budget. In Europe and the USA effort are being made to catch up with the tremendous Japanese success.

Fuzzy Logic is basically a multi valued logic that allows intermediate values to be defined between conventional evaluations like yes/no, true/false, black/white, etc. Notions like rather warm or pretty cold can be formulated mathematically and processed by computers. In this way an attempt is made to apply a more human-like way of thinking in the programming of computers. Fuzzy Logic was initiated in 1965 by Lotfi A. Zadeh, professor for computer science at the University of California in Berkley.

THEORETICAL AND PRACTICAL RELATIONSHIPS FOR COMPETITIVE COMPARISON OF DIFFERENT POWER MACHINE SYSTEMS

L. Magó Ph.D. student
University of Agricultural Sciences, Gödöllő

It is the optimal power machine park considering the technology and economy requirements what serves as a basis of the efficiency, realising higher profit and contributing the long term prosperity of the business. Making use this issue one should decide from which machine types of which manufacturers would be aggregated the machine park. Therefore procurement should be made with examining the possible widest market of power machines so that the power machine, power machine park would have the most favourable economy characteristics.

In this work the method of linear programming was used based on the sowing plan of a model company and the optimal power machine park was aggregated from the products of agricultural machine manufacturers of three regions such as East-Europe, Middle-East-Europe and West-Europe. Two distinct machine families were considered from the latter region. The families were compared on the basis of their technology and economy properties.

It can be stated that the power machines offered by different manufacturers and the optimal machine park aggregated form them have diverse technology and economy properties and the produced values greatly influence the economy of the agricultural companies operating them.

The examination carried out this way determines the operation characteristics of the optimal machine park instead of an individual machine examination. This can be advantageous both for the operating and manufacturing companies because this way it is not the characterisation of a given power machine in a given job but the information on a whole machine family in a complete production technology what is obtained.

Key words: applied operation research, machine aggregate assemblage, linear programming, mechanisation of agriculture, machine aggregate competition.

FEM ANALYSIS OF STATIONARY AND ROTATING FRAME OF THE MOUNTED REVERSIBLE PLOUGH

T. Illés - I. J. Jóri - Gy. Kerényi
Technical University, Budapest
L. Vései
Kühne Rt., Mosonmagyaróvár

Ploughs are determining machines of agriculture. It was a long development through which we reached the modern reversible plough starting with simple spade-stick. The oldest memory of Cultural activity of human dates back to about 8000 years. The Mesopothanian Uruk-Varka clay-tables that contain the oldest drawings of ploughs are 5000 year old. [*Lammel*, 1963]

The modern ploughs have been developed on the basis of experiences of these 5000 years. We expect these modern ploughs to fulfil the following demands.

- When ploughing every ploughbody should cut out furrows with the same cross-section.
- We should be able to adjust the work-depth according to the requirements, but the variation of depth and width (stability) should remain under 5%, 10% respectively.
- Ploughbodies should ensure proper turn over (ploughing) and the required pulverizing. The ploughed furrows should tilt tightly against each other, so that the coverage and mixing of organic materials should be adequate.
- Ploughbodies are required to leave no big clods behind, the ploughing should be smooth.
- Ploughbodies should leave behind a vertical, smoothly cut, non-collapsed furrow wall to avoid compression of the soil.
- The bottom of the furrow should be plane (parallel to the surface), because this way the local cumulating of water can be avoided. [*Bánházi - Koltay - Soós*, 1984]

CAVITATION AND TRANSIENT PROCESS OF GEAR PUMPS

Dr. S. Török - Z. Bártfai
University of Agricultural Sciences, Gödöllő

Pumps operating on the base of volume displacing theory are sensible very much for the boost pressure. Cavitation occurs when the pressure inside the pump is lower then the critical pressure in the inlet chamber. In order to avoid the mentioned disadvantageous phenomenon during operation of gear pumps, computer aided research activities have been run by the author at the Systems Engineering Department of the Gödöllõ University of Agricultural Sciences.

CONTRIBUTION TO THE VERIFICATION OF THE TWO-VARIABLE ENERGETIC FUNCTION (OTKA T 016 124)

Dr. I. Bölöni - Dr. Z. Bellus
Hungarian Institute of Agricultural Engineering

Once again it was justified by means of hammermill in grinding barley, corn and wheat that

(1) the specific grinding energy requirement ($kWh{\cdot}t^{-1}$) is a two-variable function of the specific superficial grinding energy consumption ($kWh{\cdot}cm^{-2}$) and of the specific grist surface increase ($cm^2{\cdot}g^{-1}$),

(2) the grinding speed ($cm^2{\cdot}g\text{-}1{\cdot}s^{-1}$) is a linear function of the quotient of the useful grinding power input (kW) and of the momentary load quantity (kg), if the specific superficial grinding energy demand ($kWh{\cdot}cm^{-2}$) remains constant.

DEVELOPMENT OF TribolOGICAL TEST-RIG FOR DINAMIC EXAMINATION OF PLASTIC COMPOSITES

Dr. G. Kalácska - L. Zsidai
University of Agricultural Sciences, Gödöllő
Dr. M. Kozma
Technical University, Budapest
Dr. Patrick De BAETS
University of Gent, Belgium

As it is well known, the basic failure process of machine elements is the wear and friction. To avoid and reduce the losses, there are some useful methods e.g. heat-treatment, surface coatings, lubrication, and appropriate material selection. Nowadays the latest becomes more and more important taking the new engineering plastics into consideration.

The relatively advantageous wear behaviour of engineering plastics in abrasive conditions gives new possibilities for design, construction and maintenance of agricultural machines as well. The basic of technical development and proper material selection is the knowledge of tribological behaviour of the plastics. However, these processes are partly known for conventional metallic materials, the behaviour of the new up-to-date engineering plastics, composites, are less known.

The replacement of traditional metallic materials usually needs tribotesting of the operational systems. In most cases it is very difficult and expensive way of the investigation, so simplified laboratory test are suggested even by standards, too. These examinations (traditional pin on disc, pin on cylinder...etc) are carried out during steady conditions, not taking the dynamic effects (acceleration, force, directions...etc) into consideration. That's why we decided to develop a new dynamic test-rig, which gives possibilities to model of dynamic systems in tribo-testing giving better correlation of the real operation of machine elements. This study gives a short overview of tribotesting and the structure of the new testrig.

PART II.

SELECTED SCIENTIFIC PAPERS

RESULTS OF THE ANALYSIS AND DEVELOPMENT OF THE VIBRATION CUTTERHEAD

Dr. P. Szendrő - Dr. J. Nagy - Dr. E. Szabó
University of Agricultural Sciences, Gödöllő

Abstract

According to the energetic analysis of field choppers it is clear that the most energy is consumed by the cutterhead. At the Institute of Farm Machinery in the Agricultural University of Gödöllő, the energetic problems of field choppers focusing especially on the chopping process is being examined already for decades. Our present technical and product development work has also been based on the experiences of the preliminary period.

In the frame of development the energy consumption o the cutterhead being used in field choppers is intended to lessen considerably by applying a novel cutterhead mechanism which realizes the sliding cut principle in a new way.

This study presents the questions of the research-development project no. FKFP 1171 MKM and the results of examinations purposing the determination of the energy balance of the cutterhead.

1. Introduction

The silage production in Hungary needs several thousands tons of diesel oil which is a most significant amount regarding that it is almost the half of the total energy consumption of the self propelled harvesting machines. The cutterhead requires two third of the entire engine performance in idle run while under standard load it can reach even 80% [4].

At the Institute of Farm Machinery of the Agricultural University of Gödöllõ the results of development performed on field choppers are indicated by several patents, numerous publications and dissertations [1], [2], [4], [5].

In the frame of development the energy consumption of the cutterhead is considerably decreased by a novel cutterhead construction realizing sliding cut in a new way.

The analysis performed in the final part of the project (1998) is to determine the energy balance of the cutterhead in actual circumstances chopping silo maize.

Beyond these the quality of the chaff has also been controlled.

2. Some constructing principles for the cutterhead „vibro cut"

As a result of our developing work in the near past a novel type vibration cutterhead called „Vibro cut" has been implemented. The cutterhead is fitted out with controlled generatrix edged knives and has been constructed to substitute a regular cutterhead of a high performance field chopper (CLAAS Jaguar 840). The connecting dimensions and the room for the control left us a relatively tight possibility.

The basic element of the control mechanism was a control groove in the first step of the development. To decrease the heavy wears made us to apply control disc instead of this. Thus, the slip of the supporting rolls decreased, making also possible the precise adjustment of the gaps during assembly by means of an eccentric pivoted supporting roll (SKF KRVE 52 PP) by pairs.

3. Aim of the analysis

The measuring examinations of the past year related to the prototype cutterhead and its integration to field chopper (CLAAS Jaguar 840 laboratory stationary measuring unit) purposed the determination of energy requirement of its control device [5]. With the „Vibro Cut" cutterhead the aim has been changed to perform examinations on the cutting energy and cutting quality [6].

3.1 Themes of analysis, measuring circumstances

Planning the measurement our starting point was that the cutterhead should be built in to a modern field chopper (decided already during the first step of the construction). The examinations have been based to the harvest of silo maize, a plant widely spread in Hungary. Since our measuring unit is stationary, the feed rolls of the chopping machine have been fed by a conveyor belt. The field chopper was run by its own engine. For safety reasons both the field chopper and the conveyor belt was operated by remote control. The computer which controlled the measurement and performed the data process was also brought to a safe place during the experiments.

Variable parameters were: the machine load, the theoretical length of cut, the speed of the cutterhead. During each measurement set up, samples have been collected for a subsequent quality analysis.

The machine load was controlled by the number of maize plants placed on the conveyor belt in the same time. The machine load [kg/s or t/h] also stayed in our disposal as a variable since the weight of the stalks and the feeding time was measured.

The examinations comprised quite a few measured parameters, which enabled the true judgment of the construction after analyzing the results. The planned number of repetitions assured the possibility of proper statistical process.

The entire measuring apparatus, the equipment for data acquisition and process which has been used for carrying out the planned experiments belong to the Institute of Farm Machinery.

The layout of the experiments guaranteed the safety of the personnel, instruments and equipment.

4. Results of measurements and their assessment

Our results are discussed in the following divisions:

- energetic results of measurements and their assessment,
- data of quality experiments,
- functional analysis of the „Vibro Cut" cutterhead.

4.1 Assessment of the analysis for cutting energy

The energy consumption of the cutterhead „Vibro Cut" during the cut could be properly determined using a measuring apparatus with a data providing capacity of 600/minutes. Besides the torque demand which was measured by electro-tenziometric way, the momentary speed of rotation has also been registered.

In the following charts the mean torque values of some set up has been summarized. Column Fig.1 represents the mean torque values of the set up with 5 mm theoretical chop length.

Beyond the trend of growing torque demand as a function of machine load, it can also be observed, that by the application of the „Vibro Cut" cutterhead in the CLAAS Jaguar 840 field chopper meant a lower torque requirement in all the set up cases with a theoretical chop length of 5 mm having the largest importance in the practice. This trend could be observed not only in the mean values but in the repetitions as well. Therefore not a unified repetition mean is shown bellow, in order to be able to represent the previously drafted trend-stability of the measured data.

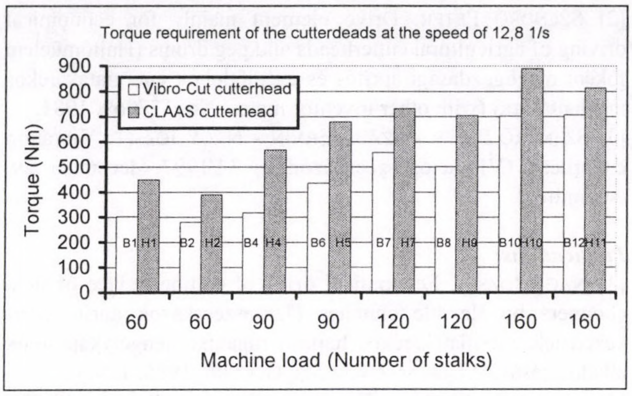


Fig 1. Torque requirement of the „Vibro Cut" cutterhead with a theoretical chop length of 5 mm

On the basis of the former the conclusion is obvious that the energetic advantages of the „Vibro Cut" cutterhead shows significant in set-ups having importance in practice, and this means a 15-30% drop of torque requirement.

The possibility of drawing the exact conclusion could be increased by the overview of the specific performance requirement [kW/kg] based on the weight of the silo maize to be cut.

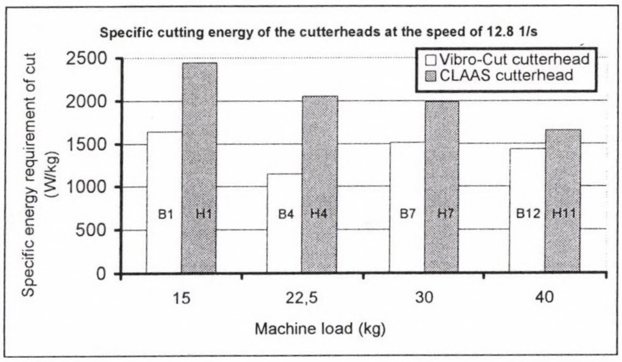


Fig 2. Specific performance requirement [kW/kg] of „Vibro Cut" cutterhead with a theoretical chop length of 5 mm

The characteristic of the diagram is similar to the one with the torque data, so the finding has been confirmed according to which the „Vibro Cut" cutterhead possesses a significantly lower torque requirement producing short chaffs at low speed of rotations.

Beyond the diagrams that have been picked out to visualize, their source tables are also going to be shown bellow. These comprise both the measured and the calculated data.

4.2 Quality assessment of the cut plant bulk

The „Vibro Cut" cutterhead did not show any drop in any quality indices beside the favorable cutting energy features.

Picked out the mean value (S_l=2.72mm) and the standard deviation (P=0.75) of the defining standard distribution from the 6 characteristic parameters of the complex distribution it shows a fairly good chop quality in accordance with the adjusted chop length of 5 mm. The cut bulk could be qualified as good also by subjective assessment and survey.

5. Summary, conclusion

Regarding the results of the development project we came to the conclusion that the planned novel working principle can be accomplished with the „Vibro Cut" cutterhead.

Closing the project the following important findings can be listed as theses, based on extensive experiments:

1. The planned mechanism – based on the results of preliminary theoretical research – at the beginning of the development project can be constructed, fabricated and to the field chopper integrated.
2. The „Vibro Cut" cutterhead realizes the novel chopping effect, which according to our aims enables pull-cut in field choppers.
3. The improvement (15-25%) of the specific cutting energy index [kW/kg] caused by the move of the edge of the knife can be achieved independently of the load of the field chopper [t/h] at a cutterhead speed of n≅13 1/s, by 5 mm chop length harvesting silo maize [7].
4. According to our experiments the conclusion could also be drawn that the „Vibro Cut" cutterhead enables the production of short, premium quality chaff at a lowered cutterhead speed.

Table 1. Summarized data of the „Vibro Cut" cutterhead built in to the CLAAS Jaguar 840 field chopper with a theoretical chop length of 5 mm[7]

	Machine load I					Machine load II		
Code	B1	B2	H1	H2	H3	B4	H4	H5
Cutterhead torque [Nm]	303.78	280.52	450.63	390.15	288.84	318.02	568.28	678.73
Angular velocity [1/s]	81.22	81.22	81.43	81.43	81.43	81.22	81.43	81.43
Performance requirement [W]	24673.01	22783.83	36694.80	31769.91	23520.24	25829.58	46275.04	55268.98
Specific work [J/kg]	7237.41	10632.45	14213.12	7412.98	7495.11	5062.59	9563.50	12453.94
Specific performance [W/kg]	1644.86	1518.92	2446.32	2117.99	1568.01	1147.98	2056.66	2456.39
Bulk flow [t/h]	6.75	5.62	7.62	7.50	7.63	10.12	10.90	11.21
	Machine load III				Machine load IV			
Code	B7	B8	H7	H8	B10	B12	H10	H11
Cutterhead torque [Nm]	558.57	501.99	732.86	704.88	701.61	706.24	890.98	814.96
Angular velocity [1/s]	81.22	81.22	81.43	81.43	81.22	81.22	81.43	81.43
Performance requirement [W]	45367.05	40771.62	59676.79	57398.37	56984.52	57360.81	72552.50	66362.19
Specific work [J/kg]	9315.36	10342.40	11398.26	8743.68	6268.29	9536.23	10483.83	9771.83
Specific performance [W/kg]	1512.23	1359.05	1989.22	1913.27	1424.61	1434.02	1813.81	1659.05
Bulk flow [t/h]	12.00	10.73	14.79	14.59	17.39	13.10	18.41	18.87

From the data of the table it is clear, that our findings are confirmed by not only the qualities represented in the diagrams but also by the similar behavior of the specific characteristic features.

5. The quality of the chaff is premium independently of the rate of the bulk flow. Drop in chopping quality could be shown not even by measuring examinations.

6. Regarding the novel quality of the construction we started to take out a patent for an invention on the 20th of December 1997. Its number of registration is P 97 02517 at the Hungarian Patent Office [3].

The tough research-experiment work of the development personnel can already show practical results, and can project actual opportunities. The development being discussed has not stopped in the mind of the development personnel, only a part of a financial support is finished.

The further process of this success projecting idea is needed by the „goose-step" at the larger agricultural machinery manufacturers worldwide according to which it has not been managed any considerable breakthrough in the development of the cutterhead in spite of its high energy requirement.

References

Patents:

[1] SZENDRŐ PÉTER: Revolving drum type cutting device especially for forages (Forgódobos aprítóberendezés, különösen szálastakarmányhoz) No. 168907, 1973. (with other inventor mates)

[2] SZENDRŐ PÉTER: Drive element mainly for economical driving of agricultural cutterheads and peg drums (Hajtóműelem főként mezőgazdasági aprító- és cséplődobok energiatakarékos meghajtására) (with other inventor mates) No. 177069, 1981.

[3] SZENDRŐ PÉTER - SZABÓ ERVIN - NAGY JÓZSEF: Vibration cutterhead (Vibrációs szecskázódob) 34/1997. december 29. (submitted)

Publications:

[3] NAGY JÓZSEF: Economical drive of cutting device of field choppers by flexible clutches (Járvaszecskázók aprító szerkezetének energiatakarékos hajtása rugalmas tengelykapcsolók alkalmazásával) Doktori értekezés, Gödöllõ, 1986. 124 p.

[4] SZENDRŐ PÉTER: Chopping of green forages (Szálas zöldtakarmányok szecskázása) Akadémia Kiadó, 1995. 157 p.

[6] SZENDRŐ PÉTER - SZABÓ ERVIN - NAGY JÓZSEF: Development and analysis of vibration cutterheads (Vibrációs szecskázódobok fejlesztése és vizsgálata) Jármûvek, Építôipari és Mezőgazdasági Gépek, Budapest, 44. évfolyam, 6. szám, 1997. június, 205-209. p.

[7] Decreasing of cutting energy requirement for field choppers (Járvaszecskázó gépek aprítóteljesítmény szükségletének csökkentése) OMFB M 007 zárójelentés 1995-1998., ATE Gödöllő, 1998. november, 91 p.

HIGH FREQUENCY AND MICROWAVE DIELECTRIC PROPERTIES OF BASIC FOOD MATERIAL

Dr. P. Sembery - G. Géczi - M. Kovács - M. Douba
University of Agricultural Sciences, Gödöllő

Introduction

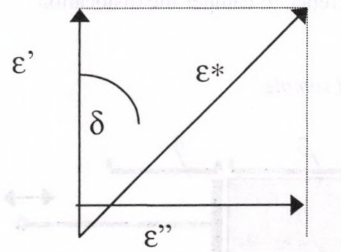
High frequency (**RF**) and microwave (**MW**) procedures successfully can be applied in the technological treatment for certain agricultural products and basic food materials. For example, here can be mentioned enzyme-inactivation of Soya bean, mustard seeds and wheat, pre-cooking of rice, blanching of peas and corn, etc. Developing the technology treatment for these products can not be done without suitable knowledge for main properties of electrophysic and science of heat.

Through our investigations we would like to study the dielectric properties for the above mentioned food and basic food materials. Measurement system of high frequency and microwave has been developed in RF and MW frequency range. Here will be introduced the most important results of these developments.

Dielectric properties

If we locate material in high frequency space, the material will have dielectric behaviour. Heat will be generated in this material by effect the high frequency space. Elementary dipole can be fined in the dielectric material, which become settled under effect the direct of the electric field. The dipole can be settled under effect the changed electric field in suitable speed as the frequency. These rearrangements cause inner frictions and that cause heating in the material. Dielectric properties significantly depend on the moisture content in the material. Because the dielectric constant for the water is high. Next, we can summarise the dielectric properties and the relationships among them.

Dielectric constant (real permittivity):	ε'
Dielectric loss factor:	ε''
Loss tangent:	tgδ
Complex permittivity:	ε^*



$$\varepsilon^* = \varepsilon' + j\varepsilon''$$

$$\mathrm{tg}\,\delta = \frac{\varepsilon''}{\varepsilon'}$$

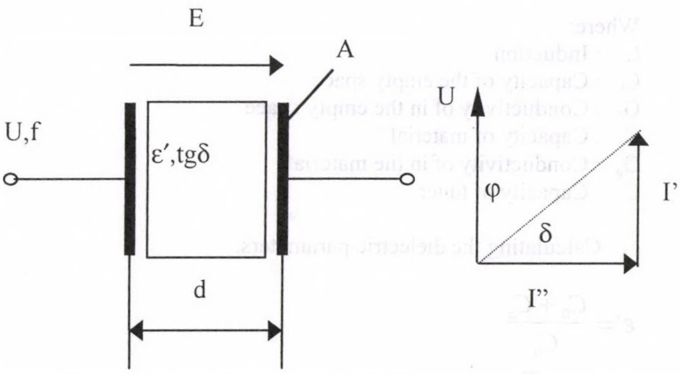
Next we try to determine the relationships of the dielectric properties, relationships of frequency, relationships of moisture contents and relationships of temperatures:

ε' = f (f)	**Frequency range** (f) depends on used treatment procedure tgδ = f (f) type (high frequency, microwave).
ε' = f (w) tgδ = f (w)	**Moisture content (w)**depends on the moisture content of the basic food material (seeds, vegetable).
ε' = f (T) tgδ = f (T)	**Temperature range (T)** depends on the relationship of treatment system (enzyme inactivate, blanching, pre-cooking, drying, backing)

To study the dielectric properties of materials, first of all, it is need to know design of the equipment of high frequency and microwave. For example let us study that, how the generated energy in material can be determined by knowing the dielectric data.

Determining dissipation of energy

U - Voltage	V
f - Frequency	Hz
E – Electric force	V/m
d – Distant of capacitor	m
A – Surface of capacitor	m^2



$$P = U \cdot I'$$

$$U = E \cdot d$$

$$I' = I'' \,\mathrm{tg}\,\delta$$

$$I'' = \frac{U}{X_c}$$

$$X_c = \frac{1}{2\pi \cdot f \cdot C}$$

$$C = \frac{\varepsilon_0 \varepsilon' \cdot A}{d}$$

$$P = 2\pi \cdot f \cdot E^2 \cdot A \cdot d \cdot \mathrm{tg}\,\delta \cdot \varepsilon_0 \cdot \varepsilon' \;\; [\text{watt}]$$

↑ ↑

material depending

Determining the dissipation of energy needs to know of the material properties (ε, tgδ).

Selected materials Frequency range:

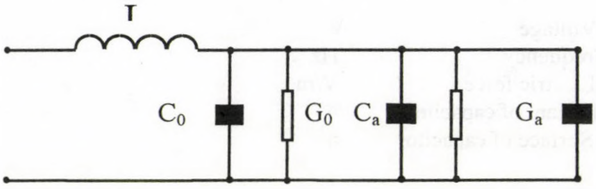
Mustard	RF – Radio frequency
Soya	13,5 MHz
Pea (yellow)	27 MHz
Pea (green)	MW – Microwave
Sweet corn	2450 MHz
Wheat	
Rice	

High frequency or microwave procedures can be applied to treat the above mentioned food material, enzyme inactivation in case of Soya bean, mustard and wheat, pre-cooking in case of rice and blanching in case of pea and corn. Developing the technological procedures carried out as a result of co-operation of several local (KÉKI, Veszprémi KKKI) and foreign (Prague, Bristol, Torino) institutions, which work together in frame of Inco-Copernikus project.

Measurement methods

Here we introduce measurement principles for dielectric properties of high frequency and microwave.

High frequency (RF) measurement:
Measurement of resonance-frequency:



Where:
L : Induction
C_0 : Capacity of the empty space
G_0 : Conductivity of in the empty space
C_a : Capacity of material
G_a : Conductivity of in the material
C : Capacity of tuner

Calculating the dielectric parameters:

$$\varepsilon' = \frac{C_0 + C_a}{C_0}$$

$$\mathrm{tg}\delta = \frac{G_a}{\omega_0 \cdot C_a} \omega_0 = 2\pi f_0, f_0 - \text{ resonancy - frecuency}$$

$$\varepsilon'' = \varepsilon' \mathrm{tg}\delta$$

$$\varepsilon^x = \sqrt{(\varepsilon')^2} + (\varepsilon'')^2 \text{ complex dielectric constant}$$

Results of the measurements:

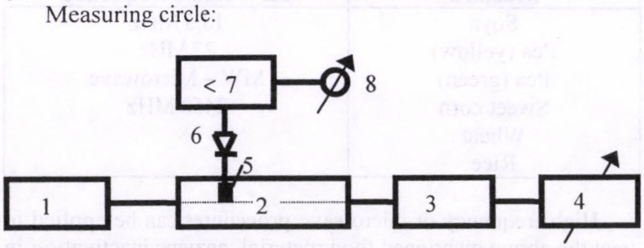
In our high frequency measurements in case of mustard seed we used:
Frequency: 0,1 - 40 MHz
Moisture content: 6 - 16 %
Temperatures: 20 - 80 °C

The results,
$\varepsilon' = f(f)$ parameter: t °C
$\varepsilon' = f(w)$ parameter: t °C
$\varepsilon' = f(t)$ parameter: f MHz
The relationships can be seen on figures 1,2,3.

Measurement of (2450 MHz) microwave (MW)

We developed measurement system to measure the used microwave on the above mentioned products. The figure shows principles of measurement and the measuring circle.

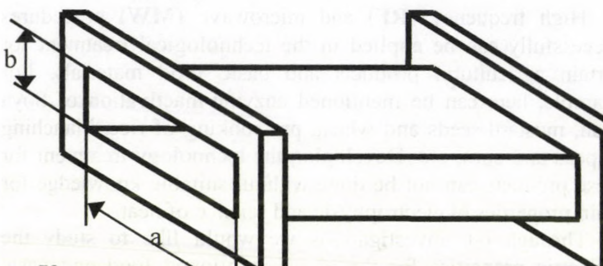
Measuring circle:



1. Microwave signal generator (f = 2450 MHz)
2. Measuring line (split wave guide)
3. Sample holder (rectangle profile)
4. Tuning Impedance
5. Antenna
6. Detector (current rectifier)
7. Selective amplifier
8. Indicator instrument

The Sample holder (3) on the figure, which appropriate to contain sample of product, has the next dimensions:

Sample holder:

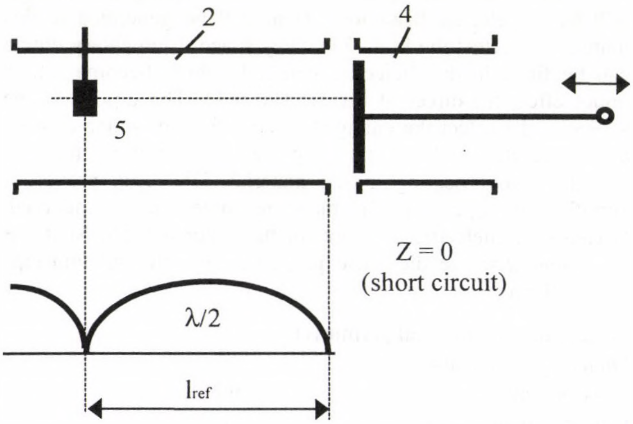


a = 72 mm
b = 30 mm

Principle of measurement

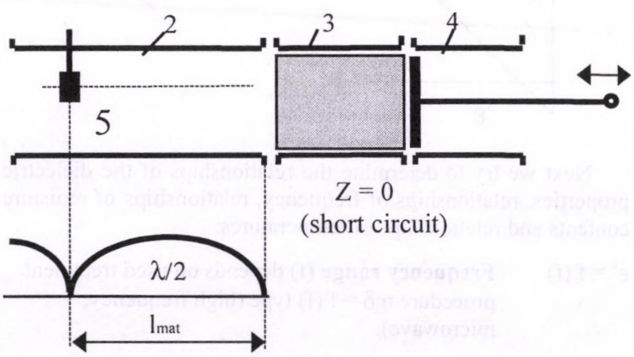
1. Determine phase dislocation caused by food sample:

1.a. Empty measuring line



In case of short circuit we selected reference point will be determined. It will be the reference to camper the dislocation caused by the sample.

1.b. Measuring line with food sample

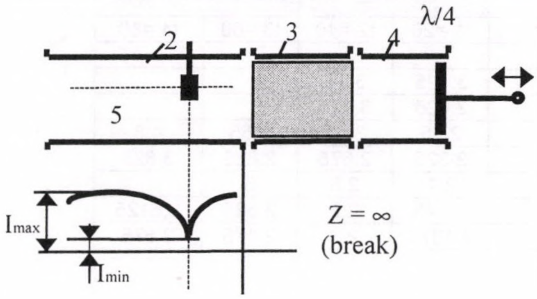


Phase dislocation: $\Delta l = l_{ref} - l_{mat}$ [m]
Phase angle: $\varphi = \Delta l / \lambda_g \bullet \Delta l =$ [rad]

After locating sample holder (3) to the line we measure the dislocation, and from that we determine angle of the input impedance (φ). In case of closing "caused by cut" we repeat the measuring process.

2. Determine ratio of standing wave:

After that we measure ratio (r) of the standing wave in the waveguide, in case of closing caused by "short circuit" or by "cutting":



Ratio of standing: $r = I_{max} / I_{min}$

3. Determine real-and imaginary part of admittance

From knowing ratio of the standing wave (r) and the phase dislocation (φ) we can determine the input admittance for the waveguide by using Smith diagram, in case of closing caused by "short circuit" or by "cutting". From these variable we calculate the admittance by using the next equation.

$$\Delta Y = Y_V + Y_k = Y_{ber} \bullet Y_{besz}$$

Where:

- ΔY – admittance determinant
- Y_V – the real part of admittance
- Y_k – the imaginary part of admittance
- Y_{ber} – the input admittance for the wave guide in case of "short circuit"
- Y_{besz} – the input admittance for the wave guide in case of "cutting"

4. Determine MW dielectric properties:

Real permittivity

$$\varepsilon' = \frac{Y_V + \left(\frac{\lambda_g}{\lambda_c}\right)^2}{1 + \left(\frac{\lambda_g}{\lambda_c}\right)^2}$$

λ_g = wave length in the line
λ_c = limit wave length

Loss factor

$$\varepsilon'' = \frac{Y_K}{1 + \left(\frac{\lambda_g}{\lambda_c}\right)^2}$$

Loss tangent

$$\mathbf{tg}\delta = \frac{\varepsilon''}{\varepsilon}$$

5. Results of the measurement

We used the developed system to test the dielectric constant of mustard seeds. The experiment parameters are:

Measuring frequency: 2.45 GHz
Moisture content of the seeds: 9 %
Temperature of the seeds: 18 °C
ε' Real dielectric constant: 2.05
ε' Loss factor: 0.32

03.03.99		Dielectric constant of moustard seeds The frequency								
Moisture content: 14%						C0 = 8 PF Er=Cref-C/C0				
		C					Er			
f MHz	C ref	t1 =20	t2 =40	t3 =60	t4 =80	f MHz	t1 =20	t2 =40	t3 =60	t4 =80
0,1	327	x	x	x	X	0,1				
0,5	375	350	345	x	X	0,5	3.125	3.75		
1	239	218	214	x	X	1	2.625	3.125		
2	318.4	298	294	290	280	2	2.55	3.05	3.55	4,8
5	295.6	277	274.2	273	265	5	2.325	2.675	2.825	3.825
10	180	163.2	160	156	165	10	2.1	2.5	3	
20	262,4	245	244	242.2	241.5	20	2.175	2.3	2.525	2,6125
40	112.6	95,5	95	92,8	92	40	2.1375	2.2	2.475	2.575

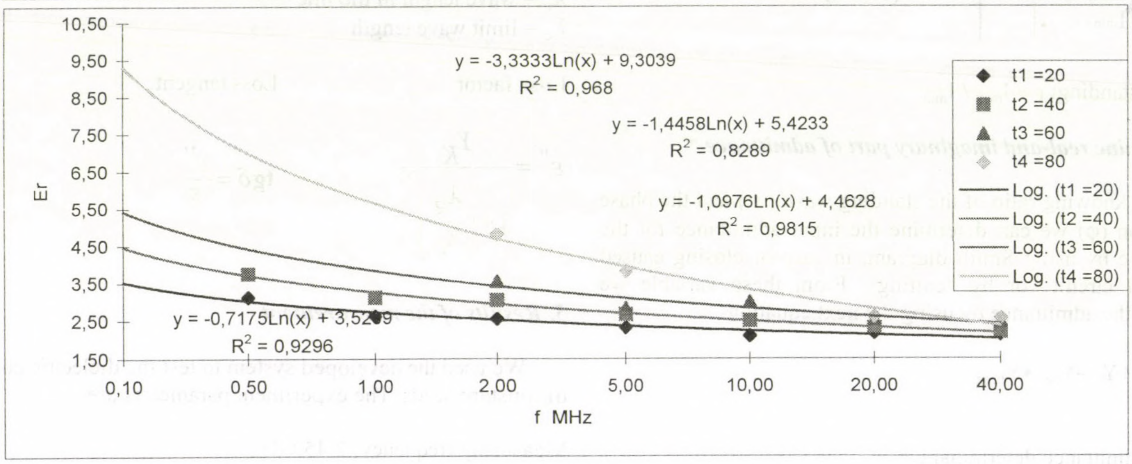


Fig. 1

Dielectric constant of mustard seeds Moisture content				
Frequency: 10 MHz				
	t1 =20	t2 =40	t3 =60	t4 =80
w=6	1.625	1,7	1.75	1.775
w=8	1.6	1.6875	1.875	2.125
w=10	1.75	1.875	2.125	2.1875
w=12	1.9375	2	2.2	2.4375
w=14	2.175	2,3	2.525	2.6125
w=16	2.1875	2.625	2.5	2.7

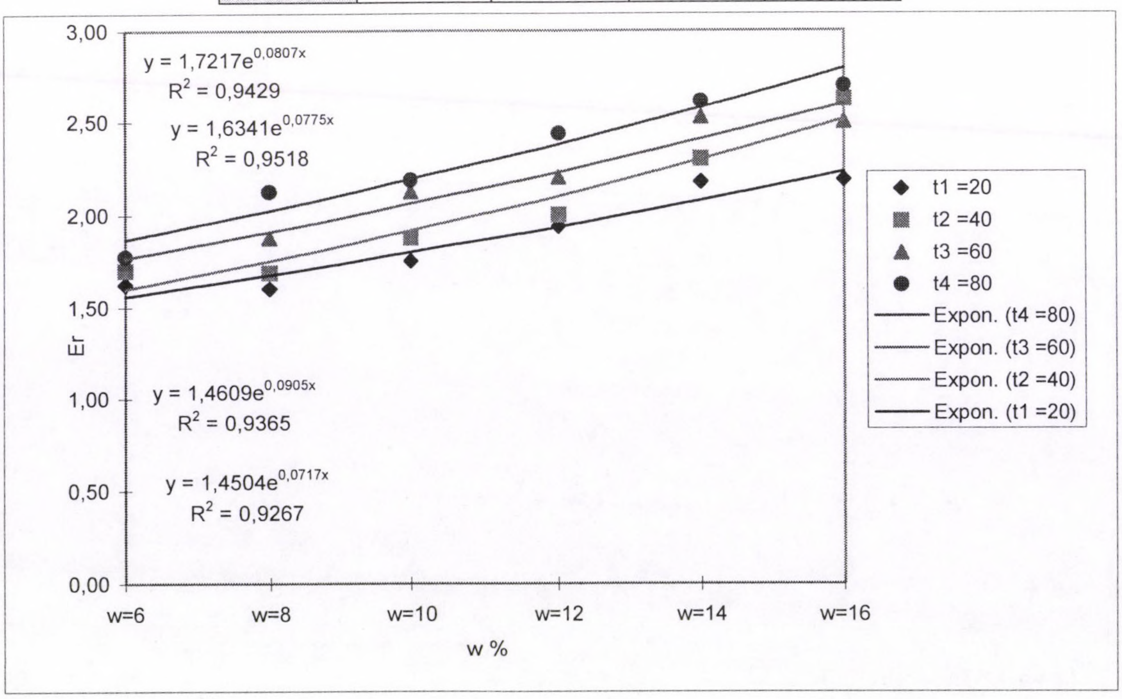


Fig. 2

Dielectric constant of mustard seeds								
The temperature								
Moisture content: 12%								
	fr =0,1	fr = 0,5	fr =1	fr = 2	fr = 5	fr = 10	fr = 20	fr = 40
t1 =20	2.5	1.85	1.875	1.8625	1.7	1.625	1.675	1.7
t2 =40	3.0625	2.125	2.1	2.1125	1.95	1.825	1.75	1.825
t3 =60	4.625	2.875	2.75	2.55	2.2	2.5	2.05	1.975
t4 =80	5.875	3.875	3.625	3.175	2.7	2.5	2.25	2.2

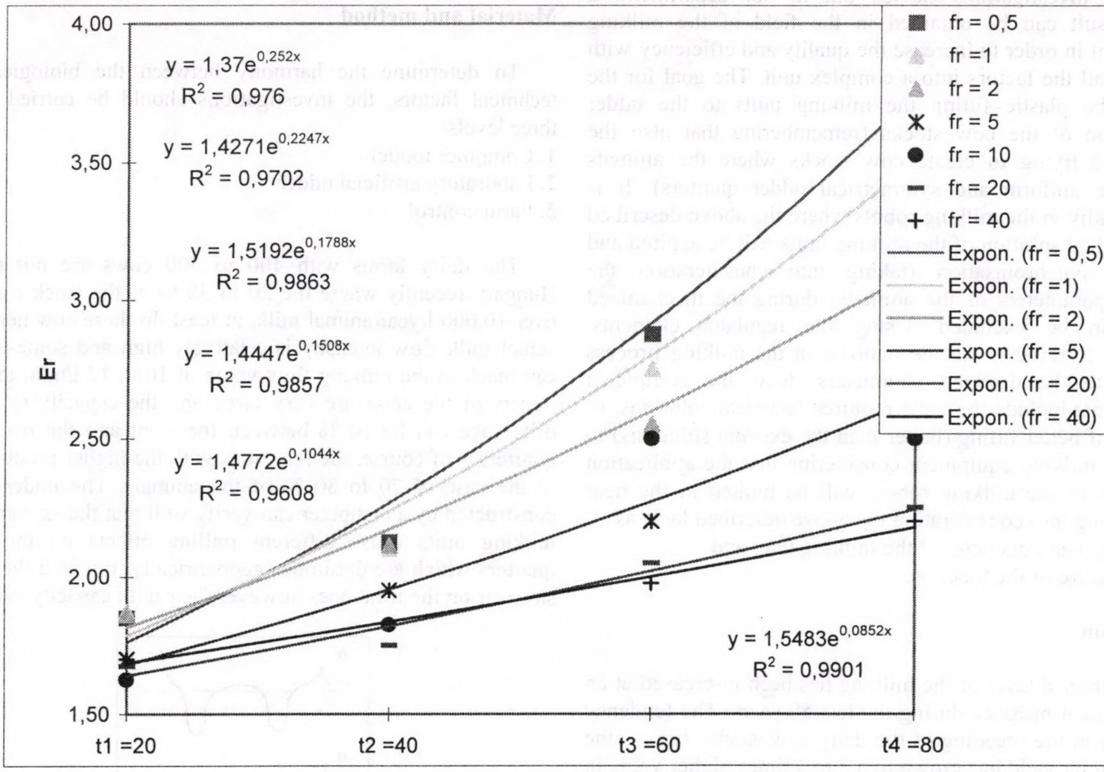


Fig. 3

MAIN TRENDS OF THE MECHANIZATION IN MILKING

Prof. Dr. L. Tóth - Dr. L. Fogarasi - G. Horváth Ph.D. student
University of Agricultural Sciences, Gödöllő

Summary

By the investigations carried out in our department, a positive result can be obtained in the field of the milking development in order to increase the quality and efficiency with organising all the factors into a complex unit. The goal for the future is the plastic fitting the milking units to the udder configuration of the cow stocks (remembering that also the breeders are trying to create cow stocks where the animals would have uniform and symmetrical udder quarters). It is realized finally in the milking robots where the above described dissymmetrical solution of the milking units will be applied and nor other synchronisation (taking into consideration the individual parameters of the animals) during the mechanized process can be excluded. Using the regulator elements, continuous corrections can be realized in the milking process according to the detected parameters. Now the completed improvements include the most required technical solutions, of king units of better fitting (better than the existing solutions) to the present milking equipment considering that the application possibilities of the milking robots will be limited in the near future. Taking into consideration the above described facts as

- the length and diameter of the milking liner and
- the measure of the tubes etc.

Introduction

The technical level of the milking has been in-creased at an enormous great measure during the last 50 years. The tendency was similar in the breeding of the dairy-cow stocks, too, as the individual milk yield has grown to a 3 to 4 times higher value in this time. However, it could not be managed to create homogenous herds yet taking into consideration the udder configuration – i.e. in which, the udders of cows would be proportionate similarly to the milking equipment. So the main characteristics of the mechanized milking in these days are

- absolutely symmetrical machine-units (milking equipment) and
- asymmetry (of a lower or higher degree) in udders – considering the form and capacity.

The major part of the hard manual work is eliminated with the help of the modern milking equipment (automatons) but not the mental charge upon the operators when the production (performance) is intensive. The very effective and biologically perfect milking can be performed only with the help of the full-automatic equipment (robots).

Tasks

Two basic goals are being sketched for the researchers and in the development work of which solutions extend for the future in the next millennium, too:

1. To clear up completely the relationships between the biological and the technical factors and to solve the contradiction of the asymmetrical udder with the symmetrical milking equipment. It is necessary to improve such sensors which will be able to influence the quality of the milking processes and can help the control and save of the health in the cow herds and can guarantee to produce milk of unexceptionable quality.

2. The working efficiency of the milking equipment cannot be improved significantly already with the conventional systems because there are not possibilities for the milkmen to control the cows if the number of animals is high. In the same time the decreasing in working quality can be expected because of the work pressure of great measure and the nervous exhaustion of the milker. All the processes has been automated on the modernist equipment except the putting-up of the teat cups. Conclusively, it is (was) necessary to search for another way that is (was) completely, realized in the milking robots.

Material and method

To determine the harmony between the biological and technical factors, the investigations should be carried out at three levels:

1. Computer model
2. Laboratory artificial udder
3. Farm control

The dairy farms with 400 to 500 cows are not rare in Hungary recently where the 20 to 30 % of the stock can yield over 10,000 l/year/animal milk, at least. In these cow herds, the actual milk flow intensity is relatively high and some-times it can reach to the milking flow value of 10 to 12 l/min, too. The udders of the cows are very large and the capacity (yielding) difference can be 10 % between the front and the rear udder quarters – of course, the rear ones with the higher production – in the case of 70 to 80 % of the animals. The udder model constructed by a computer can verify well that the asymmetrical milking units cause different pulling effects on the single quarters which are dissimilar geometrically, too, and the pull is stronger on the front ones however their milk capacity is lower.

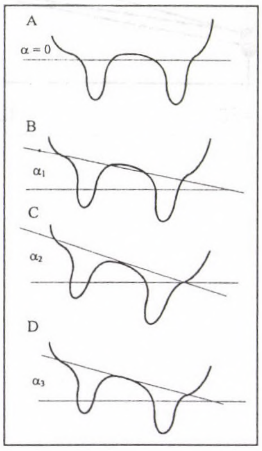


Fig. 1. The typical asymmetrical udder quarters

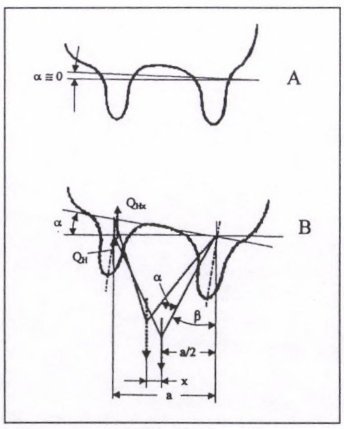


Fig. 2. The symmetrical udder has a different pulling effects on the asymmetrical udder

Because of the capacity and the higher pulling effect, the front udder quarters are emptied earlier and, this way, a relative blind milking will be the consequence between the front and the rear ones. Its harmful effects are well know and can cause infection in the udder quarters still during the milking. This is another point of view why the construction of milking equipment is reasonable to be harmonized with the asymmetry of udder in order that the udder quarters ought to be emptied in the same time.

Pulling force on the front udder quarters Q_H:

$$Q_{Hx} = a \cdot \left(0{,}5 + 0{,}5 \frac{x}{a} \right)$$

$$x = a \cdot \left(\frac{\sin(\alpha + \beta)}{\sin \beta} - 1 \right)$$

Q_{Hx} = the difference in the pulling force on the front udder quarters:

Three possibilities of this were examined:

1. Different rations of the milking and atmospheric phases (strokes) between the front and rear udder quarters – of course, with a longer milking phase on rear quarters.
2. Use of (rear short) milk tubes with bigger diameter to ensure a possibility of forming same values in flowing resistance (drag) when the milk flow is higher.
3. Use of longer front (short) milk tubes in order to balancing the pulling effect on the udder.

Results

Different udder configurations were created by computer and the above mentioned processes were modeled on these – at first the re-structuring changes of the milking unit mass and the expected effects from the re-distribution of mass upon the deformation of udder.

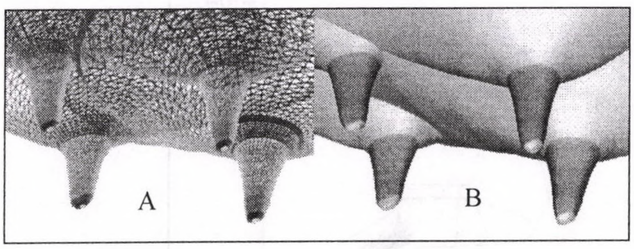


Fig. 3. The model of the cow udder for finite element modeling

There is a basic relationship between the size of teat and the length and diameter of the rubber liner. The suitable measure-sequence is necessary because of the stimulation i.e. the stimulus on the receptors.

The kinetic (kinematics) mechanism of the space under the teats in the rubber liner, and because of the effects (raised with this) on flows from a teat to another teat, is important like that at least. If the difference is high (i.e. the liner is much bigger), the infected matter will reach the teat tips within 1 or 2 pulses already because the back-flowing caused by the too large space under the teats is intensive. If the difference is small (e.g. the liner is short or the teat is long), the mechanical effect of the liner is not realized under the teat tips but onto the teat so it causes traumatic effects that makes the animal ill and remaining changes will come about. Also because of that, the liner of smaller size is better. Similarly, the milk tube of higher nominal diameter is more advantageous because the flow velocity is mush lower, conclusively, the intensity of the flow back is reduced, too.

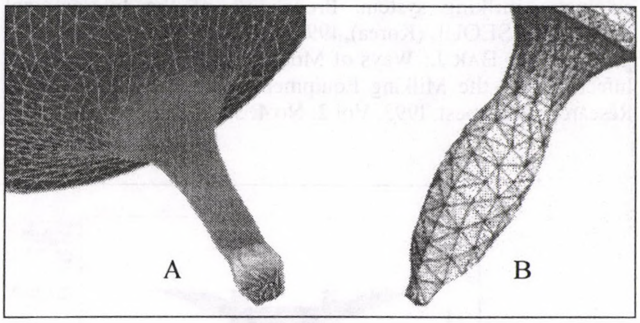


Fig. 4. The reaction on teat when the liner is too long (A), or the teat is short (B)

Likewise, the balanced cross-section-areas are more advantageous considering the points of view of cleaning the equipment, too, because the number of section is increased which can be washed at a lower efficiency using only liquid flow, caused by the bigger cross-section area is decreased to the measure that its mechanical cleaning effect would be even eliminated.

These processes can be demonstrated well on finite element models, here applied specially for hydro-dynamic problems (bodies).

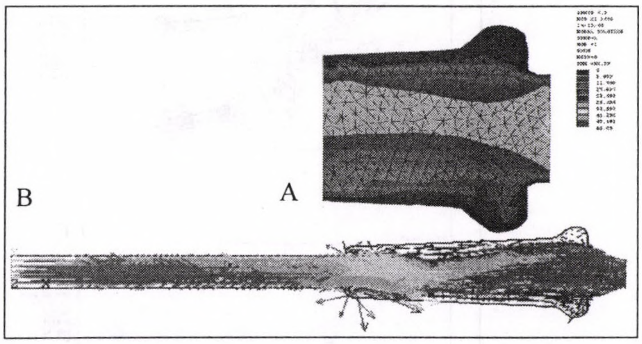


Fig. 5. The washing fluid flow in the milk tube describing the washing efficiency
A - Fluid flow at the massaging head of the liner
B - Fluid flow through the liner

The influence of the mass distribution of the milking unit is significant upon the measure of the blind milking system is much lower (it is cheaper) than a positioner of milking unit.

The ratio of milking to atmospheric phase can be changed very easily with the help of an electronic controlled pulsator and, on top of that, the four quarters can be regulated (controlled) even one by one without any special intervention.

Where cow identification systems of radio (RF) frequency (transponders) are operated, the characteristics of the pulsators can be set after identifying the animals, according to the individual properties. With the help of this, it is possible to control the stroke ratio of milking and atmospheric phase making differences in it at the udder quarters, too (e.g. Quatropuls). The investigations in place on asymmetric milking equipment verified that the milk quantity, which yielded by equipment during the posterior (after-) milking, decreased from the value of usque 0.6 and 0.7 to 0.2 l per cow as a result of the balancing with setting of the ratio of milking to atmospheric phase. (Below the above value, the investigation could not be carried out with a reliable result).

References

[1] TÓTH L. - BAK J.: Result of further development of on automatic milking system. Proceeding of the International Symposium SEOUL (Korea), 1993. C 331-335 p.

[2]TÓTH L. - BAK J.: Ways of Moderating the Transmission of Infections by the Milking Equipment. Hungarian Agricultural Research, Budapest, 1993. Vol 2. No 4. 32-37 p.

[3]TÓTH L. - BAK J.: The effect of the teat cup assembly size upon the aerosol flow rate. CIGR Congress, Milano, 1994. Nr.94-C6-106 p.

[4]TÓTH L. - Bánházi Gy.: Faktoren mit Einfluss auf die Zitzengumi-Bewegung und deren Wirkung auf die Effektivitat des Melkens Grundl. Landtechnik Bd. 35. Nr.2. 1985.

[5]TÓTH L. - BAK J.: Automatisation of milking device cleaning process. Hungarian Agricultural Engineering, Hungarian Academy of Sciences. NR. 6/1993.Gödöllő.

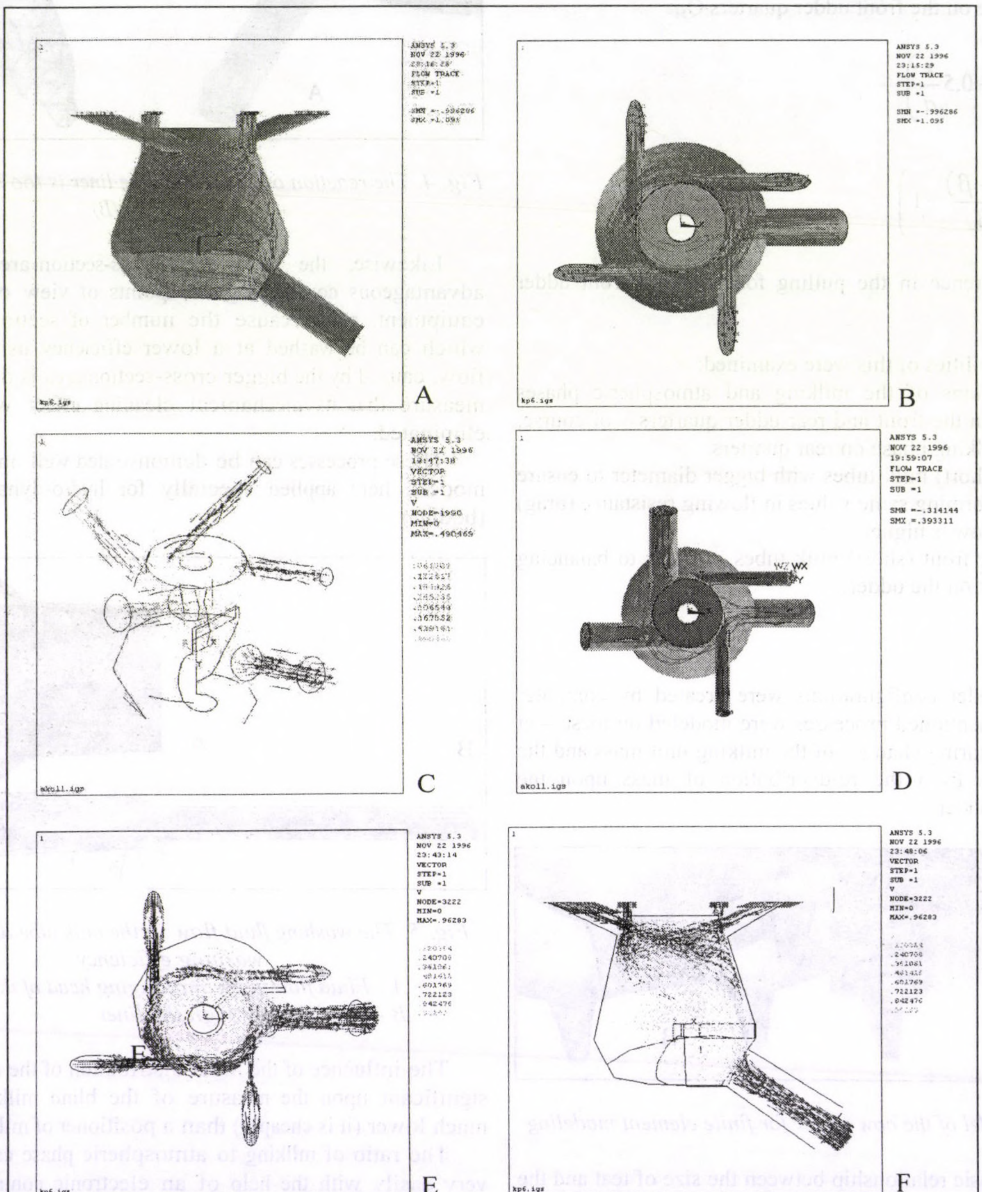


Fig. 6. The collector model with dynamical milk flow lines. A and B - the milk flow, when all four milk pipe-ends are with the same diameter, C and D – the milk flow velocity , when all four milk pipe-ends are with the same diameter , E - the milk flow velocity, when the diameter of rear milk pipe ends are bigger

APPLICABLE SLURRY TREATMENT METHODS ON LARGE-SCALE PIG HUSBANDRY

Dr. L. Fenyvesi - L. Mátyás
Hungarian Institute of Agricultural Engineering
Gy. Mészáros, FVM - MoARD
Prof. G. Hörnig, ATB Potsdam-Bornim

Summary

Nowadays the state of the housing system, manure/slurry removal and handling of pig farms, apart from some reconstructions, reflects a near 30 years of situation. Those pig farms have the most serious problems where the housing system is literless and where could not minimize the amount of surplus technologic water that gives the most part of the slurry because most of the pig farms do not dispose over arable land of their own for utilizing their slurry production. Because turning to bedding system, that has meaningful advantages zootechnically, in most of the cases are impossible, we have to calculate the presence of slurry for years. Taking info consideration the present economic situation we have to find the not expensive but effective solutions in order to reduce the volume of slurry and the environmental load.

1. Results and conslusions

Amount of daily slurry production depends on removal system and other factors, and for example in the case of a pig farm with 500 sows varies between 50-300 m^3. Specific slurry production characteristics can be seen in Table 1.

The pig farms are in difficult situation, so it is essential that minimize their slurry production. The greatest possibility to reach this aim is the modernization of the feeding-drinking and housing systems (e.g. application of water-saving combined feeders, high pressure cleaning-disinfecting machines, bedding; separation of rain water etc.)

After reducing the amount of slurry to the possible minimum quantity it is practical to do some kind of handling. Because slurry basins during usage for more decades are silted up, soil pores are clogged. By means of separation 1/3-2/3 part of solid from slurry can be separated so the life time of the cleaned basins and recultivated poplar plantations can be multiplied. Separation and further handling of the separated liquid phase then using it as technologic water, recycling it into the slurry gutters is another possibility to decrease the quantity of slurry. (Fig. 1.)

Following a simple handling of slurry by lime hydrate, that decreases the germ population, and recycling its required volume, quantity of slurry production can be decreased by 30-50%. A complex slurry handling and utilization method is shown on figure 2. Following a separation (3) the liquid phase can be utilized in the agriculture (11, 12). The separated solid is composted (5-8) and can be purchased for vegetable producers or flower gardeners.

Table 1. Slurry production characteristics

Nomination	Slurry removal system			
	Mechanical	Damming	Floating	Flushing
Specific slurry production (m^3/sow place, day)	0.083-0.165	0.165-0.22	0.22-0.33	0.33-0.55
Dilution rate	1:0.5-1:2	1:2-1:3	1:3-1:5	1:5-1:9
DM content of the slurry (%)	5.3-2.7	2.7-2.0	2.0-1.3	1.3-0.8

References

[1] MÉSZÁROS GY. - KULI B. - FENYVESI L. - MÁTYÁS L.: „Minimizing the environmental pollution of pig husbandry". ICAMPE '93, Seoul, Korea, 5 October 1993., Vol. 5, pp 1395-1405

[2] MÁTYÁS L. - FENYVESI L.: „Trágyakezelés a sertéstartásban". Mezőgazdasági Technika, 1997. 38. évf. 5. sz., pp 23-24.

[3] MÁTYÁS L. - FENYVESI L. - MÉSZÁROS GY.: „A hígtrágya okozta környezetterhelés csökkentési lehetőségei. VI. Országos Agrár-Környezetvédelmi Konferencia, Budapest, 1997. nov. 12-14. FM Szakmai Kiadvány, pp 52-53.

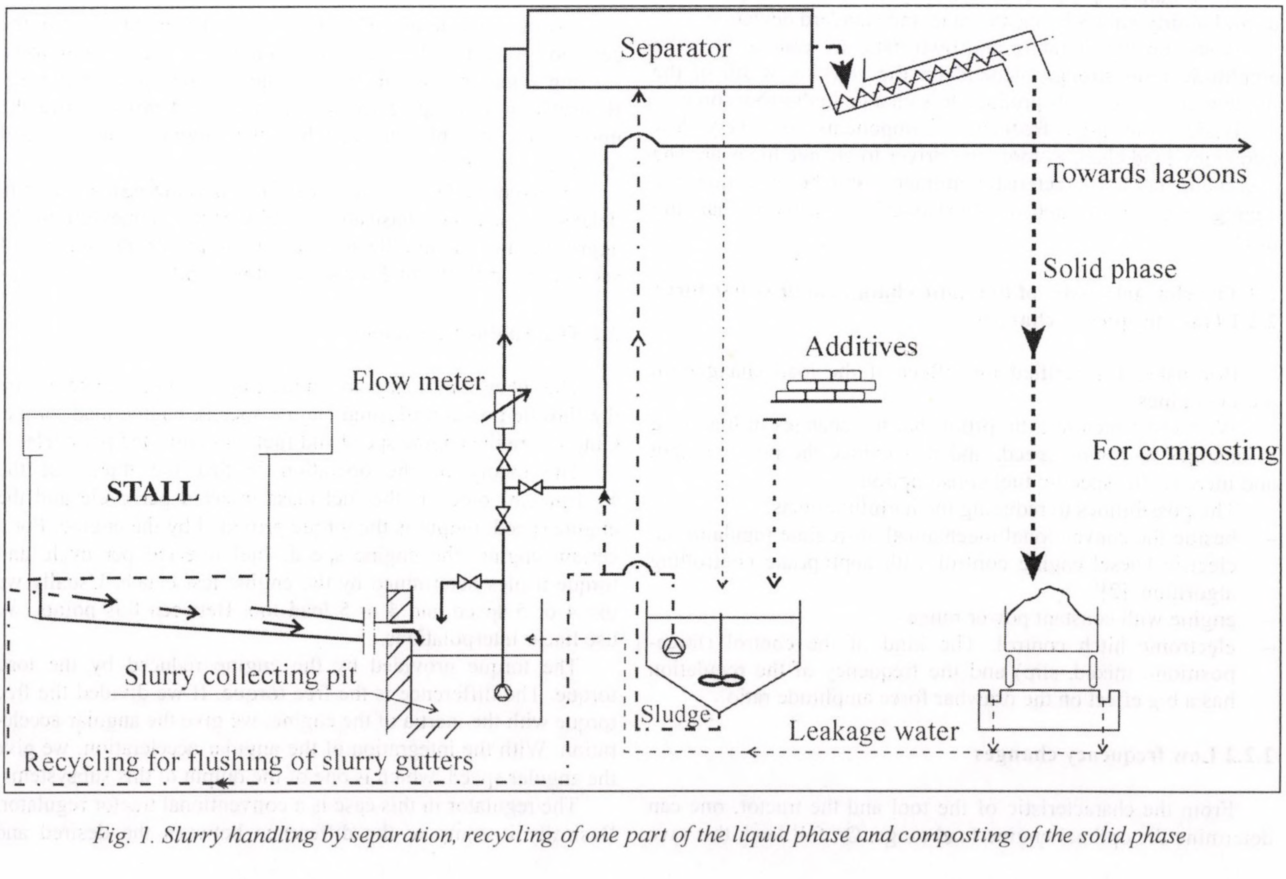


Fig. 1. Slurry handling by separation, recycling of one part of the liquid phase and composting of the solid phase

STUDY OF THE RELATIONS OF DYNAMIC DRAW BAR PULL FORCE AND ENGINE LOAD BY MATHEMATICAL MODEL

Dr. A. Vas - Z. Lajber
University of Agricultural Sciences, Gödöllő

1 Introduction

In the agriculture, the tractors are one of the biggest fuel consumers, hence the good efficiency of tractor engines is very important. During the operations of the tractors, the engine load dynamically changing, and this reduce the efficiency. In this study we examine the reasons and possible solutions of this changes.

2 Characterisation of draw bar pull changes and their effects

2.1 Characteristics of dynamic draw bar pull

During the pulling, the pulling force dynamically changing. Several author examined this phenomena with different assumptions. Boltinskiy [1] described the dynamic drawbar pull with mean value, amplitude ratio and frequency or period time. In his wide scale examination, he identified different frequencies and amplitude ratios, and their sources. The dynamic changes of the drawbar pull can come from:

- From the physical and mechanical features of soil, soil irregularity, surface irregularity, and the moving of the aggregate. In this case, the amplitude ratio is in the range of 0.002-0.33, and the period time is between 6-18 secundum.
- From the kind of tillage and the nature of the implement. In this case the amplitude ratio is in range of 0.06-0.33, the periode time is between 0.1-3.5 secundum.
- From the kinematics of power train. The amplitude ratio is 0.2-0.85, the frequency proportional on the speed of the wheel and gear box rotation speed.

Other authors [3] describing the dynamic drawbar pull force as probability values by mean value and standard deviation.

Based on the literature and own data, we can say that the amplitude ratio strongly depend on the working width of the implement. Wider tools produce less change in drawbar force.

Beside the high frequency components, the very low frequency load changes force the driver to change the gear. The aggregate has a characteristic moment, and because this, the aggregate can go trough on short overloads without changing gears.

2.2 The characteristics of dynamic changes in drawbar force

2.2.1 High frequency changes

Boltinskiy [1] verified the effect of the load changes on diesel engines.

With test bench test, he proof that the changes in load lead to changes in engine speed, and this reduce the power output and increase the specific fuel consumption.

The possibilities to reducing the harmful effects:

- beside the conventional mechanical all-regime regulator, an electric Diesel engine control with appropriate controlling algorithm. [2]
- engine with constant power range
- electronic hitch control. The kind of the control (force-position-, mixed, slip) and the frequency of the regulation has a big effect on the drawbar force amplitude ratio.

2.2.2 Low frequency changes

From the characteristic of the tool and the tractor, one can determine the optimal engine load range. On full load, this give a certain engine speed range too. The 1-2 second overloads can be overcome by the momentum of the aggregate, but the longer required to shift down to lower gear by the operator.

With the conventional gear boxes, the torque flow interrupted for 1-3 second. If the torque flow interrupted more than 0.5 second during tillage, the aggregate will stop. The restart increase the wear of the clutch, reduce the quality of the work, and increase the load of the operator too.

In the past years, the more and more tractor sold by gear boxes which can shift gears under load (PowerShift, PowerQuad). The operators of such equipped tractors experienced with easier, continuous work, but the fuel consumption usually increased too.

In our opinion this occur because the operators don't know the characteristics of their tractors, thus don't operate it on the best working point. The tractors equipped with PowerShift gear boxes together with the high torque-backup constant power range engines [4] need a new usage.

Because several parameters of the aggregate changes during the gear shift, extensive measurements need to work out an appropriate gear strategy.

The amount of test, so the cost of the development can be reduced by development of a tractor dynamics model and simulation. In this way we need less measurements, namely for the identification of the model and for the final proof tests.

3 The tractor model

We developed a tractor dynamical model, which is capable for the base simulations. For the development, we choose MATLAB-SIMULINK environment. The input parameters of the model come from the MATLAB workspace, and the output of the simulation is stored there too. The post processing of the simulation output is convenient in this way. The main structure of the model is on the 1. Below we will shortly describe the main components.

3.1 The driver subsystem

This is a simple gear shifting logic. If the input is not 0, the gear box is kept in that gear. If the input is 0, the up- and down shifting done in the function of the engine speed and time. Basically, it shift up, when the engine speed raised above the upper limit, or shift down, when the engine speed dropped below a lower limit.

To avoid the fast up and down shifting (hunting), we built in delays. These delays basically function of the momentum of the aggregate. For the middle size tractors and tools, this delay is 4 second for up shift and 2 second for down shift.

3.2 The Engine subsystem

The subsystem's diagram on the Fig. 2. Input parameters are the throttle position (desired engine speed), engine load torque. Outputs are the engine speed and fuel mass injected per cycle.

The theory of the operation is that the inputs of the M=f(m_c,n) block is the fuel mass injected per cycle and the engine speed, output is the torque provided by the engine. For a certain engine, the engine speed, fuel injected per cycle and torque triples determined by the engine test bench. Usually we use 4 or 5 speed and 4 or 5 load too. Between this points, we use linear interpolations.

The torque provided by the engine reduced by the load torque. The difference is the free torque. If we divided the free torque with the inertia of the engine, we give the angular acceleration. With the integration of the angular acceleration, we give the angular speed, which is one of the output of this subsystem.

The regulator in this case is a conventional tractor regulator. Basically it compute the difference between the desired and actual engine speed, and determine the fuel injected per cycle as function of this difference. There is a maximal value for the fuel injected per cycle, which is function of the engine speed. This build-in by the block labeled mc_max=f(n).

The group of components on the bottom is for stopping the simulation if some-thing goes wrong, namely the engine speed dropped very low (*nmot* < 500 *rp*m) or very high *(nmot* > 3000 *rp*m).

3.3 The transmission subsystem

This subsystem is the model of the whole power chain except the engine, the half axles and the wheels. Input parameters are the selected gear, engine speed, and the required torque by front and rear axle. The outputs are the rotating speeds of the the front and rear axle, and the engine load torque.

At this stage, the model of the transmission is simple. In function of the selected gear, it read out the total ratio from a table, and compute the input and output speeds and torques in function of this. We can take account for the ration between the front and rear axle. During gear change, the change of the total ration is not sudden, because it lead a big instability in the simulation. The most important development task in the future is to identification and modelling of the gear change event on PowerShift gear boxes.

3.4 The vehicle subsystem

This is the most complicated subsystem of the model, built up by several subsystem. Practically this is the dynamic model of the tractor. It contains the half axles, the wheels and the body of the tractor.

The inputs are the front and rear angle rotation speed, the pulling force required by the implement, the angle of the slope which the tractor is moving (if any). Outputs are the rotation speed of the wheels (4 element vector), the traction force provided by each wheel (4 element vector too), the tractors moving speed, and the torque required by front and rear axle.

3.4.1 The wheel load subsystem

The input parameter is the drawbar force, the outputs are the vertical force on the wheels (wheel load). This subsystem is for handle the dynamic wheel load change by drawbar force. At this moment, it handle the right and left side together. We need significant improvement here if we want to use computer animations to show the results.

3.4.2 The axle subsystem

This is a simple torsion axle model. The torsion parameters of whole power chain is modeled here. We use the stiffness and dumping parameter of the wheels here, because of the stiffness and dumping of the all transmission is smaller by several order than the stiffness and dumping of the wheel.

3.4.3 The wheel subsystem

This is the model of the wheel. The input parameters are the driving torque, the vehicle speed and the vertical load. The outputs are the wheel angular speed, the wheel tangential speed (for easier computation) and the provided traction force.

The flow of the calculation is the next. From the driving torque and the periferical force we can compute the free torque. This torque divided by the inertia lead us to angular acceleration. With integration, we can give the angular speed. This is one of the output parameters. With multiplication by the radius (and some unit conversion) we give the wheel tangential speed. This is the second output parameter, and using this and the vehicle speed, we can compute the wheel slip. From the drawbar test, we know the relation of the wheel slip and the adhesive coefficient (Fig. 4, slip -> adh. teny. blokk), Using this coefficient and the wheel vertical load, we can compute the traction force. The traction force summed by the rolling resistance give us the periferical force.

3.5 The results from the simulation

The result of one run of the simulation is on the Fig. 6 and 7. In this case we load the tractor with 31kN pulling force, and in the 10^{th} seconds of the simulation we reduce this to 15kN, and in the 20^{th} second of the simulation it goes back to 31kN. We can see that during the settling time of the load, the specific consumption of the engine is increased, even if the load reducing, and the aggregate using the moving energy for pulling.

4 Conclusions

Based on literature we investigated the dynamic changes of the draw ball pull force on agricultural tractors, consideration to the effects on the engine working parameters.

The methods to reduce the effect of the high frequency drawbar pull force changes are know, new result can be achieved by using the electronic control on Diesel engines and hitch.

The primary method to handle the low frequency drawbar pull force is the gear shifting without torque flow interruption. Whit this solution, the operating range of the engine can be wider.

We set up a tractor model for deeper examination on tractor-implement dynamics. In the future, we need to identify the model, and improve certain parts of it, if needed.

Whit this model, we need to identify the characteristic load of the typical working cases. Whit this knowledge, we need to set up an appropriate gear shifting strategy, which provide the maximum power or the maximum efficiency.

References

[1] V. N. BOLTINSZKIJ: A változó jellegű terhelés hatása a traktormotor jellemző mutatóira. Az MTA Agrártudományok Osztályának Közleményei, 1963.

[2] A. FEKETE: Engine load monitor and control system. In *Proc. of* 9^{th} *International Conference of ISTS*V, pages 343–350, Barcelona, 1987. ISTV.

[3] A. FEKETE: Tractor engine operation under full-load conditions. In *Proc. Of 5th European Conference of ISTS*V, pages 718–725, Budapest, 1991. ISTV.

[4] A. VAS - Z. LAJBER - G. VANDENBERG: Üzemi viszonyok elemzése állandó teljesítményű traktormotor alkalmazása esetén. In *MTA AMB Konferenci*a, Gödöllő, 1999.

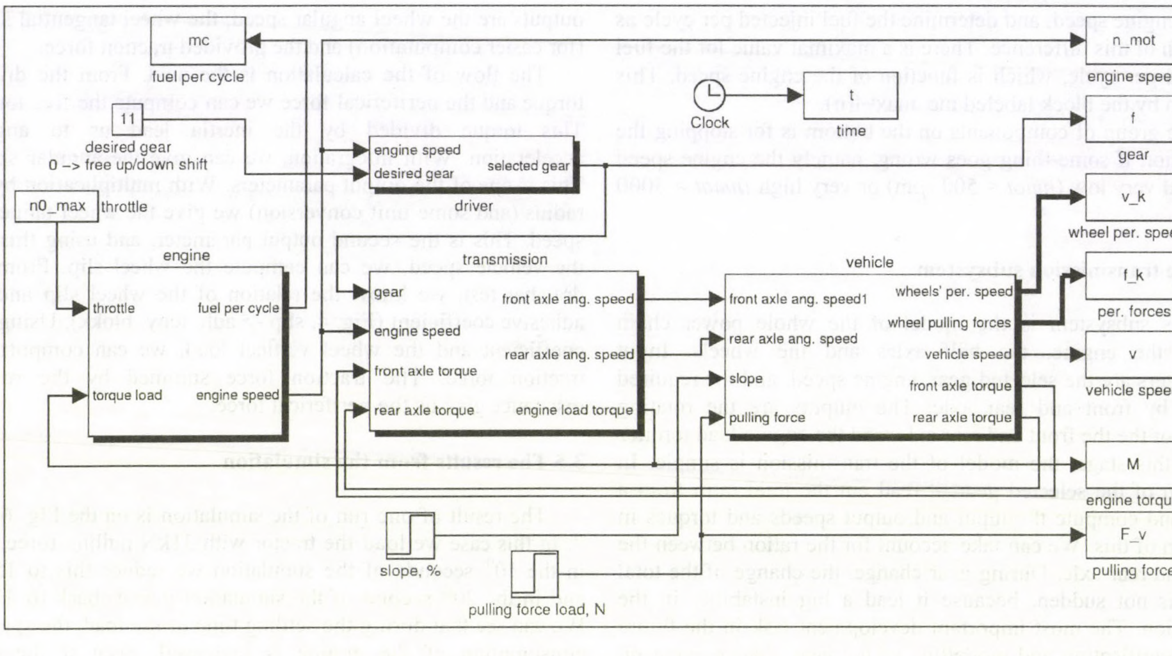


Fig. 1. The top level of the tractor model

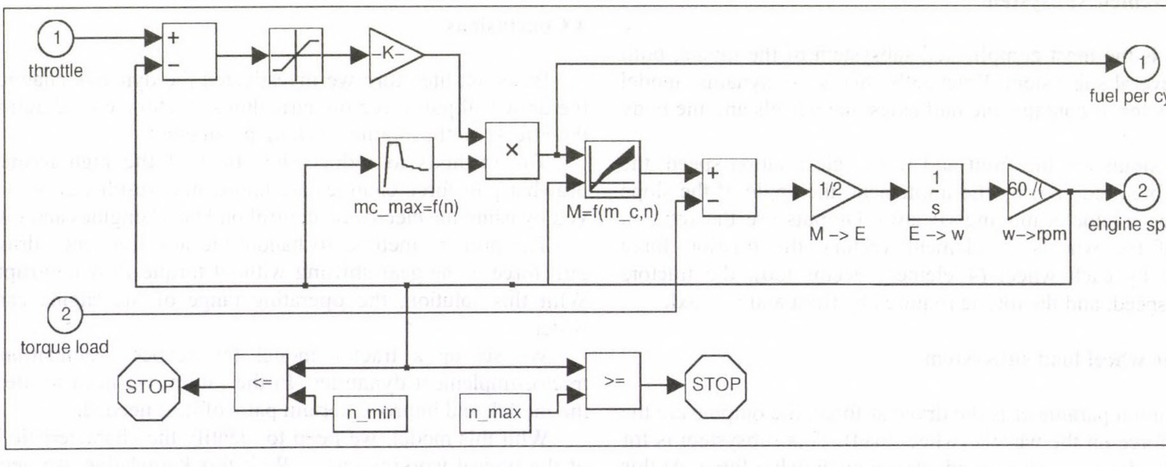


Fig. 2. The structure of engine subsystem

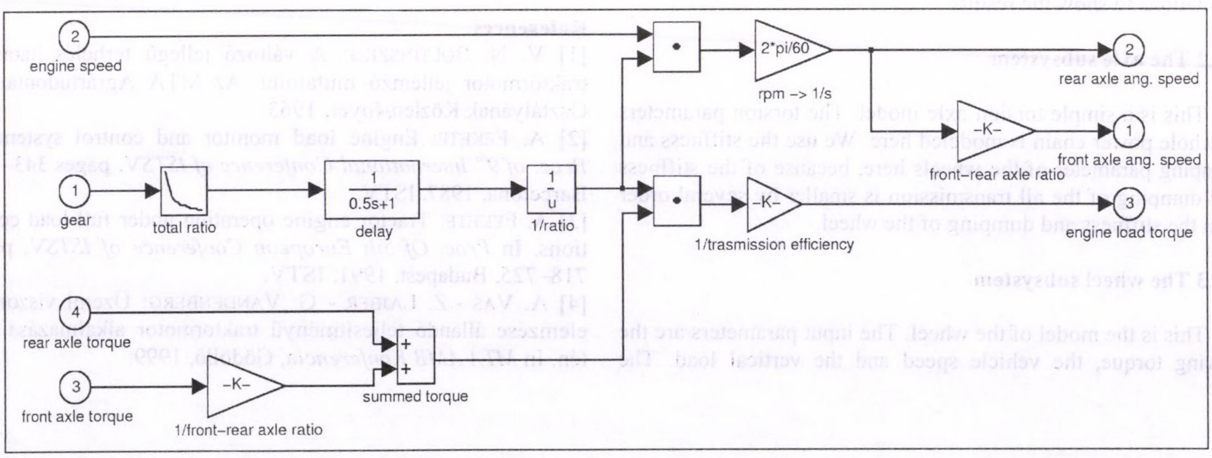


Fig. 3. The model of the transmission

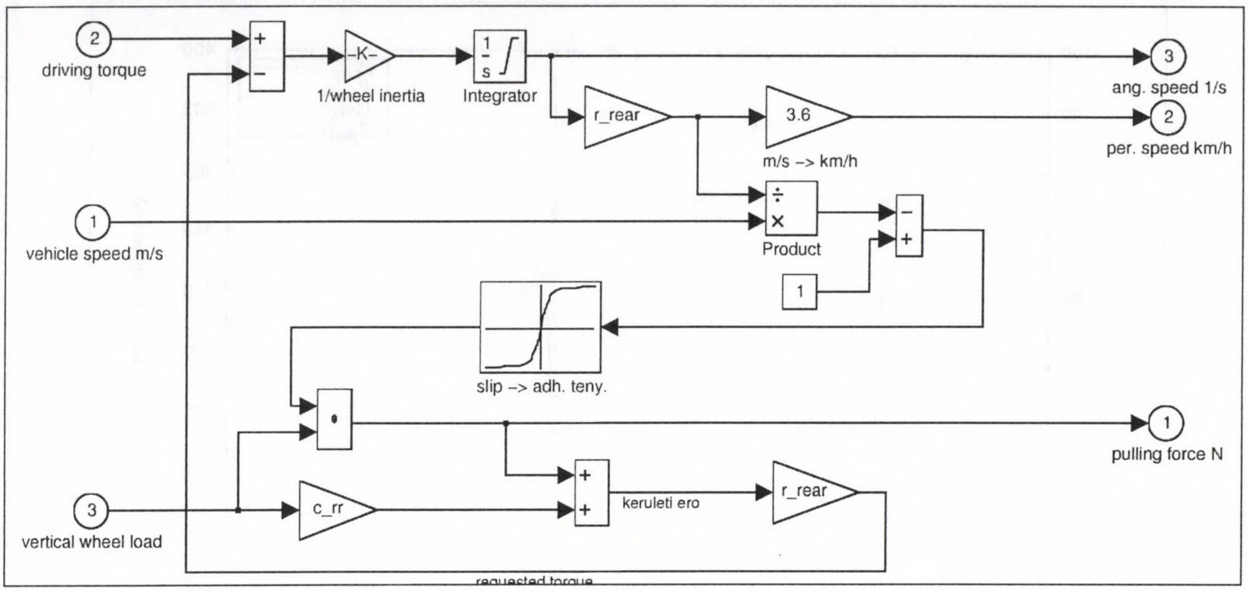


Fig. 4. The model of the wheel

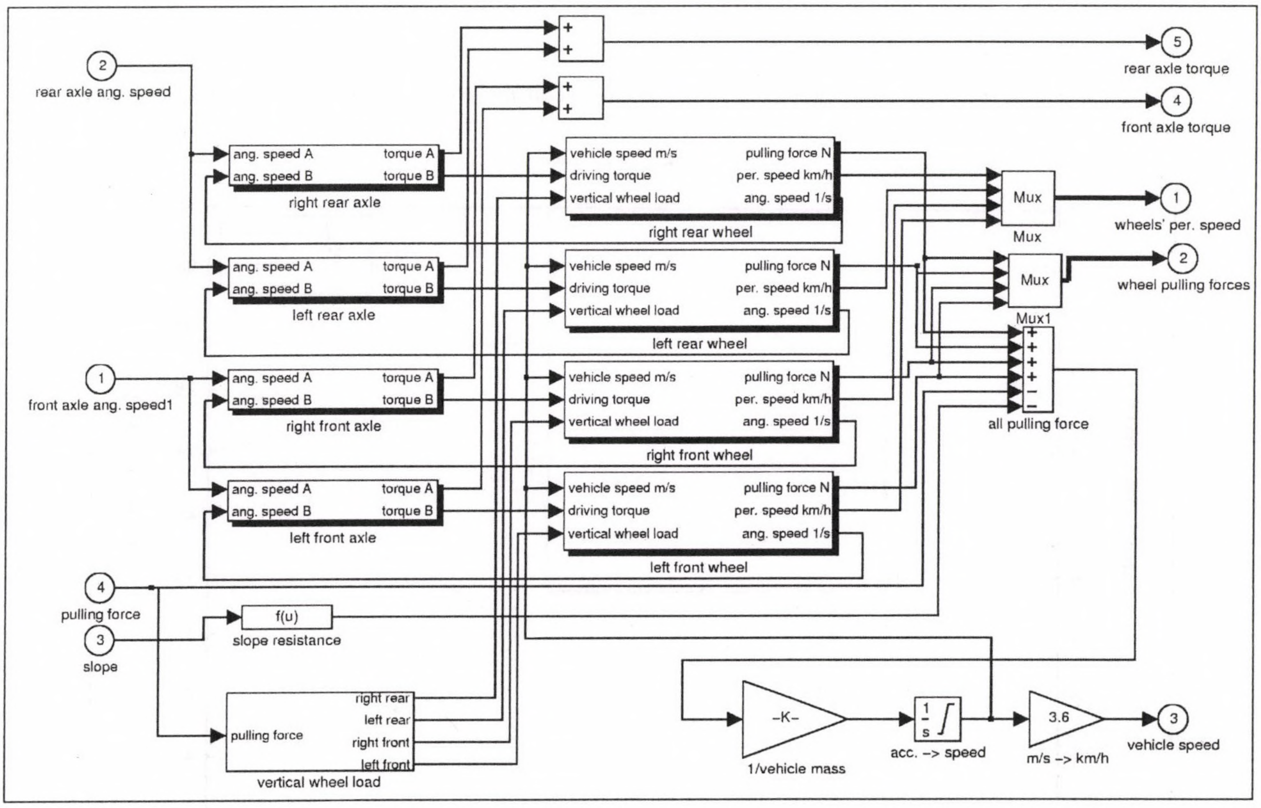


Fig. 5. The vehicle subsystem

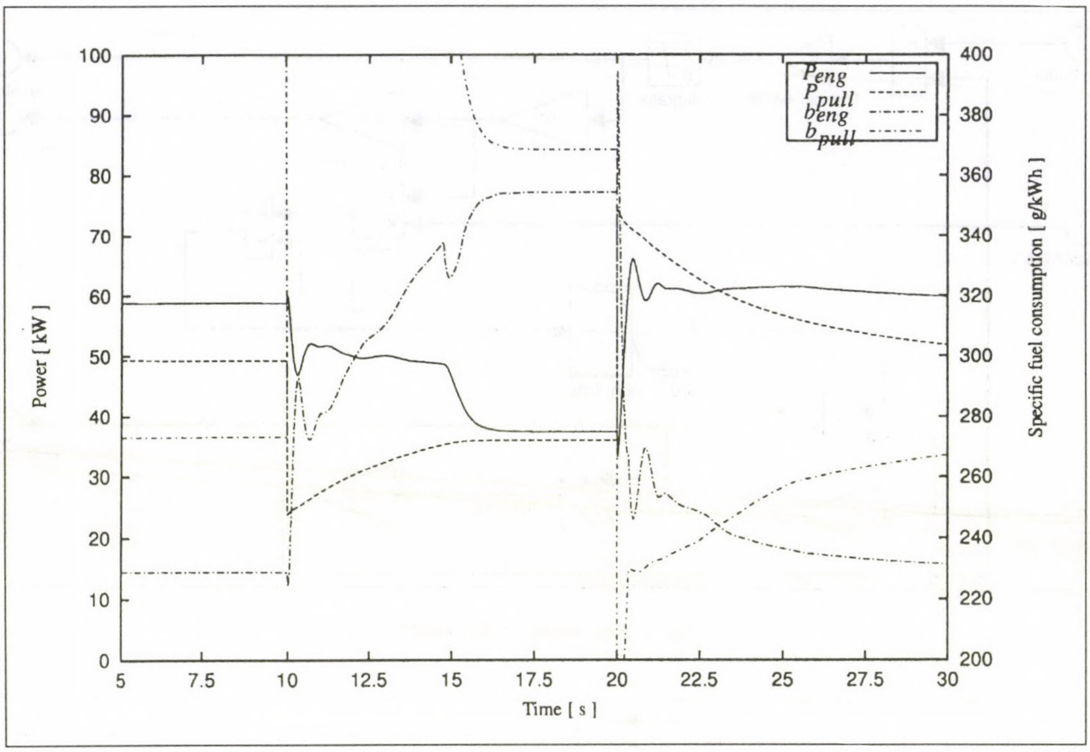


Fig. 6. The engine (P_{eng}) and pulloing (P_{pull}) power, and the specific fuel consumption respectively (b_{eng} and b_{pull})

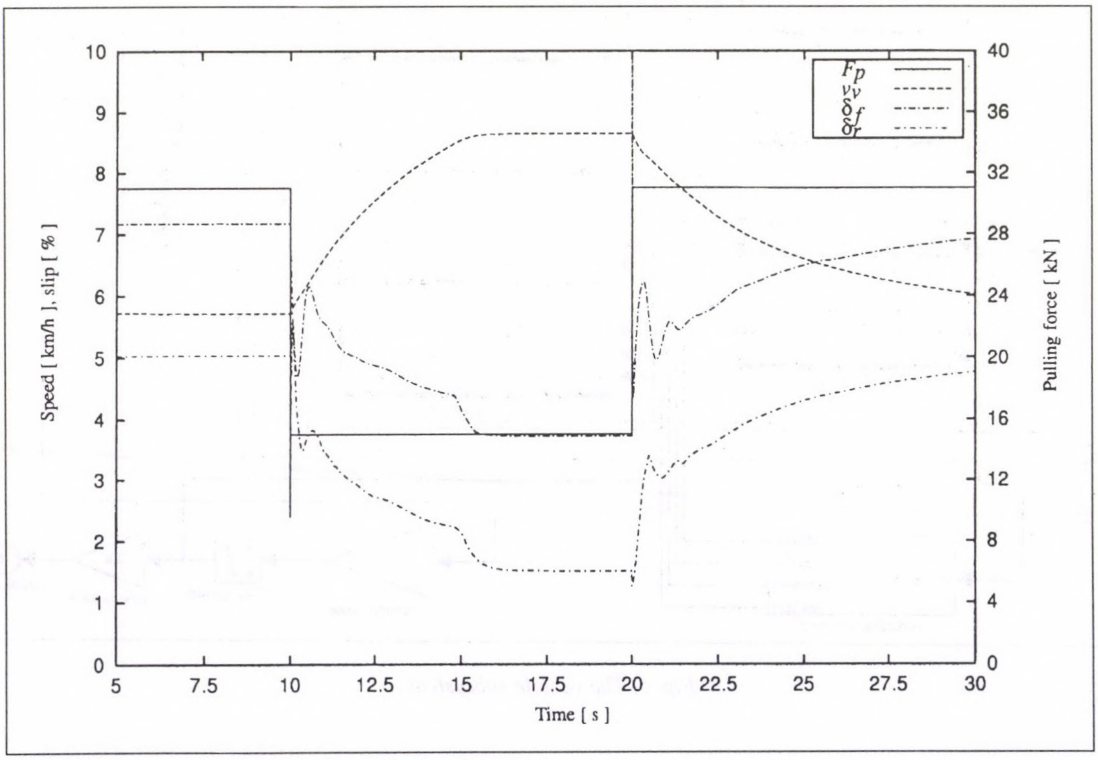


Fig. 7. The traction force (F_p), the vehicle speed (v_h) and the front (δ_e) and the rear wheel (δ_h) slip

DYNAMIC METHOD FOR QUICK AND NON-DESTRUCTIVE MEASUREMENT OF THE SURFACE FIRMNESS OF FRUITS AND VEGETABLES

J. Felföldi - T. Ignát
University of Horticulture and Food Industry

Introduction

The firmness measurement of produces – fruits, vegetables, some foods – is very important for quality assessment, for describing the ripening and generally for the decision support in processing, storage or marketing. The methods – both the widely used traditional methods and the new methods as well – can be separated into two different groups:

a) compression methods, based on the slow compression of the produce and on the analysis of the stress/deformation relation

b) dynamic methods, based on impact (or vibration) of the produces and on the analysis of the force, acceleration or deformation changes after the excitation.

The dynamic methods offer some advantages related to the traditional methods. The most important advantages are that the dynamic methods are mostly non-destructive and very quick, providing with the possibility of the on-line individual testing of the produces (Chen, 1998). Therefore the research work of our department was concentrated – in addition to the traditional compressive destructive and non-destructive methods – on the dynamic methods as well.

The aim of the work is to develop and analyse a non-destructive impact testing method for quick and objective characterisation of the surface firmness of wide range of fruits and vegetables.

Methods and materials

The samples used for the test were balls and cubes of rubber and plastic of different firmness (as model material) and fruits and vegetables of different ripening states (apple, apricot, peach, tomato, paprika). The changes during the storage were tested on Jonagored and Jonica apple samples and Ho and HRF paprika samples (12-25 pieces/class). In the case of apple tests, the acoustic firmness coefficient (Felföldi, 1996) was determined as well, as a reference firmness characteristic.

The basis of the developed measuring system is an impact hammer fitted with a piezo-electric force sensor and dynamic signal analyser (HP 35670A) for the signal processing (Fig. 1). The hammer is fixed in an adjustable distance above the sample by an electromagnet. The force signal of the hammer falling down on the sample surface gives information from the viscoelastic properties of the sample but it is affected by other parameters too. Modelling of the impact process makes possible to choose the appropriate firmness parameter depending on the hardness of the produce but non affected by other parameters.

According to our assumption the force is proportional to the deformation ($F = -D_*x$) in the range of applied deformations (<1 mm).This assumption was confirmed by the precision penetrometer (SMS Texture Analyser) tests on model materials and fruit samples (Fig 2). In the case of viscoelastic materials the compression force is depending on the speed of the deformation as well, but according to our experience this dependence is negligible under several mm dropping height.

This linear relation between the force and deformation means, that the movement of the hammer during the first phase of the impact is mechanically equivalent to the harmonic oscillation of a m mass connected to a spring of stiffness D in which case the deformation, the acceleration and force are changing according to a sine wave with period $T = 2\pi(m/D)^{1/2}$. In the case of paprika samples – with relatively low mass and viscosity – the force change versus the time was in a very good agreement with the supposed sinusoid trend (figure 3.) and the results for the model materials and horticultural produces were similar. On this basis the *dynamic firmness coefficient*

$$D = c_* 1/dT^2$$

was introduced where

- dT is the time necessary to reach the first peak of the impact curve (Fig. 3) and
- c is a temporary constant (for ideal materials it is equal to $m_*\pi^2/4$, for real materials it is affected by the oscillating mass and the viscosity of the produce (for an adequate model finite element analysis can be used); in presented phase of experiments a practical arbitrary value (10^{-3}) was used.

Results and conclusions

According to the experiments the introduced parameter was found to be independent on the dropping height for a wide range of tested cultivars. Figure 4 represents the results of the test on apple cultivar Jonagored. The test was non-destructive for the given cultivar until 6-8 mm dropping height. The coefficient of variation of the results of the repeated tests on a given crop was about 10% in agreement with the natural variability of the local surface firmness of the horticultural produces.

Significant correlation was found between the *dynamic firmness coefficient* and the acoustic stiffness factor measured as a reference parameter (Fig. 5). The method was used for some apple and paprika cultivars to test the firmness change of the samples during the storage. The impact method was found to be suitable for repeated non-destructive tests on individual samples and the *dynamic firmness coefficient* was found. to be appropriate to characterise the firmness change during the storage (Fig. 6).

The impact method is suitable for fast, reproducible and non-destructive measurement for many fruit and vegetable cultivars. The *dynamic firmness coefficient* is characteristic for the texture of the produces, it is suitable to characterise the firmness of individual samples and bathes as well. Due to the arbitrary constant used in present phase of experiments the method is suitable mainly for relative measurements; further tests are to be performed for more detailed analysis of the drelationship between the parameter on other physical characteristics (viscosity, mass of the sensor and mass of the produce, etc.).

The sponsor of the work was the OTKA organisation of the Hungarian Academy of Sciences.

References:

[1] Chen, P. - Y. Tjan (1998) A real-time impact sensing system for on-line firmness sensing of fruits. International Conference on Agricultural Engineering, Oslo, Paper No. 98-F-006

[2] Felföldi J. (1996) Firmness assessment of fruits and vegetables based on acoustic parameters - J. of Food Physics 58:39-47.

[3] Mohsenin N. N. (1986) Physical properties of plant and animal materials. Gordon and Breach Science Publishers, New York

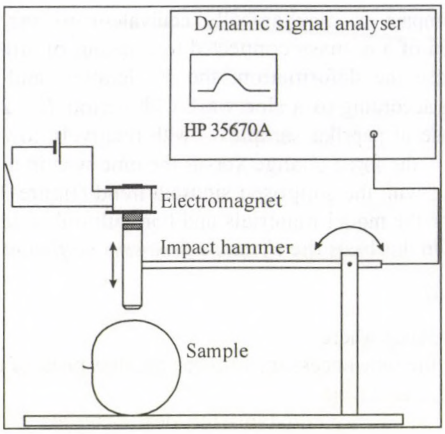


Fig. 1. Experimental setup

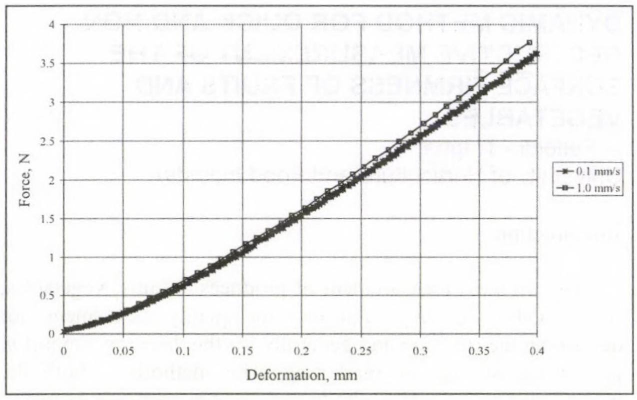


Fig. 2. Force-deformation curve of apple sample (measured by precision penetrometer)

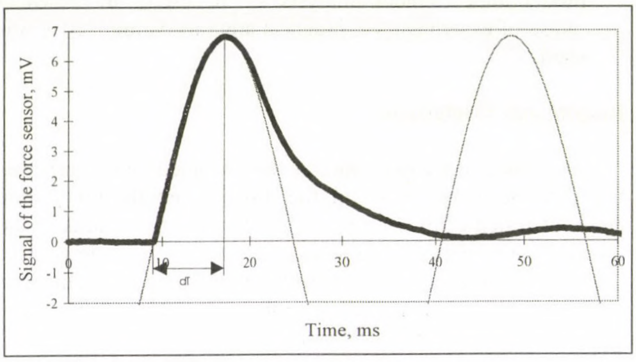


Fig. 3. Impact curve of paprika sample presenting the sine function fitted on the first phase of the curve

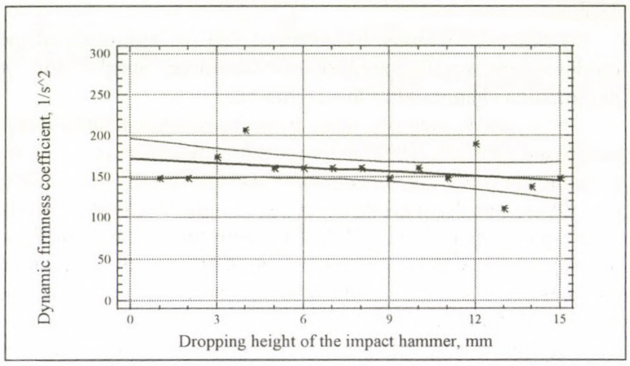


Fig. 4. The introduced firmness parameter vs. the dropping height of the impact hammer

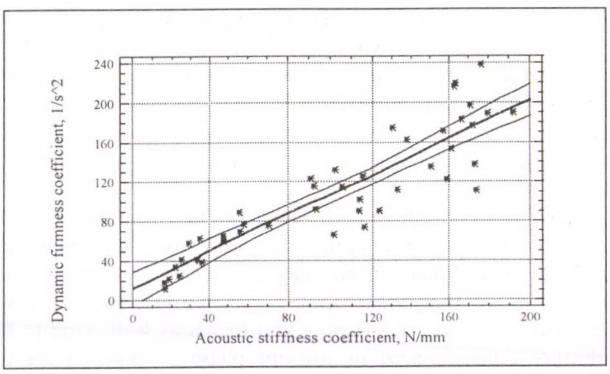


Fig. 5. The introduced firmness parameter vs. the acoustic stiffness coefficient of ripe Jonagored apple samples presenting regression line with the 95% confidence interval, r = 0.91

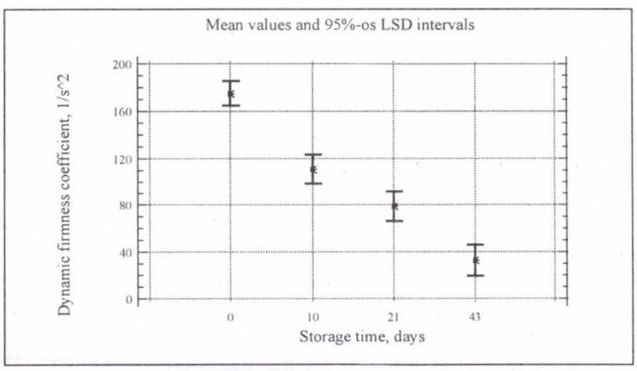


Fig. 6. Firmness change of Jonagored apple samples during the storage at room temperature

RESPONSE OF BIO-SYSTEMS ON WHITE NOISE EXITATION

P. Szendrő - G. Vincze - A. Szász
University of Agricultural Sciences, Gödöllő

Summary

The pink- (1/f -) noise is one of the most common behaviour of the bio-systems [4]. Our present paper is devoted to clarify the stochastic answer given to the white-noise excitation of bio-systems. It is shown that the white-noise powered bio-system generates also pink-noise spectrum. It is used that the living objects in general has cyclic symmetry in infinite degrees of freedom, and their dynamism covered by stationer random stochastic processes.

1. Introduction

Recently much attention has been given to the theoretical and experimental studies of the self-organisation processes in various physical, chemical and biological systems [1], [2]. The living system is random stationary stochastic self-organising process [3]. The self-organising procedure is defined by the spatio-temporal-fractal structure which self-similar both in space and time [4]. The system is based on cyclic symmetry and has infinite degree of freedom. Its time behaviour has a special noise, which has a power spectrum definitely reversibly proportional with the frequency, (1/f-noise or pink-noise, or Flicker-noise), [5]. Based on the self-organising processes a new approach of the living state has been developed. These calculations are devoted to clear the basic of this thinking. We present our calculation for the living object which is powered by white noise. To modelize the stochastic processes we have to base our investigation with Fourier transforms approach. Let us denote the time dependent function (the process) by $x(t)$. Its Fourier transform is defined by [6]:

$$X(f)=\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}x(t)e^{-j2\pi ft}dt:=\mathrm{F}\{x(t)\} \tag{1}$$

Let define the work of the $x(t)$ process and take into account the Parseval's formula [6], then we get

$$W=\int_{-\infty}^{\infty}x^2(t)dt=\int_{-\infty}^{\infty}S(f)df, \tag{2}$$

where $S(f)$ is so called spectral density function.

2. Linear system with finite degrees of freedom

Assume that the stationary random variable $x(t)$ has equilibrium fluctuation of a macroscopic variable, which is linear functional of a generalised force F, i.e.the Fourier transform of this equation has the form:

$$X(f)=[\phi(0)+\Phi(f)]F(f)=Y(f)F(f). \tag{3}$$

Since $\varphi(o)$ and $F(t)$ are real functions, the imaginary and real parts of $Y(f)$ must hold the following relations: $\mathrm{Re}Y(f)=\mathrm{Re}Y(-f),\mathrm{Im}Y(f)=-\mathrm{Im}Y(-f)$. It is well know that the Kubo formula is a relation between the imaginary part of $Y(f)$ and the power spectral density $S(f)$ of the equilibrium fluctuation x [7]. At the room temperature and bellow infrared region ($kT>>hf$) this formula is reduced to the form:

$$\mathrm{Im}Y(f)=\frac{\pi fS(f)}{kT}. \tag{4}$$

Assume that the considered system is causal, then by means of Kramers-Kronig relation we can write [7]:

$$\mathrm{Re}Y(f)-\phi(0)=\frac{1}{\pi}P\int_{-\infty}^{\infty}\frac{\mathrm{Im}Y(z)}{z-f}dz. \tag{5}$$

If we take into account that in the case of pink-noise $\mathrm{Im}Y(f)\approx\mathrm{sgn}\,f$, then the above relation implies: $\mathrm{Re}Y(f)-\phi(0)=\infty$. Consequently, no linear system (with finite degrees of freedom) exists with equilibrium pink-noise. Let us study in the next section the linear system with infinite degrees of freedom.

3. System with infinite degrees of freedom

Assume a vector with infinite dimensions valued stationary random process with orthogonal co-ordinates $x(t,\tau),\tau\in[0,\infty)$. Let us consider, that it has a power spectrum density as:

$$S(f,\tau)=C\frac{1}{1+(2\pi f\tau)^2}, \tag{6}$$

where C is a positive constant. This relation leads to the power spectrum of a pink-noise:

$$S(f)=\int_0^{\infty}S(f,\tau)d\tau=\frac{C}{4}\frac{1}{|f|}. \tag{7}$$

Consequently, the main task is to realise a system with the power spectrum density of Eq. (6). The stationary random process $x(t,\tau)$ generalised by the Langevin equation is:

$$\frac{\tau}{\sqrt{C}}\frac{dx(t,\tau)}{dt}=-\frac{1}{\sqrt{C}}x(t,\tau)+\Gamma_\tau(t) \tag{8}$$

Eq. (8) has the desired power spectrum density, if $\Gamma_\tau(t)$ is unit white noise. In the next consideration it is convenient to enable that $x(t,\tau)$ and $\Gamma_\tau(t)$ are complex valued functions. Approximate the integral in Eq. (7) with a power series as:

$$S(f)=\frac{C}{4}\frac{1}{|f|}=\int_0^{\infty}C\frac{1}{1+(2\pi f\tau)^2}\approx\sum_{i=0}^{N}C\frac{\Delta\tau}{1+i^2(2\pi f\Delta\tau)^2}, \tag{9}$$

where $\Delta\tau=\frac{\mathrm{T}}{N}$.

It is possible to deduce the power spectrum density $C\frac{\Delta\tau}{1+i^2(2\pi f\Delta\tau)^2}$ as the power spectrum density of the stationer solution of the Langevin equation:

$$\frac{i\Delta\tau}{\sqrt{C\Delta\tau}}\frac{dx(t,i)}{dt}=-\frac{1}{\sqrt{C\Delta\tau}}x(t,i)+g_i\Gamma(t,i),\ (i=0,...N), \tag{10}$$

where every $\Gamma(t,i)$ is unit white noise and every 'g_i' is arbitrary complex number with unit magnitude. To realise the Eq. (10) let us start from Langevin equation:

$$\overline{\overline{C}}_1(c_{10},\ldots c_{1i},\ldots c_{1n})\frac{d\overline{x(t)}'}{dt}=-\overline{x(t)}'+\overline{\Gamma(t)}, \tag{11}$$

Here $x(t,\tau)'=x(t,\tau)/\sqrt{C\Delta\tau}$ and $\overline{\overline{C}}_1(c_{10},\ldots c_{1i},\ldots c_{1n})$ is an n-dimensional symmetric and cyclic matrix, where 'n' is an arbitrary natural number. The Eq. (11) is physically realisable for example an array of n R-L circuits coupled magnetically through $n-1$ mutual inductances results this Langevin equation. Assume that the array is powered by white-noise voltage vector $\overline{\Gamma}(t)$. Any cyclic matrix may be diagonalised. If we apply this transformation to the Eq. (11) we obtain:

$$\lambda_i\frac{dx_{si}}{dt}=-x_{si}+\Gamma_{si}(t) \qquad (i=0,\ldots n-1)\cdot \tag{12}$$

Here the new co-ordinates of $\overline{x(t)}'$, $\overline{\Gamma(t)}$ and the eigenvalues of the cyclic matrix are:

$$x_{si}=\frac{1}{\sqrt{n}}\sum_{k=0}^{n-1}a^{-ik}x'_k,\Gamma_{si}=\frac{1}{\sqrt{n}}\sum_{k=0}^{n-1}a^{-ik}\Gamma'_k{}',\lambda_j=\sum_{k=0}^{n-1}a^{jk}c_k\ \cdot \tag{13}$$

If the elements of a symmetric cyclic matrix are real numbers, then the eigenvalues are real numbers as well and satisfy the relations: $\lambda_i=\lambda_{n-i},(i=1,\ldots n-1)$. Assume that:

$$N=\frac{n-1}{2},x_{s0}=0,\lambda_i=\lambda_{n-i}=\frac{i}{2},\Gamma_{si}=\frac{1}{2}a^{ki}\Gamma(t), \tag{14}$$

where $\Gamma(t)$ is unit white-noise and 'k' is an arbitrary element of the set of $\{1,2,3,\ldots,n-1\}$. Now it may be seen that the Eq. (14) with the restriction Eq. (14) is equivalent to the Eq. (8). On the other hand, since the transformation matrix is hermitic, thus the effective power of $\overline{x(t)}'$ may be evaluated as:

$$\lim_{T\to\infty}\frac{1}{2T}\int_{-T}^{T}\overline{x}'(t)\overline{x}'^{*}(t)dt=\int_0^\infty S'(f)df= \tag{15}$$
$$=\sum_{i=0}^{N}\lim_{T\to\infty}\frac{1}{2T}\int_{-T}^{T}x_{si}(t)x^*_{si}(t)dt=\int_0^\infty\sum_{i=0}^{N}S_{si}(f)df$$

where we taken into account the Parseval's formula. Here $S'(f)$ and $S_{si}(f)$ are the power density functions of the process $\overline{x(t)}'$ and the co-ordinate process $x'_{si}(t)$, respectively. Because the Eq. (13) with the restrictions Eq. (14) are equivalent to the Eq. (8) the power density function $S_{si}(f)$ can be written in the form:

$C\dfrac{\Delta\tau}{1+i^2(2\pi f\Delta\tau)^2}$. Thus the effective power of $\overline{x(t)}'$ can be calculated by the series:

$$\lim_{T\to\infty}\frac{1}{2T}\int_{-T}^{T}\overline{x}'(t)\overline{x}'^{*}(t)dt=\int_0^\infty\sum_{i=0}^{N}C\frac{\Delta\tau}{1+i^2(2\pi f\Delta\tau)^2}df \tag{16}$$

Compare this relation with Eq. (6) it is clear, that the pink-noise may be realised by an array, which has cyclic symmetry and powered, by white noise.

4. Concluding remarks

It is proven that all the bio-systems are self-similar in their construction [8]. We had shown above, that the white noise powered (excited) system with infinite freedom and cyclic symmetry emits pink noise. It works like a special filter creating 1/f noise from the non-correlated white noise spectrum. Du to its self-similarity every bio-structures satisfies the cyclic symmetry criteria. The infinite freedom of the bio-matter is trivial, so the bio-systems are pink-noise filters if the excitations are uncorrelated.

References

[1] H. HAKEN (1987), Phys. Scripta, 35, 247
[2] G. NACOLIS, M. MANSOUR (1987), Phil. Mag. 9, 281
[3] M. MARJAN AND A. SZASZ (1998), Self-organisation Processes in Non-crystalline Materials, monograph, to be published, manuscript is submitted
[4] M.S. SCHELESINGER (1987), Ann. N.Y. Acad. Sci. 504, 214
[5] B. J. WEST (1990), Fractal Physiology and Chaos in Medicine, World Scientific, Singapore, London
[6] NIGAM N., C. (1983), Introduction to Random Vibrations. The MIT Press Cambridge, Massachusetts, London, England
[7] GITTERMAN.M., HALPERN V. (1981), Qualitative Analysis of Physical Problems. Academic Press, New York
[8] F.CRAMER (1995), Chaos and Order (The Complex Structure of Living Systems) VCH, Weinheim, NewYork, Cambridge

MODELLING OF COLOR CHANGING DURING STORAGE

A. Szepes Ph.D. student
University of Horticulture and Food Industry

Introduction

The storage is very important part of trade. The quality of the fruits and vegetables changes during the shelf-life. These changes can be positive or negative. The process is positive after the harvest until reaching the total ripeness. After this time the harvest will be negative. The state of crop in the process of ripening is determined by a numerical system [1].

The fruits and vegetables are stored before selling on the market. On this place the appearance of the fruits and vegetables is very important factor. Especially the color tested during the experiments, because the customers decide on the basis of the color. This external parameter is of great importance.

Objective

The objective of this work was to develop a model suitable for description of the color change of fruits during the ripening and the model should be suitable for prediction of the changes during storage.

Materials and methods

Two apple cultivars were measured during the storage at 15-20°C temperature from the harvest to their overripe state. One of the cultivars was the FLORINA and the other was the FREEDOM (the harvest was on 21.09). Three samples from different time of harvest were examined from the cultivar of FLORINA (1st harvest was on 21.09), about a week was the difference between the different picking time of two samples. Each sample consists of 25-30 apples. The changing of color was measured for a month after starting the storage .

The test apparatus was a computer vision system developed at Physics-Control Department, University of Horticulture and Food Industry [2]. This system can measure non-destructively the fruits and vegetables. Fig. 1 shows the measuring system.

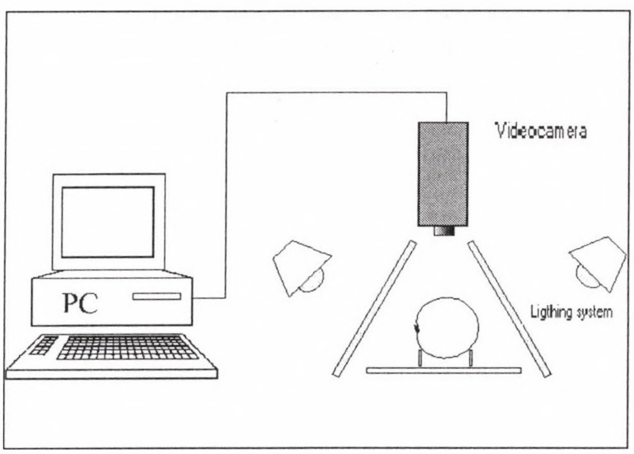


Fig. 1. The computer vision system

These images were taken from the surface of apples, 120 degrees were between the positions. These three images were averaged to examination.

The results of image processing are the average R, G, B values in the R-G-B color system. These values were converted into the 'a' and 'b' values of the CIELab color system. In this system the 'a' value means the transition from green to red color and 'b' value means the transition from blue to yellow color.

Results

Fig. 2 shows the color changing of FLORINA. All of the three samples are shown in the same diagram.

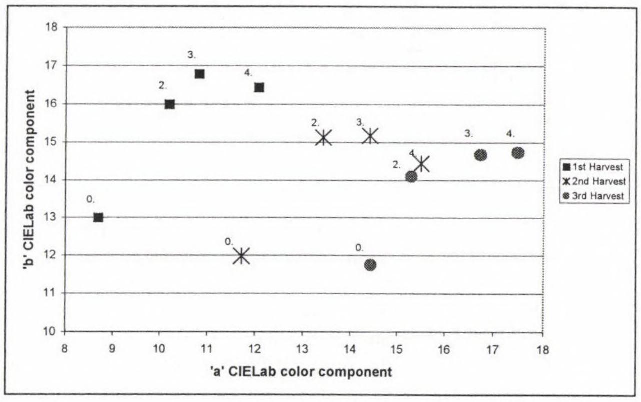


Fig. 2. Changing color of cultivar FLORINA during the storage (Date of measurement just of for harvest, 2^{nd} week, 3^{rd} week, and 4^{th} week after picking)

There is a difference on the chart among the samples of three difference harvest time. Because the red color became more importance in the two latest harvests, it is a natural result of ripening that. The trend of post ripening during the storage is same like the difference among the three different harvests. Each of three sample curves becomes saturated, especially the 3rd sample shows this process. The other two sample curves show a little decreasing of 'b' color component at the last time of measuring. It can be caused by the turning brown, but this observation needs further tests. The complete curve that can prove this saturation a complete examination of ripening process is needed. It means the images have to be taken from the beginning – the state unripe – up to a state of unsuitable for consumption. The duration of experiments performed was shorter than the whole period between unripe and overripe stages of the fruits.

The process of ripening the cultivar FREEDOM was analysed by variance analysis, the LSD confidence interval is 95%. Namely the averages and standard deviations of 'a' and 'b' values were analysed with this statistical method.

Figs. 3 and 4 show the results with cultivar FREEDOM.

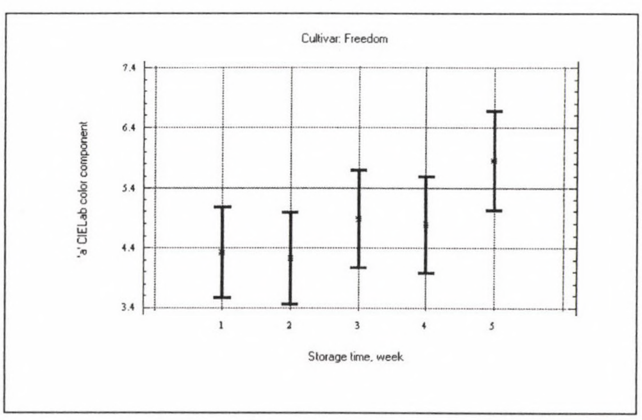


Fig. 3. The average and standard deviation of 'a' value of cultivar FREEDOM in the function of storage time

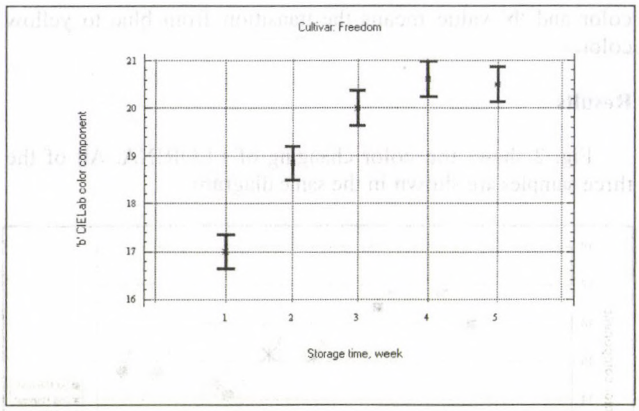


Fig. 4. The average and standard deviation of 'b' value of cultivar FREEDOM in the function of storage time

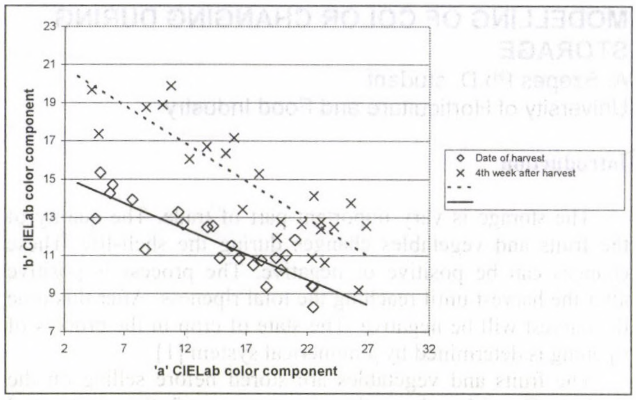


Fig. 5. Changing color of cultivar FLORINA (3rd harvest) during the storage

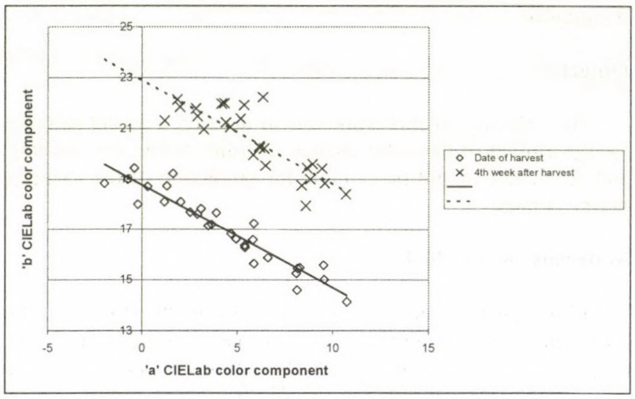


Fig. 6. Changing color of cultivar FREEDOM during the storage

The change is the similar with cultivar FLORINA. In the case of 'b' component, among the date of measuring time has significant difference . The trend of these results is the similar with cultivar FLORINA. In the case of 'a' component, the significant difference is between the first and the last date of measuring, and the standard deviation of values is higher than the case of 'b' component. Changing of green color state causes it. The basecolor of apples was green. This color changing was stronger than the cover color, which was red color. The changing from green color to yellow color is more significant than the changing from purple-red to red.

The standard deviations of average of samples are shown on Figs. 5 and 6.

Figures represent the samples in CIELab system. The lines show the extension of samples. The high standard deviation is found in of samples. The first and the last date of measuring are represented on the diagram.

Conclusions

The results of tests show the trend of the process of ripening. This trend is suitable for the development of prediction model, that could be used to predict the ripening and the change of the color during storage. Further experiments of long duration are proposed for development and validation of food ripening models.

Preferences

[1] FELFÖLDI, J. - F. FIRTHA - E. GYŐRI (1995) Colour analysis of fruits and vegetables aided by PC based vision system – Hungarian Agricultural Engineering, 8/1995, pp.43-45.

[2] T. VÍZHÁNYÓ - CS. BALLA (1998): Vacuum cooling of mushrooms. Conference on Physiological and Technological Aspects of Gaseous and Thermal Treatments of Fresh Fruit and Vegetables, Madrid, 15-16. October, 1998 (In press)

EFFECT OF SOIL DEFORMATION ON THE ENERGY BALANCE OF TRACTORS[1]

P. Kiss
University of Agricultural Sciences, Gödöllő

Abstract

In our paper we analyzed the relationship between a tractor's energy balance and the soil deformation taking place under its tires. The goal of this research was the development of a mathematical model to determine the energy balance equation for a tractor. This equation consists of two parts, one describing the „vertical energy transfer" from the tire into the soil and the second part is he „horizontal energy transfer" which is expended to overcome various resistances. This model takes into account the soil deformation. Our analysis was based on data obtained via field testing a tractor at many different speeds and tire inflation pressures.

Introduction

The theory of land locomotion is a relatively young discipline which deals with the motion of off-road vehicles on different terrains, often having deformable soil cover. The development of this discipline started nearly 100 years ago. It is based on mechanics, physics and mathematics and it utilizes research results gained from studying cross-country vehicles.

Research first was concentrated on the relationship between normal pressure acting on the soil and sinkage because this is the fundamental phenomenon which governs vehicle-soil interaction. One of the most significant side effects of cross-country locomotion is soil stress caused by normal load resulting in compaction and sinkage. Soil pressure is determined by the distribution of normal stresses in the soil-wheel interface area and these stresses cause compaction. The latter is an important factor because it influences vehicle sinkage and motion resistance and it is also significant from the viewpoint of environmental protection. Excessive compaction hinders root growth and, therefore, it affects farming detrimentally.

Objective

The mobility and traction of tractors and agricultural vehicles over plow fields depend on their engine performance, their mass, on motion resistances, on the surface layers of the terrain and on soil parameters.

In this paper we are dealing with the investigation of the energetics of cross-country motion. Our aim is the determination of what parts of the engine performance are expended to overcome losses, for the creation of traction and for the modification of the terrain profile. We can draw conclusions from data gained from energetic tests and, thus, we can explore the energy outlay needed for deforming the soil. Once we have the exact energy balance we wish to separate the energy and performance transferred in both horizontal and vertical directions. What we mean by horizontal energy transfer is the energy needed to overcome power train losses, slip, rolling resistance and to create traction. Vertical energy transfer comes from that portion of the engine performance which is needed for deforming the soil.

Test Method and Equipment

To realize our objectives we conducted field tests using an JD experimental tractor. We ran tests using four different transmission gears, five different inflation pressures both in two- and four-wheel drive modes. Braking was accomplished by a Dyna-Cart dynamometer vehicle. We recorded the terrain profile before and after the vehicle passed over it. (Original and deformed profiles.) Table 1 shows how we varied the test parameters. Profiles were recorded by an apparatus whose function is based on the principle of communicating vessels. We could measure with this device sinkage as well as profile modification. These traction tests were conducted on sandy clay terrain, the soil having about 8% moisture content. We also measured the cone index both in front and behind the vehicle in the wheel rut. We took 20-30 cone index measurements, up to 40 cm depth, at every 5 cm along the profile and we computed their average value.

We employed a 14 channel recorder whose data were saved by a computer. The tested data are depicted in Table 2. We used the following instruments: strain gauges for torque and force, an electronic tachometer for RPM, a radar for vehicle velocity, a piezo electric crystal accelerometer for acceleration, a NiCrNi thermocouple for exhaust gas temperature and a flow meter for fuel consumption.

Table 1. Systematic list of the measuring

Terrain profile	Drive system	Tyre inflation pressure [bar]	Gear
1	4WD	1,4	B2
2	2WD	1,4	B2
3	2WD	1,4	C1
4	2WD	1,4	B3
5	2WD	1,4	C2
6	2WD	1,0	B2
7	2WD	0,8	B2
8	2WD	1,4	B2
9	2WD	1,2	B2
10	2WD	0,6	B2

Results

Table 2. The measured data of field test

Channel	Measured value	Dimension
1	Engine speed	1/min
2	Engine torque	Nm
3	RPM of front drive	1/min
4	Torque of front drive	kNm
5	Torque of rear drive on left side	kNm
6	Torque of rear drive on right side	kNm
7	RPM of rear drive	1/min
8	Vehicle velocity	km/h
9	Drawbar pull	kN
10	Longitudinal acceleration	m/s^2
11	Lateral acceleration	m/s^2
12	Vertical acceleration	m/s^2
13	Exhaust gas temperature	°C
14	Fuel consumption	kg/h

Data were recorded in every 0.01 second and plotted as a function of time. Profile points were recorded at 20 cm intervals. The data may be grouped into three categories: (1) energetics data obtained from pull tests, (2) soil deformation measured by the profilometer and (3) cone indices. Actual engine performance, losses caused by torque transfer, slip and deformation were also recorded every 0.01 second. We also recorded the drawbar performance at the same time intervals. Figs 1 and 2 show the performance balance without drawbar load and with it. The average speed of the tractor was 5.6 km/h and the inflation pressure was 1.4 bar when drawbar load was absent. Because engine performance was not utilized at a high degree in this case, powertrain losses represent a high percentage of it. (Nearly 55% percent.) Since slip was low here, slip losses amounted to 2% only. The remaining 43% was used for deforming the soil and to overcome the rolling resistance. When drawbar pull was exerted

[1] Sponsored by The Hungarian Scientific Research Fund (OTKA)

the velocity of the tractor was 4.6 km/h and the tire pressure was 0.6 bar. The average drawbar pull was equal to 20.1 kN. Sixteen percent of the engine performance was needed to overcome powertrain losses, almost 10% was absorbed by slip, 21% was needed to overcome the rolling resistance and to deform the soil and 53% was „devoted" to exert useful pull. See Fig. 2.

Table 3. Connection of the average soil deformation and the tire inflation pressure

TIP [bar]	0.8	1.0	1.2	1.4
Deformation [cm]	3.9	4.4	5.6	6.2

Next we will show the relationship between performance losses due to deformation and the deformation taking place under the tractor wheels. Fig. 3 depicts terrain profile test data. The top diagram shows the original profile measured in front of the tractor, the plot in the middle represents the profile after the tractor passed over the terrain. The bottom graph shows the vertical soil deformation.

The measured data allow us to explore the relationship between inflation pressure and soil deformation.

We ran several tests using different inflation pressures in gear number B2. Table 3 shows the relationship between pressure and average deformation. Note that a 50% increase in inflation pressure causes a 50% increase in average soil deformation. The variation of the dynamic load in the normal direction [vertical direction] can be determined from the following three quantities: vertical acceleration, rolling resistance and drawbar pull.

Conclusions

- It has been shown that it is possible to explore the relationship between a tractor's energy balance and soil deformation when one applies the test method and evaluation presented in this paper. The basis for this is the energetics data gained from traction tests.
- The soil under a driving wheel is under two different loads. (Shear caused by slip and deformation, compaction caused by the normal load.) Our method is suitable for the separation of performance losses due to slip and deformation and for the determination of the horizontal energy transfer.
- In the absence of drawbar pull soil deformation and powertrain losses absorb almost 100% of the engine performance, while slip requires only a small part of it.
- When the tractor pulls a load, a significant part of the engine performance is expended to create useful pulling force and the remainder is consumed by losses.
- An increase in tire inflation pressure increases soil deformation significantly, while vehicle velocity has a more moderate effect.

References

[1] GY. KOMÁNDI - P. KISS: Determination of the shearing stress in the surface of the soil in case of wheeled vehicles. MTA AMB Gödöllői Kutatási és Fejlesztési Tanácskozás, 1995.

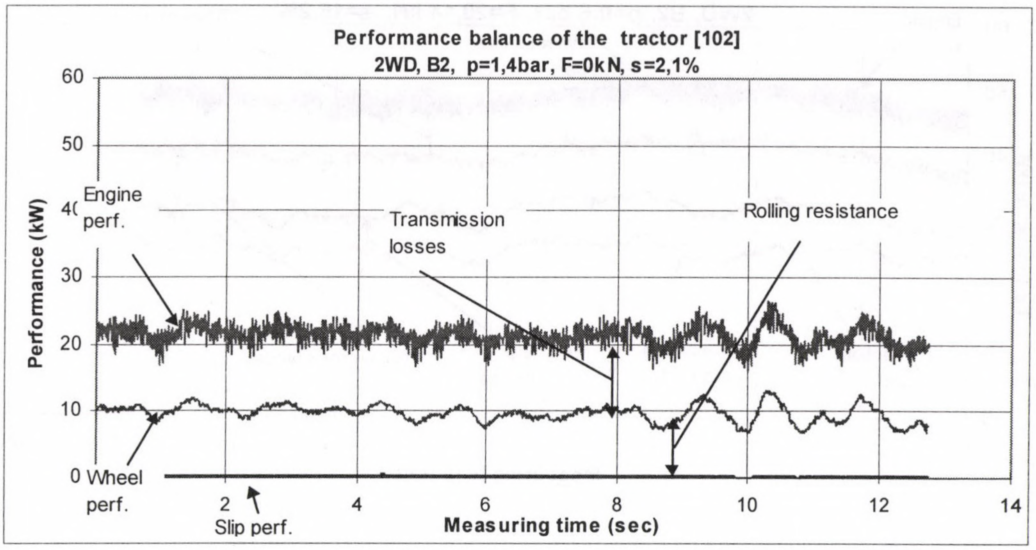
[2] P. KISS - L. LAIB - L. JÁNOSI: Some Aspects of Energetic Modelling of Off-Road Vehicles, ASAE Annual International Meeting, Advances in Soil Dynamics Session, July 17, 1996 Phoneix, Arizona USA, ASAE Paper Number: 961070

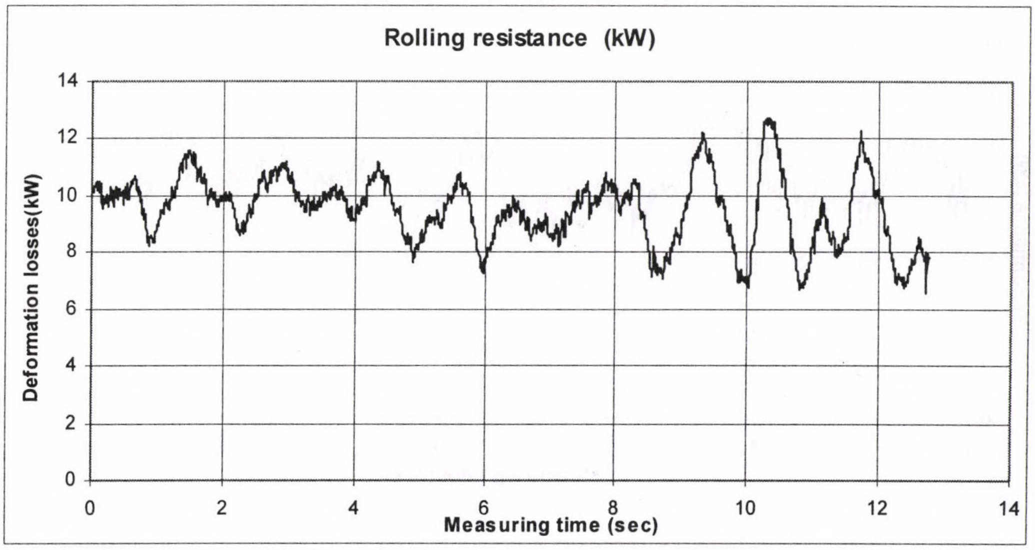
[3] L. LAIB: Analysis of the vibration-excitation effect caused by deformable soil surfaces. Journal of Terramechanics, Vol. 32, No3, 1995.

[4] P. KISS - DR. L. LAIB: Energetic Effect of Soil Deformation Connection with Tractor Energy Balance. 7th European ISTVS Conference, Ferrara, Italy, October 7-10 1997, 93-102 page

[5] P. KISS - DR. L. LAIB: Energetic Aspects of Soil Deformation Connection with Soil-Tyre Interaction ASAE Annual International Meeting Minneapolis Convention Center, Minneapolis, Minnesota USA, August 10-14, 1997 ASAE Paper Number: 971025

[6] P. KISS - L. LAIB: Tractor Energy Balance under Intationary Condition. 6th Mini Conference on Vehicle System Dynamics, Identification and Anomalies 9-11 November, 1998 Budapest, Hungary





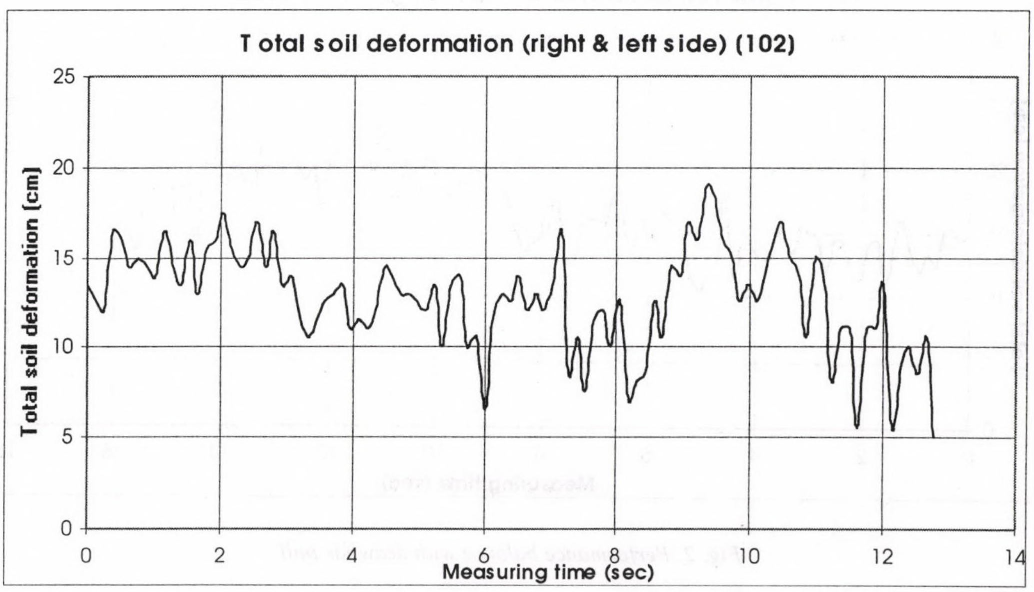


Fig. 1. Performance balance without drawbar pull

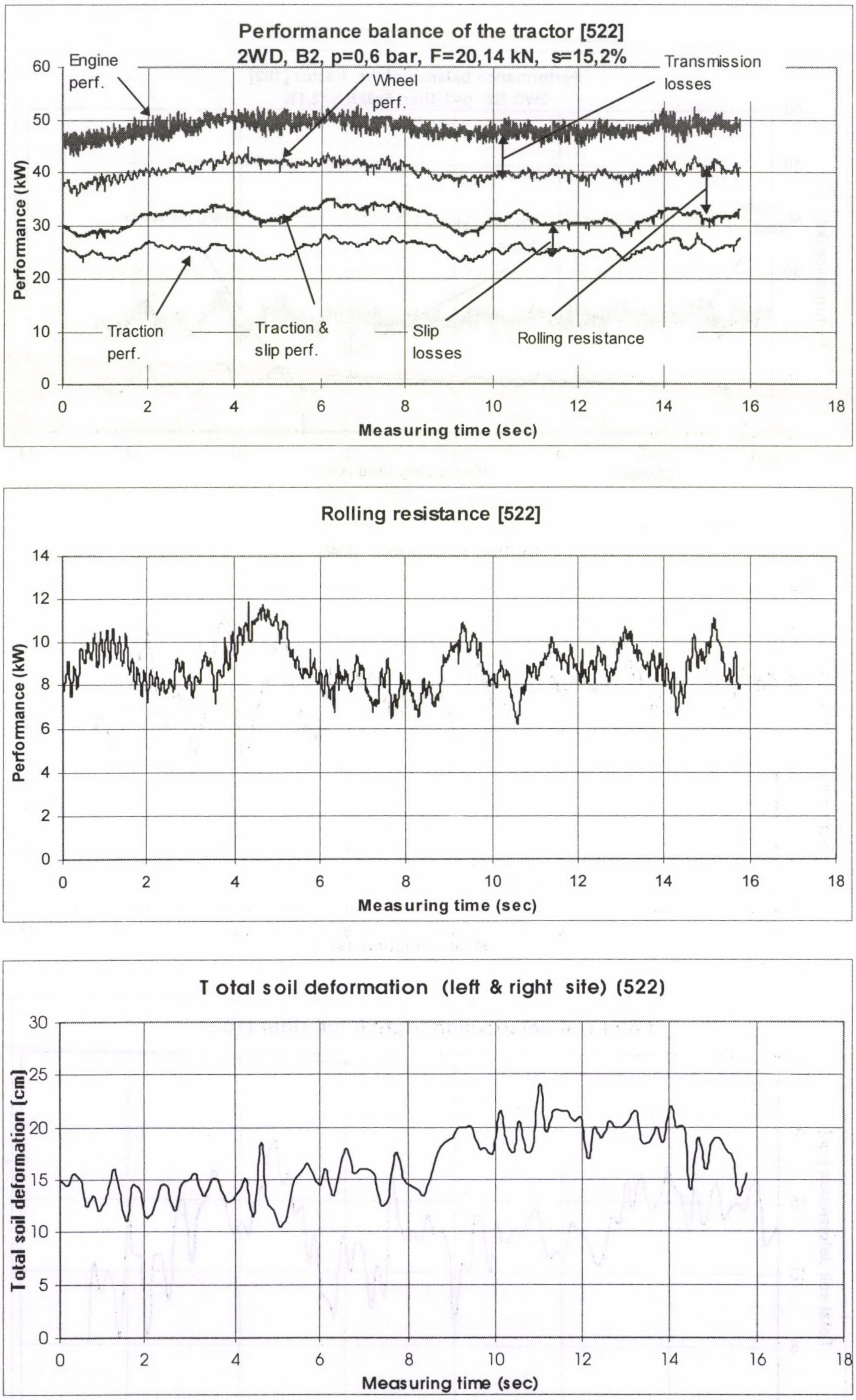


Fig. 2. Performance balance with drawbar pull

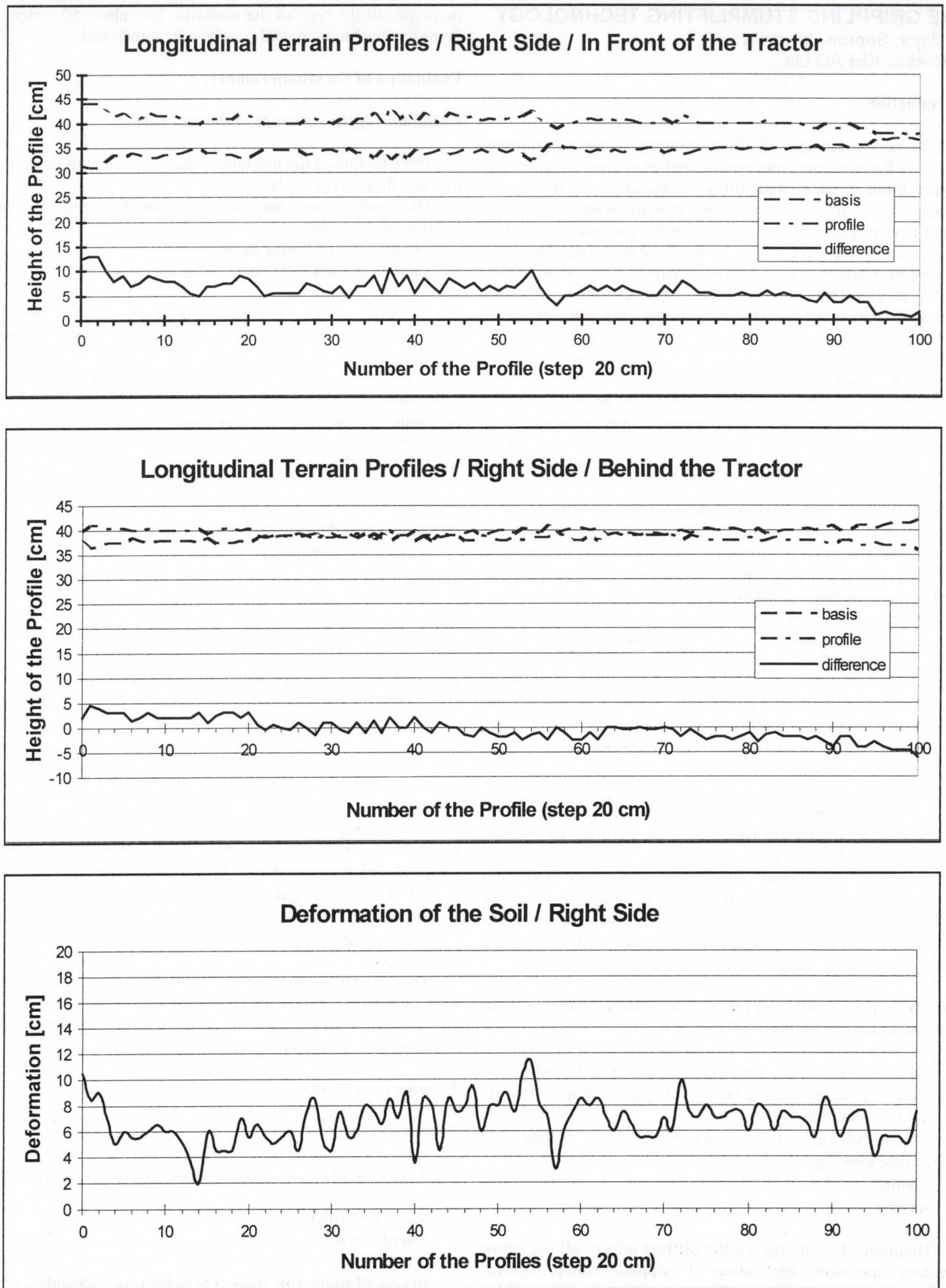


Fig. 3. Measuring longitudinal terrain profiles and soil deformation

THE GRIPPLING STUMPLIFTING TECHNOLOGY

T. Major, Sopron University
J. Rákosi, KEFAG Ltd.

Introduction

The new challanges of forest economy, a better awareness policy as far as nature conservation and protection is concerned require more efficient stumplifting technologies. Afforestation policies should focus on establishing new forest sites it means a brand new phylosophy: new forest on the premises of the old one reducing the level of the artificial intervention. This new concept resulted in a new approach which means that certain places stumplifting procedure has been cancelled. Another approach is to make the best to eliminate the side effects of spoiling natural environment with applying new stumplifting technologies and techniques.

Removing stumps may be carried out in different ways. The grippling stumpliftinf technology seems to be very popular nowdays all over the world. The traditional way of stumplifting was based on mechanical procedure or hydraulic procedure where machines equipped with forklifts with pushing or pulling function could operate.
Meanwhile this sort of operation was carried out the base machine was in work throughout the whole process, and the lifting structure pulls or pushes the stumps before finally grippling and removing them. Meanwhile this function is carried out significant soil damages occur.

To meet the high demands of environmental friendly policies a new technology appeared, which can guarantee the needs of modern forest policy as well. Actually when this new technology is applied the base machine is stationary and a horizontal rotation of lifting structure is about to remove the stump. This method is a lot more environmental friendly and protects the quality of soil in a more efficient way with a better performance. Another advantage of this application that simultaneously soil preparation can be carried out as well.

There are several machines for the implementation of the new grappling stumlifting technology. In Hungary the French product the CASE POCLAIN stump remover is available (in the forests of Kiskunság Forest and Woodwork Ltd.)This machine was designed to remove stumps with the grippling technology, to pile them up either in rows or in bulk. Simultaneously it is applicable for clearing bushes, clearing away, clipping, soil loosening and soil preparation as well.

The Ímportance of Grippling Stumplifting Machines in Afforestation Technology

The available afforestation technologies are as follows:

- soil preparation, clearing bushes, clipping, stump removing, creating stump rows
- soil cultivation, soil loosening, ploughing, trenching, soil surface clearing
- planting
- nursing

Theoretically carrying out the diffrent jobs of all the above itemized operations application of grippling stump remover machine is available. The machine was optimally designed for stump removing operation in the most efficient and economic way, but it also can be applied for the operations itemized above. But it is should be emphasized that these operations must be linked with the stumplifting procedure in order to have an efficient utilization. Otherwise the application of the machine will be inefficient.

The stumplifting procedure is to be perforemd in strips. In a certain process the width of the strip should be adjusted with the properties of the type of the machine. It is about 10 meters as far as the machines applied nowdays are concerned.

Evaluation of the stump remover

Evaluation of the structure of the machine

The structure of the machine makes it efficient to implement its basic function in a safe way.

The machine was supervised in operation and following faults were recorded:

- a failure of a hydraulic device unit
- a failure of greasing system of the accessories

The manufacturer and the trading partners were ready to repair the faults immediately on the basis of the warranty contract.

It is also very typical of the structure that under certain conditions (higher temperature than 25 Celsius degree the hydraulic oil refrigerator is not properly clean) Probably it is due to the fact that the limits were overestimated. The problems can be demolished with proper ongoing operation.

Long lasting operation – approximately half a year – some other faults have occured, which in later stages of production should be taken into consideration:

- wear and tear of jib joint
- cracking of the jib
- wear and tear of the head of the joint
- wear and tear of the tine of the head
- breakage of the tine of the head

Evaluation of the quality of works of the machine

The performance of the stumplifter is concerned to be a good one in case it removes the stumps properly, piles them properly meanwhile making the least soil damage.

According to the investigations the machine is suitable for implementing this work

It is suitable for removing stumps of a blade diameter of 40 cm with one handling.The stumps of bigger diameter is to be removed with more handlings. Meanwhile performing its job:

- lifts the stumps together with their big lateral roots
- does not spoil the soil structure
- piles up literally cleared stumps

The operation of the stump remover is environmentally friendly, and as a crown it all fuel supply is available in a totally closed system, where built in pump is to provide fuel supply from any kind of container.

Economic evaluation

Properties of its Performance

The definition of its area performance is to be carried out in different ways.:

- stump row stock
- disordered stock

In case of stump row stock it is as follows, (depending on):

- row space (**b** = 1.4 ÷ 5.0 m)
- the number of rows to be removed (**x**)
- the width of the work (**B** = 6.8 ÷ 15 m)
- the characteristics of the work and the stump of rows
- the factor of the utilization of the machine ($\mathbf{K_{03}}$ = 0.5 ÷ 0.8)

According to our investigation the time of a removal of a stump depends on the diameter of the blade. But the blade diameter and the number of stumps on a certain surface do not have a significant impact on the area performance, since the increment of the blade diameter decreaeses the number of stumps per hectare. The number of stumps per hectare was approximately 200 ÷ 500 in the investigated area.

The first Table shows the function of the time of productivity and the performance per shift figures, and the Illustration shows their correlation.

In disordered stocks stumplifting is carried out practically in a width of 10 m (**B**=10 m), and the area performance is determined significantly a the factor of utilization (**K_{03}**). The relevant figures are available in the first Table (10 m width work strip).

Cost analysis

The cost analysis was designed to demonstrate the cost structure of the stumplifting operation. If simultaneously other activities are caried out (clearing bushes, clipping, soil loosening, soil preparation) the cost structure changes. The cost analysis does not cover the expenses of the relocation of the machines, since the machine is applicable for other operations that is why stumplifting cost is only partially loaded.

The cost analysis was calculated based on the prices in January 1998.The avarage figures of the Technical Institute of the Ministry of Agriculture were used (**Gockler**, 1998).

Figures of stumplifting to start from:

- price of the machine: **A** = 29703000 HUF (VAT is not included, since it can be claimed)
- annual output of the machine (annual number of technocal performance): **$t_{év}$** = 2000 h
- writing off depreciation: **p** = 17%
- factor of maintainance (the percent of the price paid for repair and maintainance): **r** = 8.97 %
- other costs (the percent of the price paid for other expenses): **e** = 0.30 %
- wages, rates and taxes and other additional costs per working hours: **B** = 564 HUF/h
- avarage fuel consumption per working hour: **V** = 15.8 dm^3/h (based on our supervision)
- fuel cost: **G** = 111,10 HUF/dm^3.

Shift work manufactural cost of the stumplifter (per hour) (**F_{03}**):

$$F_{03} = \frac{A\,(p+r+e)}{t_{év}} + B + V \cdot G =$$

$$= \frac{29703000\,(0{,}17+0{,}0897+0{,}003)}{2000} + 564 + 15{,}8 \cdot 111{,}1 = 6221 - \text{HUF/h}.$$

Operational costs of stumplifting (**M_{03}**):

- manufactural cost of machinary per hour (**F_{03}**)
- area performance of a technical shift (**W_{03}**)

results in the following function:

$$M_{03} = \frac{F_{03}}{W_{03}}.$$

The optimal: area performance to be acheived in a technical shift is between the following value:

W_{03}=0.0459 ÷ 0.1745 ha/h, the operational cost of stumplifting is:

M_{03}=125677,- ÷ 35650,- HUF/h

Table 1. Area Performances of Stumplifter

Area Performance in Productive Time: W_{01} [ha/h]				
	Stump – Row Process		Spacing Process	
b [m]	B [m]	W_{01} [ha/h]	B [m]	W_{01} [ha/h]
1.4	9.8	0.1425	11.2	0.1628
1.423	10	0.1454	11.4	0.1658
1.5	10.5	0.1527	9	0.1309
1.6	11.2	0.1628	9.6	0.1396
1.667	11.7	0.1701	10	0.1454
1.7	8.5	0.1236	10.2	0.1483
1.8	9	0.1309	10.8	0.1570
1.9	9.5	0.1381	11.4	0.1658
2	10	0.1454	12	0.1745
2.2	11	0.1599	8.8	0.1280
2.4	12	0.1745	9.6	0.1396
2.5	12.5	0.1818	10	0.1454
2.6	7.8	0.1134	10.4	0.1512
2.8	8.4	0.1221	11.2	0.1628
3	9	0.1309	12	0.1745
3.2	9.6	0.1396	12.8	0.1861
3.333	10	0.1454	13.3	0.1934
3.4	10.2	0.1483	6.8	0.0989
3.6	10.8	0.1570	7.2	0.1047
3.8	11.4	0.1658	7.6	0.1105
4	12	0.1745	8	0.1163
4.5	13.5	0.1963	9	0.1309
5	15	0.2181	10	0.1454
Shift Work Performance: W_{03} [ha/h]				
K_{03} / W_{01} [ha/h]	0.5	0.6	0.7	0.8
0.0989	0.0495	0.0593	0.0692	0.0791
0.1000	0.0500	0.0600	0.0700	0.0800
0.1200	0.0600	0.0720	0.0840	0.0960
0.1400	0.0700	0.0840	0.0980	0.1120
0.1600	0.0800	0.0960	0.1120	0.1280
0.1800	0.0900	0.1080	0.1260	0.1440
0.2000	0.1000	0.1200	0.1400	0.1600
0.2181	0.1091	0.1309	0.1527	0.1745

The operational cost is to be related to the ongoing operational properties according to Fig. 1.

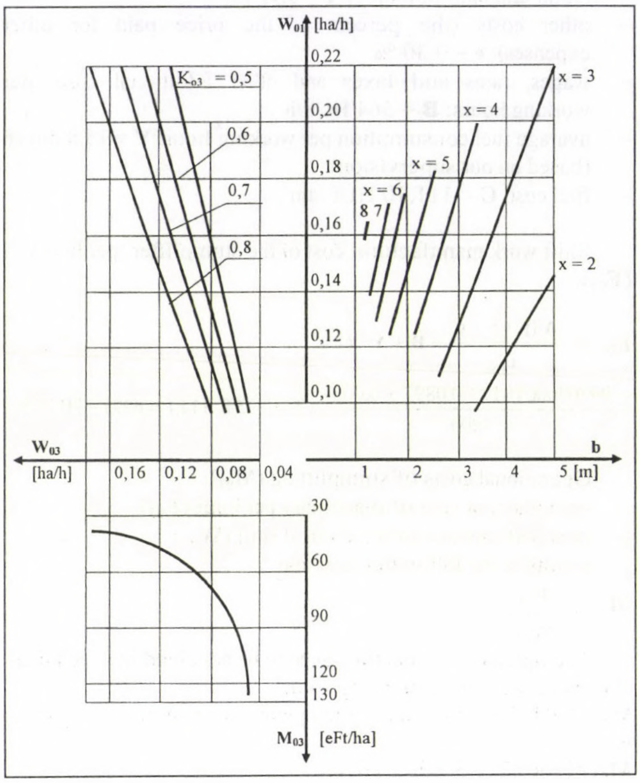


Fig. 1. The area performance and operational cost of stumplifting

References

[1] CZUPY, IMRE - HORVÁTH, BÉLA - MAJOR, TAMÁS (1998) Technological instructions to use CASE POCLAIN 1188 CK stump remover. Lecture notes, Sopron

[2] CZUPY, IMRE - HORVÁTH, BÉLA - MAJOR, TAMÁS (1998) Operational documentation of CASE POCLAIN 1188 CK stump remover. Lecture notes, Sopron page: 235

[3] GOCKLER, LAJOS (1998) Price and Cost of Agricultural Machines in 1998. Agricultural Machinary, I. Issue page: 44

[4] HORVÁTH, BÉLA (1996) The Current Situation and the Future of Forest Machinary, Agricultural Machinary, XXXVII. 8:8-9

IS THE STRUCTURE OF THE WATER CONVERTIBLE IN PHYSICAL WAY?

P. Szendrő - J. Koltay - A. Szász - Gy. Vincze
University of Agricultural Sciences, Gödöllő

Abstract

It will be proved that the structure of the water consists of two solid, a liquid and a gas structure components in the temperature interval of $0-60^0C$. The two solid components contain ice like clusters, and their proportions can be altered by means of electro-magnetic field. In this way the water can be structured. The pattern remains for a long time after the treatment as well, which cannot be described by the chemical equilibrium. Therefore we have worked out such a polarization model for the water, according to which the polarization process holds hysteresis. Hereby the permanent structure conversion can be explained. According to the Eötvös law, the structure alteration entails a change of the surface tension, which we could also demonstrate by a simple experiment. The work has been carried out in the frame of the research projects OTKA I/3–1522, the OTKA T-017717 and the OMFB 96-97-44-1054.

1. Introductiuon

The structure of the water has been modeled in many ways. One of those is the Némethy-Scheraga's flickering cluster theory [1]. We set off from this in our examinations bellow. In ice phase the water forms crystal structure. Each oxigen atom of this crystal is bound to four hydrogen atoms creating a tetrahedronic structure. During the ice - water change of phase of the first kind not all of the hydrogen bond will be split in the crystal, but only every seventh one. As a conclusion of this, there are ice crystall leftovers in the temperature range of 0-15 °C, and their number drops with the growing temperature. Besides this, a quasi crystallic structure exsists. Among the individual clusters there are free water molecules. This is the liquid structure component. By theoretical considerations Eyring, Maschi, Jhon, Ree and Grosh assumed [2], that the water consists of not one but two solid quasi crystallic structures, which stand in thermodynamic equilibrium with each other and the water. Each of the solid structure comprises clusters embracing average 46 molecules. One of the structures, the ice-I is similar to the ice in its cluster structure and density. The other solid structure cosists of ice-III clusters. These ones hold also hydrogen bonds, but their density is 20% higher than that of the ice-I clusters. In addition there are also holes in the the liquid which can be filled by water molecules by which they move similarly to the positive charged holes in semiconductors. This is the so called gas structure component. So the water regarding its micro-structure is a liquid of more structure component which macroscopically can be considered as isotropic. The role and quantity of the individual components are the functions of the temperature. So the individual structure components are the following: leftover ice crystals (MJK), ice-I quasicrystals (J-I), ice-III quasicrystals (J-III), liquid (F), gas (G). The simplified phasediagram of the water with these markings can be seen in Fig. 1. The x-axis of the diagram represents the temperature, while on the y-axis is the proportion of the single components in volume percentage.

In the diagram it can be seen that over 60 °C only the the liquid and the gas componets are present. It is remarkable, that at 37,5 °C the volumes of the liquid and the solid structure components are equal, and the role of the dispersive component is played by fluidized vacancies.

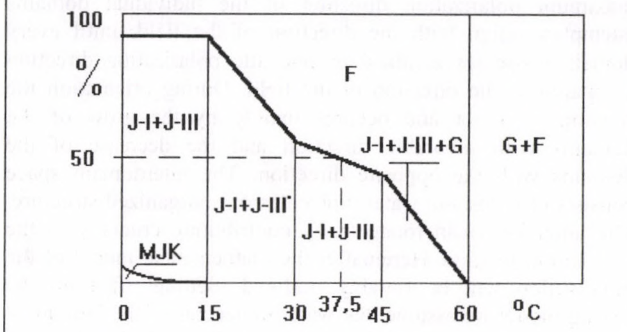


Fig. 1. Simplified phase diagram of water

2. The chemical equilibrium of water

It was assumed previously, that between ice-III and ice-I like clusters develops an equilibrium related to the material transfer which can be described by the following reaction equation:

Ice-I ⟷ Ice-III.

If an ice-I like cluster comprising q molecules converts to an ice-III like cluster, the progress of the reaction in time is described by the following

$$\frac{d\,c_{JI}}{dt} = k_1 c_{JIII}^{q} - k_2 c_{JI}^{q} \tag{1}$$

differential equation, where C is the concentrations, while k the constant of the reaktion rates. As known, the K constant of equilibrium of the reaction depend on the energy of the electro-magnetic field $W(E,H)$ according to the following equation [3]:

$$K(E,H) = \frac{c_{Ji}}{c_{Jiii}} = K\left[e^{-\frac{W(E,H)}{RT}}\right]^{q}. \tag{2}$$

From the equation it is clear that the electric or magnetic treatment changes the concentration of the ice-I like cluster on the account of the concentration of the structure consisting of ice-III like clusters. Accordingly, the electro-magnetic field rearranges the clusters of the individual structure components in the microstructure of the water. As seen before, the density of the individual clusters and thus their refractive index are different. By this fact the pattern can be visualized using the Schliren method. The above described structuring process reversible, therefore it does not account for the permanent structure modification of the water.

3. The polarisation process of the water

A model for polarization of clustered water was worked out by Eyring [4]. Hereinafter we use this as a starting point analyzing some interesting aspekts of the polarization of the water. At first the Eyring model for the polarization of the water will be discussed. The water consists of domains, which have a maximum polarization direction. In this direction the individual water molecules hold an average dipolemomentum of $\mathbf{p_e \cos\Theta}$. It is importanat, that the Θ angle between the polarization and the field is approximately zero. In termodynamical equilibrium the neighbouring domains try to reach the position in which the angle is 180° between their maximum polarization angle and the maximum polarization of their neighbour. In electric field the maximum polarization direction of the individual domains attempt to align with the direction of the field, until every domain possesses identical or opposite polarization direction compared to the direction of the field. During orientation the rotation is minor and occures mainly by the grow of the domains with favorable direction and the decrease of the domains with the opposite direction. The interdomain space consists of holes and water molecules of unorganized structure. The latter ones can rotate freely contributing crucially to the realaxation process. Hereinafter the mathematical model of the polarization will be roughly outlined. Setting off from the Eyring model we assume that water molecules of the individual domains hold two orientation states: one is (marked as 1) when their direction is fairly close to the direction of the field. In this case the average value of the dipolemomentum provided by a dipole into the direction of the field is $\mathbf{p_e \cos\Theta}$. The other (marked as 2), when they stand opposite to the field, having an average dipolemomentum of $\mathbf{-p_e \cos\Theta}$. Let n_1 and n_2 the number of those dipoles, which belong to the state of the one or the other at an istant. Let $w_{12}dt$ furthermore the probability of that a dipole passes through from the group no. 1 to the group no.2. Similarly let $w_{21}dt$ the probabilty of the reverse transition. Then the Pauli's master equation is:

$$\frac{dn_1}{dt} = -w_{12}n_1 + w_{21}n_2, \quad \frac{dn_1}{dt} = -w_{21}n_2 + w_{12}n_1 \tag{3}$$

If $\mathbf{N}$ is the number of the molecular dipoles in a volume unit, then $\mathbf{n_2 = N - n_1}$.

On the other hand the dipolemomentum of the volume unit, the so-called polarization quantity, is: $\mathbf{P=(n_1-n_2)\ p_e \cos\Theta}$. Substituting this to the master equation and reducing it, the following equation is obtained:

$$\frac{dP}{dt} = -(w_{12} + w_{21})P + (w_{21} - w_{12})Np_e\cos\Theta \tag{4}$$

The temporary probabilties can be determined by the Boltzmann statistics from the conditions of the local equilibrium. With these the equilibrium polarization can be calculated from the

$$P_e = Np_e\cos\Theta\frac{w_{e21} - w_{e12}}{w_{e12} + w_{e21}} = Np_e\cos\Theta\tanh\frac{p_e\cos\Theta}{kT}E_i \tag{5}$$

equation, where E_i is the internal field force which stimulates the polarization and could be calculated as the sum of the external electric field force E and the field force deriving from the interaction of the dipoles $\mathbf{E_i = E + \frac{\lambda}{\varepsilon_0}P}$. Here λ is the coefficient of the interdomain field generation. Taking all these into consideration the following equation is obtained to describe the polarization of the water

$$\frac{dP}{dt} + \frac{1}{X}P = \frac{Np_e\cos\Theta}{X}\tanh\left(\frac{Ep_e\cos\Theta}{kT} + \frac{\lambda Pp_e\cos\Theta}{\varepsilon_0 kT}\right), \tag{6}$$

after introducing the $T = w^{12} + w^{21}$ designation. Hysteresis is the quality of the equation having importance for us can be shown by numeric methods. Fig. 2. represents the results of two computer analysis.

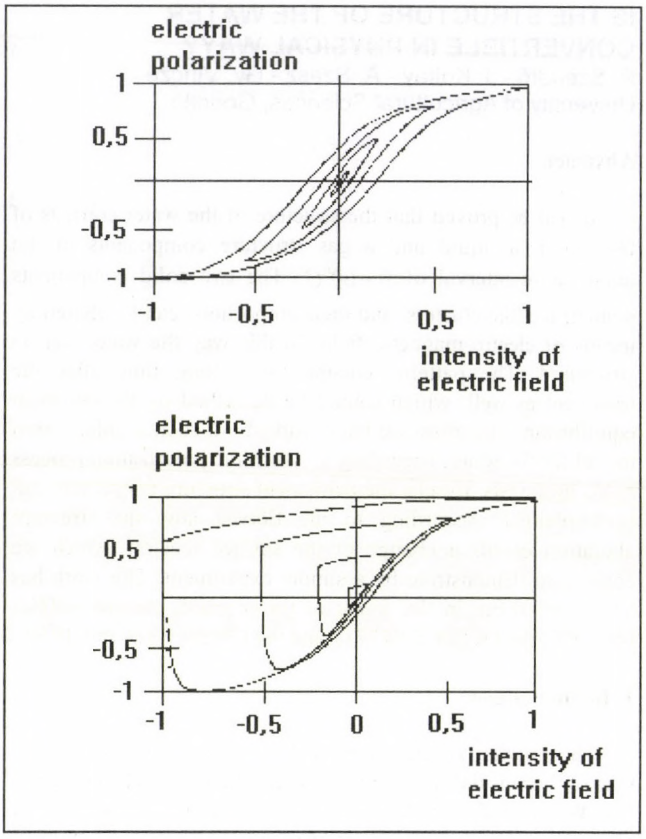


Fig. 2. Hystresis loop of water for sinusoidal and sawtooth variation of electricfield

From the figures it is obvious that after the electric impact the water can possess remanent polarization. The question is brought up, whether it is possible to certify the permanent structuring predicted by the theory. We will prove bellow that the answer is yes.

4. The Eötvös law

Let us set off from the Eötvös law which according to the practice describes fairly exact the surface tension of liquids as the function of the temperature [5]. The law can be formulated in the following way

$$\alpha v^{\frac{2}{3}} = K(T_k - T), \tag{7}$$

where α is the surface tension of the liquid, v its molar volume, T its temperature, T_k its critical temperature, and finally K is a universal constant. If the water turns to more organized under the effect of an electric treatment, large size clusters will form as seen before. These large size clusters can be regarded as giant molecules according to the cinetic theory. Evidently these "giant molecules" hold larger molar volume. Therefore grows the average molar volume of the treated water and according to the Eötvös's law lowers its surface tension.

5. The water uptake experiment

Table 1.

Uptake length [cm]	4	5	6	7	8	9	10	11
Uptake time [sec] reference water	14	25	41	54	82	115	152	220
Uptake time[sec] treated water	21	32	50	72	104	145	224	370

As proved above, the surface tension reduces with the form of larger size clusters in the electrically treated water. It can be demonstrated by the water uptake expriment, in which water is being absorbed by blotter and the length of the uptake is being registered as the function of time. In order to preclude the magnetic field during the experiment, the destilled water of 21°C was treated in the electric field of a bifilary winded solenoid. The treatment was performed in weak electric field, with an average field force of $50\frac{V}{m}$. The length of the treatment was 20 minutes. The results of the measuring are shown in Table 1.

In the same time with the uptake experiment we have carried out a viscosity measuring as well, and we have found the viscosity of the treated water 10% higher than that of the reference one. From the water uptake experiment taking also into consideration the change of the viscosity it follows a 20.4% reduction in the surface tension. Thus the structure of the water became more organized according to our expectations.

6. Concluding remarks

The answer for the title question is yes. The structuring of the water in electro-magnetic field can be predicted and proved simply by experiment.

References

[1] NÉMETHY G. - SCHERAGA H. (1962), J.Chem. Phys. 41, 680
[2] EYRING H. J. (1936), Chem. Phys. 4, 223
[3] EYRING H. - HENDERSON D. - JOST W. (1971), Physical Chemistry. Academic Press, New York and London
[4] EYRING H. J. - JOHN M. S. (1969), Significant Liquid Structures. John Wily and Sons Inc. New-York, London, Sydny, Toronto
[5] Eötvös L. (1886) Ann. d. Phys.(2), 27. 488

EXPLORATION OF TECHNICAL AND FERMENTATION-BIOLOGICAL RELATIONSHIPS OF WRAPPED SILAGE BALES (OTKA T 022420)

Dr. L. Fenyvesi - Dr. Z. Bellus
Hungarian Institute of Agricultural Engineering

1. Preliminaries

Silage-making of alfalfa is a well-known preservation method. Ensuring of coarse fodder of good quality, containing low content of fermentable sugar and high content of protein, in winter and in the case of monodietic feeding is adversely effected by the preservation.

The special harvesting and wrapping machines that have been appeared recently on the market of the western countries have been created the conditions for the long-time preservation of the coarse fodder in good quality.

Balers, as the main machines of the technology, have come on to the market with bale-chamber and slicing unit in order to get more favourable compaction.

Against of the traditional harvesting technology of alfalfa and coarse fodder in home conditions, these new machines have been appeared in Hungary too.

For the solution of the fodder supplying problems of small and middle size farms wrapping machines with simpler construction are suitable while on large-scale farms the best solution is to use the press-in-bag technology.

To start the fermentation process and to preserve the nutrient content of the fodder as for as to reduce losses and to avoid the harmful post-fermentation applying of different kind of additives, pro-biotics and enzymes is necessary.

In our present research report we give an account of the result of the foil tests in laboratory conditions and of the bale wrapping examinations in operative ones.

2. Method

In the case of bale wrapping examinations of alfalfa silage, capacity, energetic and running parameters of the technology have been carried out.

Bales that were made by traditionally and by slicing method were wrapped on 24-36 min^{-1}. In the frame of a simple operative observation, according to the standard of MÉMMISZ 00-00-03-87, time elements, mass of the wrapping foils and its measures were stated and examined.

Specific energetic parameters were calculated on the basis of the given hydraulic and power transmission characteristics.

Capacity parameters and the specific foil consumption also were calculated. During the relaxation tests of the agricultural STRECH foils the material was gripped between two of clamp jaws of 650 x 40 x 20 mm size to avoid the damage and slipping out. Relaxation forces were 50-100-150 N. Velocity of the loading was continuous.

3. Results of the tests

During the bale wrapping examinations moisture content of the pre-withered alfalfa was 55-60 %. Type of machine was PÖTTINGER ROLLPROFI 3200 L SC with constant bale chamber. Number of bales were 9. The 8 bales, made of sliced material had the measure of ∅ 1200 mm x 1200 mm. In this case the type of wrapping machine was PÖTTINGER ROLLPROFI G 90 S.

Volume mass of the former traditional bales was 405 kg/m^3 while the mass of bales of sliced materials was 420 kg/m^3. We applied two of wrapping methods. In the first case a shorter storage time can be used in the second case time of storage is more longer. So the laping indices were 24-fold and 36-fold.

Capacity and energetic characteristics using tractor operating unit of MTZ-82 type machine, can be seen in Table 1. and 2.

Table 1. Capacity characteristics of the bale wrapping

Sign of the measurement	Average mass of the bales (kg)	Winding number n_t (min^{-1})	Time of winding T_1 (min)	Capacity W_1 ($t\ h^{-1}$)
PH I.	564,5	24	1,27	26,7
PSZ I.	568,8	24	1,28	26,7
PH II.	608,4	36	1,94	18,8
PSZ II.	625,0	36	1,98	18,9

Notices:
PH = PÖTTINGER bales with traditional lenght of fibre
PSZ = PÖTTINGER bales of sliced materials

Table 2. Energetic characteristics of bale wrapping

Sign of measurement	Winding number n_t (min^{-1})	Fuel consumption (dm^3)	($kg\ h^{-1}$)	Specific energy consumption ($MJ\ h^{-1}$)	($MJ\ t^{-1}$)
PH I.	24	0,15	6,24	261,26	9,80
PSZ I.	24	0,15	6,20	259,16	9,72
PH II.	36	0,27	7,05	295,17	15,68
PSZ II.	36	0,28	7,30	303,96	16,05

Nevertheless the PÖTTINGERT type bale wrapper is tipically a field machine its service was done by a CLAAS RANGER 907 T typ loader.

The most important operation and time elements are summarized in Table 3.

Table 3. Operation and time elements of the wrapping process

Nomination of operation and time elements		PÖTTINGER bales Traditional $n_t = 24$	Traditional $n_t = 36$	Sliced $n_t = 24$	Sliced $n_t = 36$
Basic time	T_1 (h)	0,012	0,0323	0,0213	0,0330
Additional time	T_2 (h)	0,0238	0,0253	0,0238	0,0253
Productive time	T_{01} (h)	0,045	0,0576	0,0451	0,0583
Capacity during basic time	W_1 ($t\ h^{-1}$)	26,67	18,82	26,66	18,94
Productive capacity	W_{01} (th^{-1})	12,54	10,56	12,61	10,72
Productive utilization factor	K_{01}(%)	0,47	0,56	0,47	0,57

Foil consumption is given for pre-stretched and original measures. Calculated data against winding number can be seen in Table 4.

Table 4. Foil consumption of the PÖTTINGER type bale wrapping machine

Sign of the measurement	Pre-stretched foil (m) $n_t = 24$	Pre-stretched foil (m) $n_t = 36$	Original foil (m) $n_t = 24$	Original foil (m) $n_t = 36$
PH	117,19	175,83	73,27	109,89
PSZ	116,28	174,40	72,68	109,00

Wrapping foil of KÖRÖSPACK Cooperative. In the case of the developing examinations of the KÖRÖSPACK mad agricultural STRECH foil, measurement elements were loaded smoothly by 50-100-150 N mass-forces.

Strain and creep curves related to the 150 N/min load velocity can be seen on Fig. 1 and Fig. 2.

During the relaxation tests 150 N mass forces ensured the transversal decreasing in measure of 100 mm. Relaxation force at 400 mm with of foil is shown on Fig. 4. While the load curve before the relaxation state can be seen on Fig. 3.

4. Conclusions

There was no essential difference among the capacity characteristics, related to the basic time, in the case of wrapping traditional made bales and sliced ones.

The mass capacity of 18.9 t h^{-1} was about less by 30 % in the case of n_t = 36 min^{-1} than the value of 26.7 t h^{-1} in the case of n_t = 24 min^{-1}.

Energetic characteristics were basically determined by the oil consumption of the hydraulic and power machine driven system. Oil consumption varied between 20-20 dm^3 min^{-1} at n_t=20, while in the second case between 6.2-7.3 kg h^{-1}. By ensuring a self-operation running, volumetric and specific parameters can be improved.

The rheological material equation as for creeping curve of the KÖRÖSPACK STRECH foil is as follow:

$$\Delta L = \Delta L_\infty - A\exp(-E\lambda^{-1} t)$$

where:

ΔL = change of the measure (mm)
ΔL_∞ = creeping limit value (mm)
A = coefficient
$E\lambda^{-1}$ = creeping factor (min^{-1})
t = time of creeping (min)

From the creeping equations it can be stated that dependings of the characteristics of the value of pre-load is non-linear.

It means that the equations can not be used generally.

The higher value of the creeping inclination as for the shape-tracking and durability is definitely advantageous.

The applicable equation in the case of the relaxation tests is as follow:

$$F = F_\infty + B\exp(-\theta t)$$

where:

F = force of the relaxation (N)
F_∞ = limit value of the relaxation force (N)
θ = relaxation factor (min^{-1})
t = time of the relaxation (min)
B = coefficient

Measure of load decreasing, that characterizes the relaxations, depends basically on the structure of the material and the measure of the deformation.

References

[1] J. CSERMELY - Z. BELLUS (1998): Korszerű takarmánytartósítási és tárolási technológiák fejlesztése. Report in Hungarian, FVM Műszaki Intézet, Gödöllő, 1-26 p.

[2] Z. BELLUS - L. FENYVESI (1998): Fejlesztett bálacsomagoló fólia paramétereinek vizsgálata. Report in Hungarian, FVM Műszaki Intézet, Gödöllő 1-46 p.

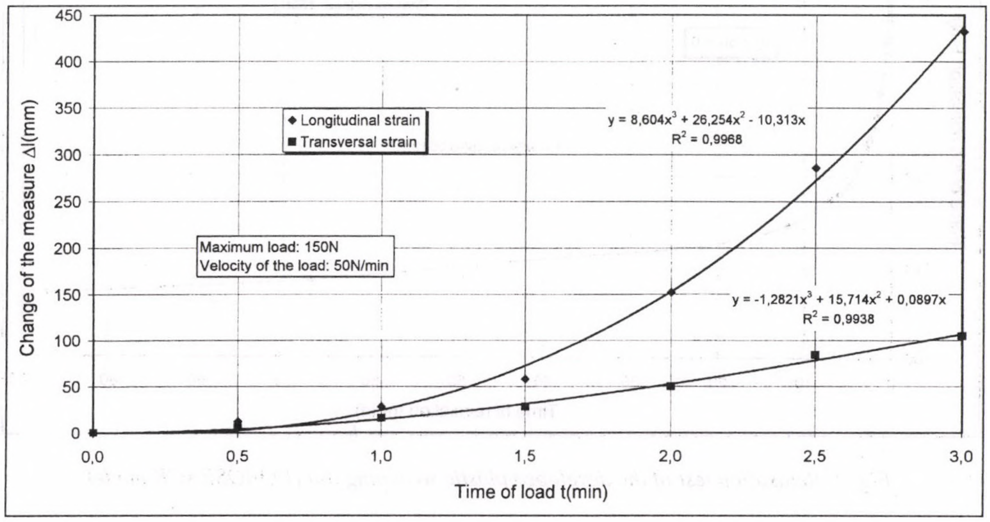


Fig. 1. Creeping test of the developed plastic foil – load (KÖRÖSPACK made)

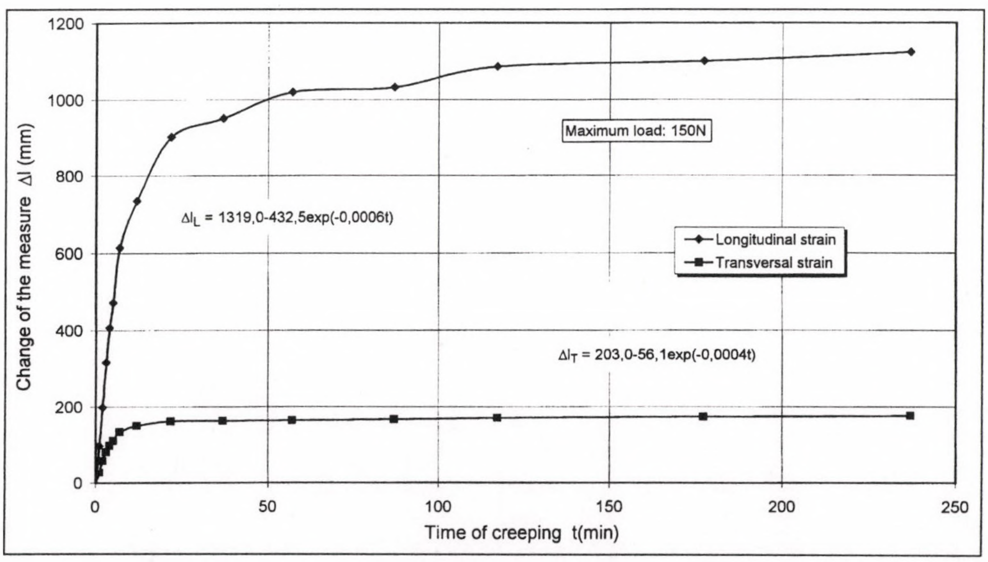


Fig. 2. Creeping test of the developed plastic foil (KÖRÖSPACK made)

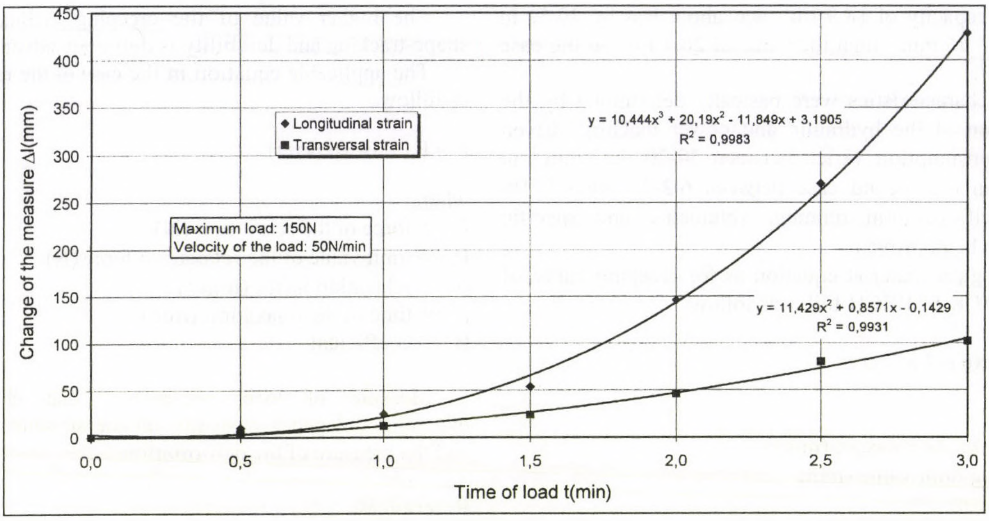


Fig. 3. Relaxation test of the developed plastic wrapping foil – load (KÖRÖSPACK made)

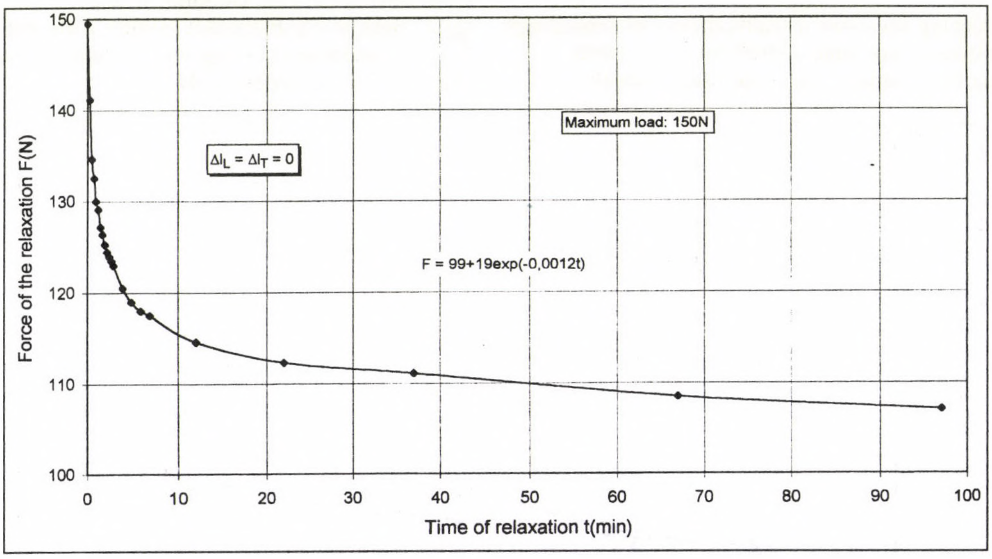


Fig. 4. Relaxation test of the developed plastic wrapping foil (KÖRÖSPACK made)

TECHNICAL, TECHNOLOGICAL AND FEEDING EXAMINATION OF FODDER FERMENTED IN BAG

Prof. Dr. J. Csermely
Hungarian Institute of Agricultural Engineering
Prof. Dr. J. Schmidt
Pannon University of Agricultural Sciences (PATE-MTK)

1. Aim of the research

The aim of three years lasting research theme that was started in 1998 are the technological establishing of the home adaptation of the new storage system, finding out the technical, technological and feeding connections and elaboration of the running costs.

2. Collaborators

- PATE-MTK Takarmányozástani Tanszék, Mosonmagyaróvár
- Dalmandi Mezőgazdasági Rt., Középhídvég
- Pankotai Agrár Rt., Szentes
- BOS-FRUCHT Agrárszövetkezet, Kazsok
- AG-BAG Hungária Kft., Mosonmagyaróvár

3. Material and method

In 1998 technological experiments were carried out under operative circumstances using TAUROS and G-6700 type equipment. Quantity of fermented fodder, consisting of alfalfa, crushing of the whole corn plant and wet corn grits was about 10,000 tons.

4. Results of the research

The main results of the technical and technological experiments are shown in Tables 1 and 2 while the results related to the fermentation quality and the utilization of nutritive materials in Tables 3; 4 and 5.

From the results of operative examinations the following most important conclusions can be drawn:

- Dry-matter content (DM) of the withered alfalfa, in most of the cases, was more than the optimum value of 30-40%. Supplement of grits and additives improve the quality of fermentation and the energy content of the fodder.
- The average size of the chopped plant influenced significantly the volume mass that is closely connected with the quality of the fermentation. Optimum DM content can be reached at 30-35 mm of chopping size, 5-6 bar of pressure and 590-630 kg/m^3 volume mass that is more by 15-25% than in the case of wall silo.

5. Summarizing, conclusions

- The average filling capacity of 7-14 t/h can be rised by more than twice by means of better service and better organising of the transport.
- Owing to the crushing and the pneumatic transport the specific energy consumption of the filling is 2.3-2.7 kWh/t at wet corn grits.
- On the basis of the preservation and feeding experiences it can be stated that by the bagging storage technology can be produced silage of good quality and of favourable digestibility.
- Owing to the better harmony with harvesting and filling the loss of harvesting can be decreased.
- By means of the more favourable storage characteristics the quality of the fodder can be preserved in better way.
- Flexibility and universality of the technology ensure favourable management advantages.
- In the case of corn, harvesting capacity can be increased, its duration can be decreased and considerable energy and drying cost can be saved.

Table 1.
The most important results of the technical and technological experiments (Alfalfa silage)

Characteristics	Dalmand Mg. Rt., Középhídvég Alfalfa+10%+5 g/t (1)	BOS-FRUCHT, Kazsok Alfalfa + 5 g/t (2)
Dry-matter content (%)	43.8 (33.9-48.8)	40.8 (35.0-45.0)
Average lenght of the chopping (mm)	55-63	34
Mass of one bag (t)	144 (130-162)	161 (150-170)
Volume mass (kg/m^3)	560 (521-584)	596 (555-628)
Bagged mass (t)	2140	3048
Working hours (h)	300	224
Average filling output (t/h)	7.3 (5.8-10.2)	13.6 (10.8-14.8)
Specific energy consumption of the filling (kWh/t)	2.40	2.72

Notice: (1) 10 % of wet corn grits + 5 g/t additives
(2) 5 g/t additives

Table 2.
The most important results of the technical and technological experiments
(Crushings of whole corn plant and corn grits)

Characteristics	DALMAND Mg. Rt., Középhídvég Crushing of whole corn plant	Pankota Agrárszövetkezet, Kistőke Crushing of wet corn grits
Moisture content (%)	64-66	25.2-31.5
Average length of the choppings/grits (mm)	27.0	1.03-1.12
Mass of one bag (t)	175 (165-185)	212 (198-216)
Volume mass (kg/m^3)	681	795
Bagged mass (t)	350	3197
Working hours (h)	42	297
Average filling output (t/h)	8.3	10.8
Specific energy consumption of the filling (kWh/t)	2.3	11.3

Table 3.
Fermentation quality of the fermented alfalfa silage

Number of Handling	Number of days								
	20.	120.	270.	20.	120.	270.	20.	120.	270.
	pH			Lactic acid (%)			Acetic acid (%)		
1.	4.20	4.38	4.51	2.06	2.72	2.28	0.53	0.61	0.82
2.	4.05	4.36	4.36	2.25	2.83	2.56	0.52	0.68	0.69
3.	3.97	4.30	4.07	2.47	3.26	3.05	0.51	0.52	0.53
4.	4.50	4.86	4.90	1.63	2.53	2.30	0.63	0.44	0.47
	Propionic acid (%)			n-Butyric acid (%)			NH_3 mg/100 g		
1.	-	-	-	-	-	0.01	51.11	117.88	115.80
2.	-	-	0.01	-	-	-	58.63	102.89	118.70
3.	-	-	-	-	-	-	35.56	96.79	90.80
4.	-	-	-	-	-	-	38.23	125.04	136.46

1st handling: withering of shorter length of time
2nd handling: withering of shorter duration completed with addition of 10% of corn grits an Pioner 1155 additive
3rd handling: withering of shorter duration completed with pre-hydrolised corn and Silaferm additive
4th handling: withering of longer length of time

Table 4.
Fermentation quality of the corn crushing

Parameters		Days of fermentation	
		20.	120.
DM content	(%)	66.03	65.75
pH	(%)	3.87	4.06
Lactic acid	(%)	0.69	1.39
Acetic acid	(%)	0.19	0.20
Alcohol	(%)	0.32	0.71
NH_3	(mg/100 g)	19.99	21.33

Table 5.
Digestibility of the nutrient content of the alfalfa silage and the corn crushings

Silage	Digestibility coefficient (%)			
	Raw protein	Raw fat	Raw fibre	N-free extract
Alfalfa silage *				
1st handling	71.4	49.8	39.9	76.8
2nd handling	71.7	59.2	38.1	83.3
Corn silage **	76.6	76.9	54.2	92.9

* Feeding by sheep
** Feeding by pigs

INDUSTRIAL DEVICE FOR STIMULATING SEEDS

P. Szendrő - J. Koltay - Gy. Vincze - A. Szász - K. Hentz
University of Agricultural Sciences, Gödöllő

Abstract

The study describes the industrial version of the so-called vectorpotential device, constructed in the frame of the research projects OTKA T-017717, OMFB 96-97-44-1054 and the OTKA TO 30764. It discusses the effect mechanism, which results the raise of germination capacity and germination rate in several seeds. It introduces the functional parts of the prototype device. The final part of the study contains the results of a small plot research.

1. Introduction

In our work the seeds have been exposed to the effect of an electro-magnetic field. In the following it is examined how to involve the effect of the electromagnetic field to the physical description. According to the present state of knowledge the quantum mechanics is capable of describing the processes in the biological systems. Thus, if the H Hamilton function of the system is known, the **H** Hamilton operator of the system can be produced by substituting the physical quantities with operators, after which the equation of motion of the system is the following Neumann equation:

$$\frac{\partial \mathbf{S}}{\partial t} = -\frac{j}{\hbar}[\mathbf{H},\mathbf{S}] \cdot \tag{1}$$

The electromagnetic field can be described by two electric $(\mathbf{E},\mathbf{D})$ and two magnetic state variables $(\mathbf{H},\mathbf{B})$. The sources of the field of force $(\rho,\mathbf{j},\mathbf{P},\mathbf{M})$ is held by the material, which in our case is the primary field generating coil. The sources generate the electromagnetic field according to the following field equations (2):

$$\begin{aligned} &\nabla\times\mathbf{H} = \mathbf{j} + \frac{\partial \mathbf{D}}{\partial t}, \quad \nabla\times\mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}, \\ &\nabla\cdot\mathbf{D} = \rho, \quad \nabla\cdot\mathbf{B} = 0, \\ &\mathbf{D} = \varepsilon_0\mathbf{E} + \mathbf{P}, \quad \mathbf{B} = \mu_0\mathbf{H} + \mathbf{M} \end{aligned} \tag{2}$$

Let us introduce the effective charge and current-density by the

$\rho_{ee} = \rho - \nabla\cdot\mathbf{P}$ and the $\mathbf{j}_{eff} = \mu_0\mathbf{j} + \frac{\partial \mathbf{P}}{\partial t} + \nabla\times\mathbf{M}$

definitions. By this, after introducing the

$$\mathbf{B} = \nabla\times\mathbf{A}, \quad \mathbf{E} = -\nabla\varphi - \frac{\partial \mathbf{A}}{\partial t} \tag{3}$$

vector and scalar potential, the Maxwell equations build their most simple form:

$$\nabla^2\mathbf{A} - \varepsilon_0\mu_0\frac{\partial \mathbf{A}}{\partial t} = -\mathbf{j}_{eff}, \quad \nabla^2\varphi - \varepsilon_0\mu_0\frac{\partial \varphi}{\partial t} = -\frac{\rho_{eff}}{\varepsilon_0}. \tag{4}$$

Let H_0 the Hamilton equation of the system and let $\mathbf{A}$ the solution of the above Maxwell equations. Then the Hamilton equation of the system exposed to the effect of an electro-magnetic field is:

$$H = H_0 - \mathbf{j}_{eff}\cdot\mathbf{A} - \rho_{eff}\varphi, \tag{5}$$

where

$$\rho_{eff}(\mathbf{r}) = \sum_i Z_i e\,\delta(\mathbf{r}-\mathbf{r}_i) - \nabla\cdot\sum_j\left[\mathbf{P}_j\delta(\mathbf{r}-\mathbf{r}_{ji})\right] \tag{6}$$

and

$$\mathbf{j}(\mathbf{r})_{eff} = \sum_k Z_k\mathbf{v}_k e\,\delta(\mathbf{r}-\mathbf{r}_k) + \frac{\partial\sum_j\left[\mathbf{P}_j\delta(\mathbf{r}-\mathbf{r}_{ji})\right]}{\partial t} + \nabla\times\sum_j\left[\mathbf{s}_j\delta(\mathbf{r}-\mathbf{r}_{ji})\right] \cdot \tag{7}$$

Here $\mathbf{P}_j$ is the dipolmomentum of the i[th] particle of the biological system, $\mathbf{s}_i$ its spin Z_i its ionization grade, $\mathbf{v}_k$ its velocity, while e is the charge of the electron and δ is the Dirac delta- distribution. The relationship between the velocity and the momentum is:

$$p_i = m_i\mathbf{v}_i + \sqrt{\varepsilon_0\mu_0}Z_i e\mathbf{A} \cdot \tag{8}$$

Completing the $\mathbf{p}\to\frac{\hbar}{j}\nabla,\ \mathbf{r}\to\mathbf{r}$ substitution in the Hamilton function, the Hamilton operator and by this the Neumann equation (1) is produced. The two equations according to (5), which contains the average value of the current and the charge density also add to this:

$$\langle\mathbf{j}_{eff}\rangle = Tr[\mathbf{jS}],\ \langle\rho_{eff}\rangle = Tr[\rho\mathbf{S}] \cdot \tag{9}$$

The equations describe the modifications of biological systems exposed to electromagnetic stimulation. Unfortunately, the equations can not be solved. In spite of this, some conclusions of great importance can be drawn. At first, biological systems are influenced not by direct field characteristics but potentials. According to the experiments the effect of the electrical stimulation is permanent. It follows, that the inner structure of the system is modified by the potentials. According to the cytological examinations there is no alteration in the chromosomes either in the proteins of the cells. Obviously it is the further structuring the already structured water, contained in great proportions by living materials.

2. The model of the germination of a seed

The effect of the electromagnetic treatment on the germination will be demonstrated on a simple chemical model. It is known, that the basic metabolic processes are catalyzed by enzymes. The chemical reaction takes place in thin water solution. The substrate molecule (protein) and the enzyme (protein giant molecule) participate in the reaction. The chemical reaction takes place in a relatively small part of the enzyme, which is called active region. The chemical activity is of „delayed effect" quality, since the presence of the water solution, which covers the surface of the enzyme with a water layer as this as a couple of molecules. If the structure of this water layer is quasy-cristallic, it improves the work of the enzyme since its better electrical features. The reaction consists of the following steps. Complex formation from the S substrate and the E enzyme molecule

$$\mathbf{S} + \mathbf{E} \leftrightarrow \mathbf{SE}, \tag{10}$$

decomposition to the F reaction product and the enzyme

$$\mathbf{SE} \leftrightarrow \mathbf{F} + \mathbf{E}, \tag{11}$$

finally, the SE complex can react with the end-product of the reaction according to the

$$\mathbf{SE + F \leftrightarrow 2F + E} \tag{12}$$

equation provided, that SE can sustain long enough. The kinetic equation of the reaction is

$$\frac{d[F]}{dt} = k([A]_0 - [F])([F]_0 + [F]) \cdot \tag{13}$$

The equation can not be compared with the experiments, since in vivo measurement of the seed interior is impossible. Therefore the constants of the equation are determined from the germination experiments. We suppose, that the value of the concentration $[F]$ is identical with the number of the germinated seeds N divided by the number of all the seeds taking part in the germinating N_{tot}. If so, the above equation can be formed as

$$\frac{d\frac{N}{N_{tot}}}{dt} = k\left([S]_0 - \frac{N}{N_{tot}}\right)\left([F]_0 + \frac{N}{N_{tot}}\right) \cdot \tag{14}$$

According to the experiments the examined equation models well the germinating process. The number of the germinated seeds after a fairly long period can be calculated from the

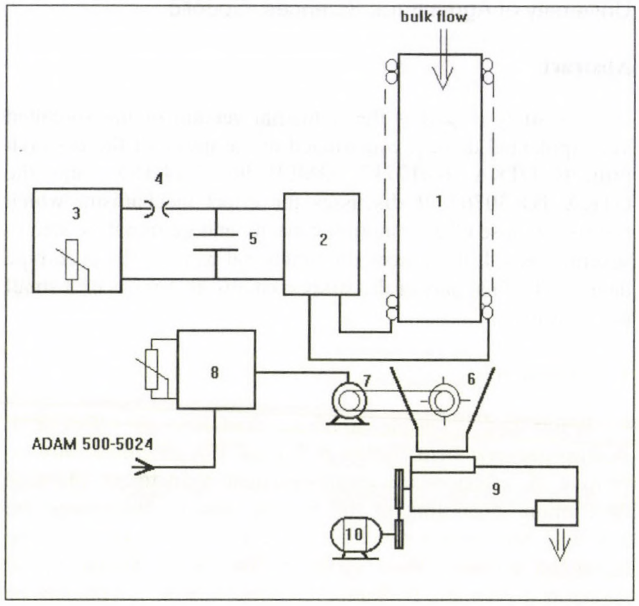
$$N_\infty = N_{tot}[S]_0 \cdot \tag{15}$$

equation, in other words the germination capacity depends on the commencing concentration of substrate reactive molecules. Reactive means, it possesses sufficient energy and it is covered by an organized water layer, which can be penetrated with a little weakening by the electrical field of the active range of the enzyme. Thus the germination capacity can be related with the commencing number of the reactive substrate molecules. It follows, that the germination capacity can be modificated by structuring the water. The germination rate according to the equation (14) is related with the sum of $[S]_0 + [F]_0$, from which it derives that the structure of the interior water of the seeds has a stimulating effect on the germination rate as well.

3. The manipulating device

The material to be manipulated is fed in an adjustable rate to the manipulating coil **1** by the cell feeder **6** fitted with a governed speed drive **7-8**. The coil and the condenser **5** forms an electrical oscillating circuit. The oscillating circuit is supplied by the high voltage supply unit **3** constructed with an adjustable source voltage and impulse frequency. After switching the supply unit on, it generates a periodic impulse-shaped voltage signal, which charges the condenser with a time constant determined by the internal resistance and the capacity of the condenser. Hereby the voltage of the condenser grows. As the voltage reaches the onset voltage of the spark gap **4**, the circuit closes through the spark gap and a high frequency oscillation will be generated in the developing oscillating circuit. The dissipated energy is high since the high frequency oscillation, thus the oscillation damps rapidly. In this way an energizing forms in the coil consisting of oscillation packages with a period defined by the supply unit. The mode selector switch **2** is for setting the connection of the coil to either parallel or bifilar.

The block diagram of the manipulating device is shown in Fig. 1.



1 - manipulating coil, 2 - mode selector switch box, 3 - high voltage supply unit, 4 - electrical spark gap, 5 - condenser, 6 - cell feeder, 7 - PM motor, 8 - electronic drive regulation, 9 - auger, 10 -driving motor

Fig. 1. The electrical layout of the manipulating device

4. Results

Some of our small plot experiment results are shown below:

- Onion seeds reached their peak germination capacity after a 15s long manipulation: it raised from 77% to 86%.
- In case of calabash seeds a 15s long manipulation brought the best result as well. Here the raise of germination capacity was 6.8%.
- Germination capacity of barley seeds showed a 9% improvement after a 20s manipulation.
- Germination capacity of carrot seeds grew from 6% to 11%. Manipulation time was 15s.
- Compared to the 25.67% level of the control group the germination capacity of safflower reached 68.33% after 5s manipulation, while 67% after 10s and 67.33% after 15s.
- The germination capacity of oil radish increased to 97.5% after 15s manipulation and 96% after 20s, while that of the control group was 93%.
- In case of wheat seeds the germination capacity of the control group was 80%. After a 30s long manipulation in parallel solenoid the germination capacity grew to 96% while a bifilar manipulation of the same length brought a raise to 93%.
- Germination capacity of barley seeds in the control group was 75%. After a 30s long manipulation in parallel solenoid the germination capacity grew to 93% while a bifilar manipulation of the same length brought a raise to 95%.
- Germination capacity increase could also be pointed out in Sudan grass after a 15 sec long manipulation which caused a raise from 85% to 93%.

According to partly our own experiments, partly literature data it should be added however that it is far not sure that the effect of favorable stimulation is expressed already in the course of germination. In majority of the cases it is revealed in the strengthening of resistance and the improvement of vitality.

PIG FATTENING ON STRAWED SLOPING FLOOR IN HUNGARY ON THE BASIS OF GERMAN EXPERIENCES

L. Mátyás - Dr. L. Fenyvesi
Hungarian Institute of Agricultural Engineering
H. Sonnenberg, FAL, Braunschweig
E. Tugyi, Újlengyel
J. Preiner
Lajta-Hanság Joint-Stock Co. (Rt)

Summary

Littering makes better the comfort feeling of pigs, the production results and at the same time considerably decreases the amount of the environmental loading of the slurry. Man power demand of litter housing can be considerably decreased by the so called small littering sloping floor system that has been developed in the German co-institutes. Spreading of straw litter is done by pigs themselves while the manure is delivered on the floor with 5-7 % slope without man power intervention towards the opposite side of the front wall of pens. Domestic adaptation of the system has been realized on a middle-scale private pig farm. Litter demand hardly reached the 0.3 kg amount per day for one fattening place. The average daily gain was 670 g while the feed conversion was below 2.8 kg/kg. Manpower demand, as for bedding and manuring out, was negligible just as the unpleasant smell effect. Favourable experiences of on another large-scale pig farm with 1,300 sows could open new vistas for large-scale pig husbandry too.

1. Introduction

Most of the Hungary's large-scale pig farms were built in the 70-s and 80-s. Lot of them have not possibilities for reconstruction. Housing system of these pig stalls is litterless, manure removal takes places by hydraulically. Volume of slurry produced is multiplied as it is required. DM content of the slurry is very low, hardly reaches the value of 2.5-3.5%. The slurry system is considerable source of the environmental pollution.

The Institute of FAL-Braunschweig and the University of Göttingen have elaborated a new housing system using slope floor and small amount of straw litter. This new housing system makes better the comfort of pigs and at the same time requires small man power demand and decreases the load of the environment alike.

2. Home adaptation

The experimental fattening pens were constructed and built on the basis of the German experiences taking into consideration of the Hungarian conditions.

The litter and labour saving pig fattening experiments were started at a private pig farm of Mr. E. Tugyi, Újlengyel village, in the second half of August 1997. The owner has 60 ha of arable land. On the 50 % of it he produces cereals (triticale) on 30% maize and on 12 % of it sunflower seeds.

Cereals are used for feeding fattening pigs. Weaning of the pigs take place after about 56 days at 15 kg live weight. Fattening lasts about 5 months. Fattenings at about 110 kg l.w. are slaughtered on a private slaughterhouse. Number of fattenings per year are about 500-550 heads.

In the same house there are two experimental pens with 15 places in each and one control pen with 30 places. Fattenings in the experimental pens are feeded from four combined self-feeders, while the stock of the control pen from traditional ones.

The experimental stall has openings along the wall, the fattening pigs push the solid manure directly outside the stall and is falling down to a longitudinal subsurface storage. In this way the dosage, move, spread and removal of the bedding – manure mixture (solid farmyard manure) is made by the animals, without any man power demand.

The capacity of the storage is about 1 m^3/animal. It means, that the transport of the farmyard manure is needed only once in a month.

Construction of the experimental pens is shown on Fig.1.

3. Main technical paramteres of the experimental pens

Number of pens	2
Places per pen	15
Specific place per fattening	0.93 m^2
Number of self-feeders per pen	2

4. Experimental results

Experimental fattening took place between the second half of 1997 and January 1998.

Average starting weight	13.3 kg/pig
finishing weight	106.3 kg/pig
Duration of fattening	139 days
Average daily gain	669 g
Feed conversion rate:	2.77 kg/kg
Meat quality:	E class
Specific straw consumption:	0.3 kg/place/day
Amount of manure with litter:	15.5 t

5. Example of a large-scale pig farm

The Lohman-Bábolna type pig farm with 1.300 sows of the Lajta-Hanság Rt. (joint-stock company) has been running for about 30 years. Slurry production was about 350 m^3 per day. In the former litterless system with liquid feeding fattening reach the 91 kg live weight by 237 life-day. Following the reconstruction of the first fattenings house with 468 places the experimental stock reach the weight of 102 kg per head by 204 life-days.

The previous feed conversion rate was 4 kg/kg while in the new technology it reduced to 3.3 kg/kg. Results speak for themselves.

Construction of the re-build fattening house is shown on Fig. 2.

References

[1] HESSE, D.: Straw in fattening pig husbandry. Workshop on „Deep litter systems for pig farming" Rosmalen, The Netherlands, 21 and 22 September 1992.

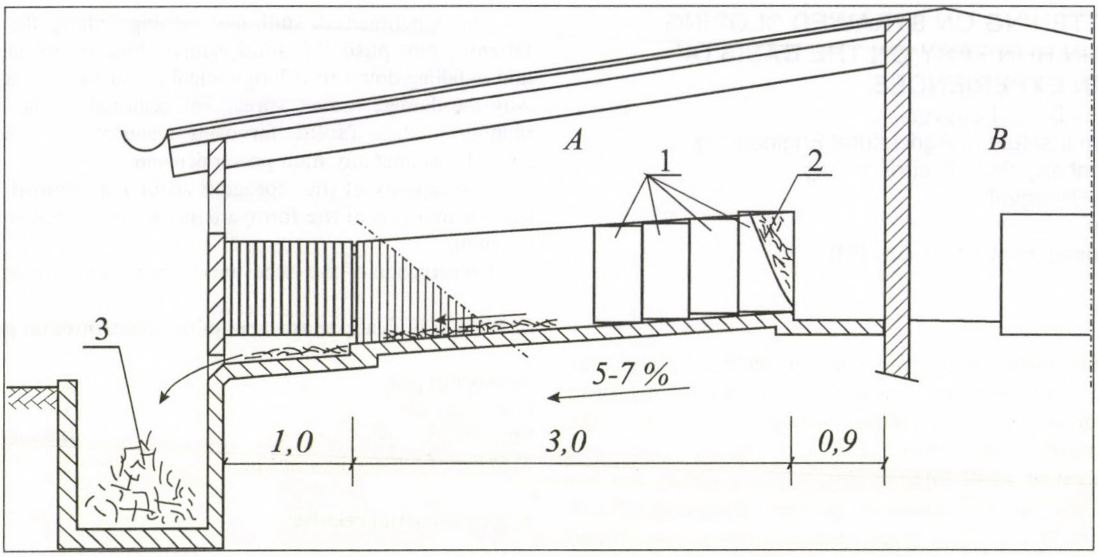
[2] KÜCHENHOFF, R. - HÖRÜGEL, K.: Haltung von Mastschweinen auf Schrägmist. Bau und Technik in der Landwirtschaftlichen Neutztierhaltung 2. Internationalen Tagung vom 14. und 15. März 1995, Potsdam

[3] HESSE, D. - JACKISCH, T. - VAN DEN WEGLIE, H.: Aspekte zur artgerechten und umweltverträglichen Mastschweinehaltung, unter Beachtung der Wirtschaftlichkeit. Bau und Technik in der Landwirtschaftlichen Neutztierhaltung 2. Internationalen Tagung vom 14. und 15. März 1995, Potsdam

[4] GY. MÉSZÁROS - L. FENYVESI - L. MÁTYÁS: Moderation of the environmental pollution of pig husbandry. AgEng '96 Int. Conf. On Agric. Eng., Madrid, 23-26 September 1996 Proceedings, pp 778-779

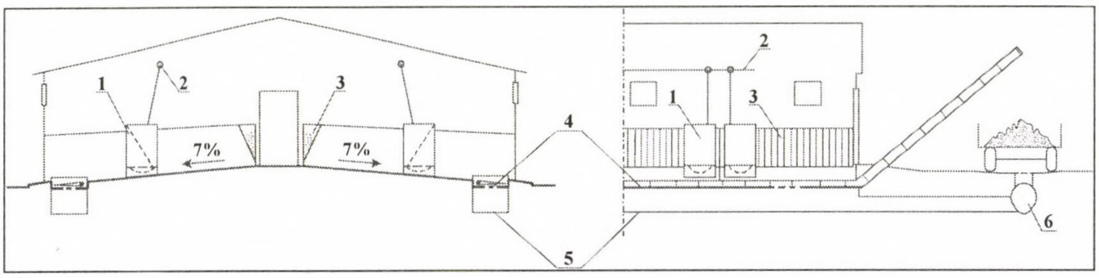
[5] MÁTYÁS L.: Munkaerő- és alomtakarékosan. Magyar Mezőgazdaság, 1998. 53. évf. 24. sz.; p 17

[6] MÁTYÁS L. - FENYVESI L.: Hígtrágya: gondok és lehetőségek. A sertés. 1998. III. évf. 3.sz. pp 10-18



A: Experimental pens; B: Control pens
1.) Combined self-feeders; 2.) Straw grid; 3.) Manure collecting pit

Fig. 1. Construction of the experimental pens of sloping floor with straw bedding



***1.)** Combined self-feeders; **2.)** Feeding line; **3.)** Straw grid;*
***4.)** Reconstructed slurry gutter with mechanical manure removal system;*
***5.)** Former slurry gutter; **6.)** Collecting channel*

Fig. 2. Litter housing system with slope floor Reconstruction of the fattenings on a large-scale pig farm

A COMPUTER AIDED FREQUENCY ANALYSIS OF A WIND TURBINE

G. Horváth Ph.D. student
Prof. Dr. L. Tóth D.Sc. of the Hungarian Academy of Sciences
G. Tóth Ph.D. student
University of Agricultural Sciences, Gödöllő

1. Abstract

The work presents a methodology developed for the structural and dynamic analysis of wind turbine blade and tower. The methodology is based on a numerical algorithm. An on site wind measurement data have been used as inlet boundary condition for a dynamic system analysis. A numerical computation and visualization software has been used for describing the structure's vibrations. The blade's natural frequencies and stress distribution were obtained from a finite element modeler. To convert the blade loads to material strain, results from a fluid flow analysis were assigned to the structural analysis creating a multiphysics application.

A basis for this algorithm is a comparison between different vibrations. A new method was developed for defining the critical frequencies. The continental wind conditions differ from the coastal area in the manner of dynamics. With computer-aided design methods the design procedures and design variables can be defined depending on the wind characteristics. As such the designer can select geometrical or operational characteristics. This model should give guidelines for wind turbine load measurement.

2. Introduction

The complex nature of fluids makes the analysis of a flow process also difficult and one needs some special methods to deal with that. Experimental measuring and order of magnitude analytical calculations are generally used but these can respectively be very expensive and approximate.

Due to the fact that the fundamental equations are solved in every part of the geometry, CFD solutions can pick up fluid flow trends which might not have been expected or predicted otherwise. The results of a simulation contain all the relevant flow variables such as velocities, pressures, densities.

The phenomenon in which the oscillation amplitude increases as excitation force frequency approaches to the natural frequency is called resonance, it refers to any system that admit oscillations and vibrations. In mechanical systems such vibrations can result in deformation and destruction of the equipment The primary objective has been to determine how the wind influences the vibrations in the wind turbine.

3. Method

The work presents a methodology developed for the structural and dynamic analysis of wind turbine blade and tower. The methodology is based on a numerical algorithm see Fig. 1.

An on site wind measurement data have been used as inlet boundary condition for dynamic system analysis. Fluid flow processor is the Computational Fluid Dynamics part. CFD is about computer solutions of the equations of fluid dynamics. By using CFD fluid flow process can be simulated and visually represented (see Fig. 2) on computer screen.

The simulation process is done mathematically by discretizing the flow equations and then solving them on a fine grid which covers the flow domain. Fig 3 shows the fluid flow-structural analysis.

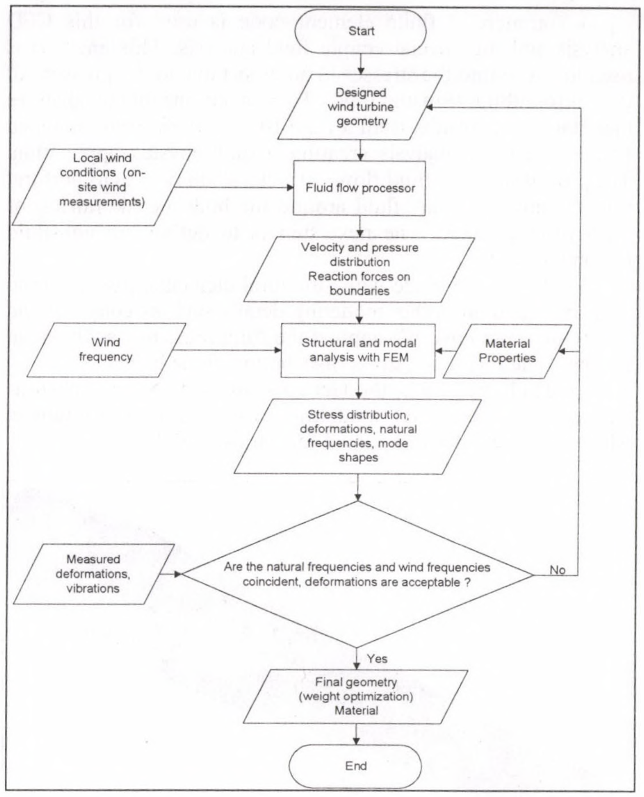


Fig. 1. Algorithm for wind turbine analysis

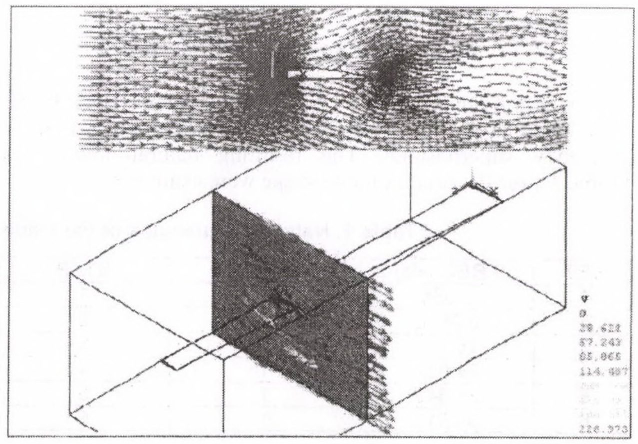


Fig. 2. 2D and 3D FE airflow around the blade with 5658 and 25814 elements generated

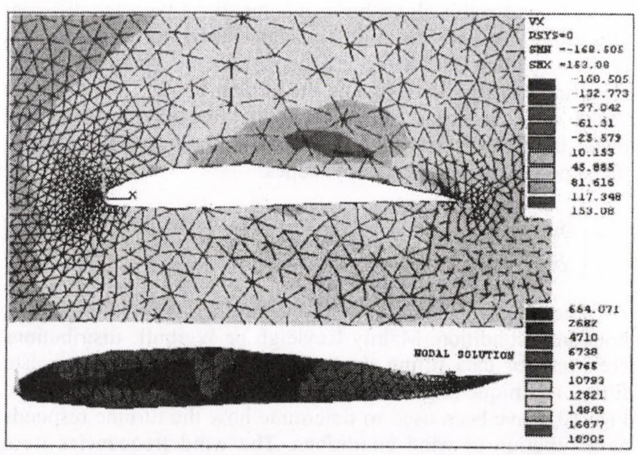


Fig. 3 Fluid-flow structural analysis

A commercial finite element code is used for this CFD analysis and the special couple field analysis. This analysis is used to determine the stresses in an object due to the pressure of the surrounding flowing fluid. To convert the blade loads to material strain, results from a fluid flow analysis were assigned to the structural analysis creating a multiphysics application. The procedure for a fluid flow - structural analysis is to perform a CFD analysis in the fluid around the body i.e. the airfoil or wind turbine blade. The next step is to define the non-fluid region elements.

We define the blade with structural elements, give material properties and any other modeling details such as coupling and constraint equations. We applied the fluid pressures as the main loading. The result is a stress distribution in the blade.

For blade modeling the German GROWIAN was taken as an example. The CAD modeling was done in Pro/Engineer which was specially formulated for multi-point design.

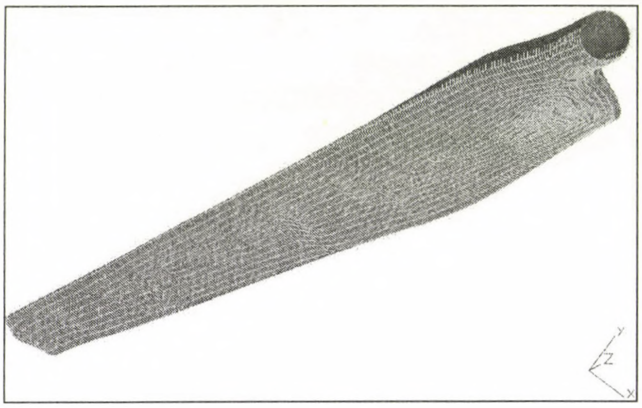


Fig. 4. Blade finite element model

Natural frequencies and mode shapes calculated with FE model (Fig. 4) are used in the Matlab algorithm (see Fig. 9) for frequency superposition. The resulting natural frequencies (Table 1.) for the first six mode shape were examined.

Table 1. Natural frequencies of the blade

SET	FREQ (Hz)	LOAD	STEP
1	3.565	1	1
2	6.2986	1	2
3	15.244	1	3
4	24.017	1	4
5	28.849	1	5
6	34.011	1	6

The first is an edgewise (Fig. 5), the second is the flapwise (Fig. 6) mode shape. The vibration occurs (Fig. 7) at a critical cross section.

A basis for this algorithm is a comparison between different vibrations. A new method was developed for defining the critical frequencies. This technique permits the synthesis of very long time series and designate the critical points. The theory is based on a superposition of changing frequencies, wind and blade frequencies in our case. The approximate solution lies in the superposition of frequency slopes.

$$y = \left(\frac{\delta x_1}{\delta t} + \frac{\delta x_2}{\delta t} \right)^{\kappa} \quad (1)$$

The data from on site wind measurements were taken as a boundary condition. Mainly Rayleigh or Weibull distributions are used for data fitting. In our case there have been no data fitting technique implemented. The wind measurement data (see Fig. 10) have been used to determine how the turbine responds as a function of wind conditions. The wind frequencies were determined with Fourier transform. We can check the FEM geometry with ambient wind frequencies.

The Fourier transform is based on the discovery that it is possible to take any periodic function of time x(t) and resolve it into an equivalent infinite summation of sine waves and cosine waves with frequencies that start at 0 and increase in integer multiples of a base frequency $f_0 = 1/T$, where T is the period of x(t), with the expression of:

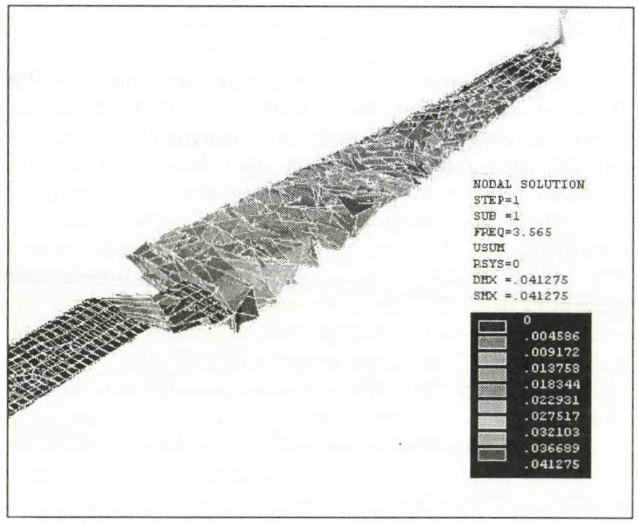


Fig. 5. Edgewise mode shape is the 1st

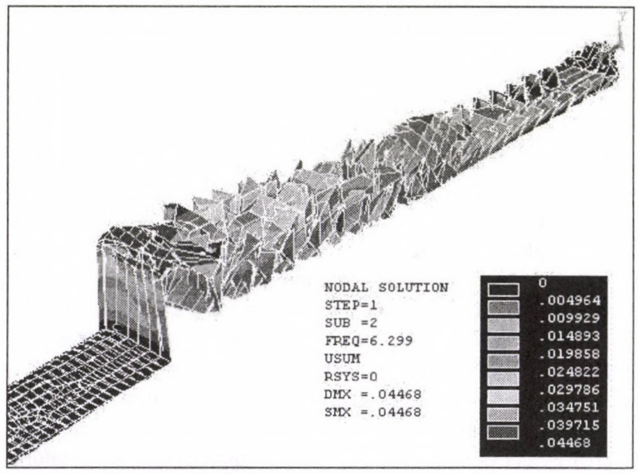


Fig. 6. Flapwise mode shape is the 2nd

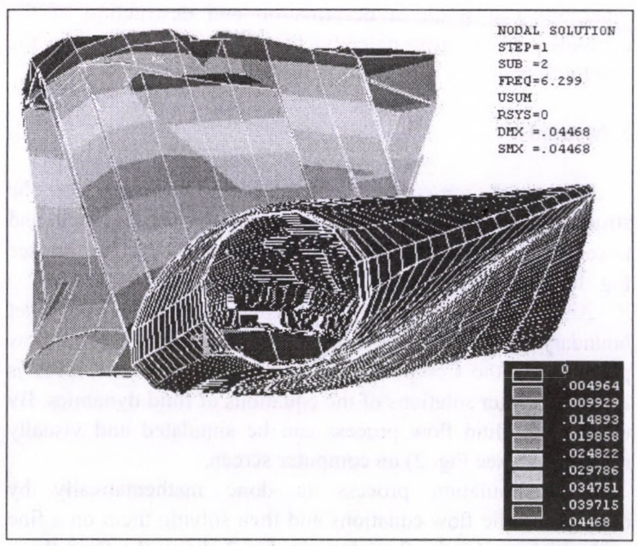


Fig. 7. A critical cross section at 2nd mode shape

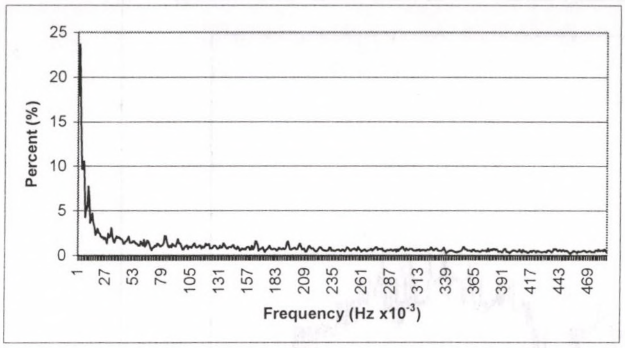


Fig. 8. Wind Frequency

$$x(t) = a_0 + \sum_{k=1}^{\infty}(a_k \cos(2\pi k f_0 t) + b_k \sin(2\pi k f_0 t)) \qquad (2)$$

The load frequency is always changing in the natural circumstances. The distribution of load amplitudes can be a basis for fatigue life estimation. The overall result reflects the wind condition at a given site. It could be applied to any site for which it might be intended. It is easy to see (on Figure 11. to Figure 13.) the difference between the classical frequency superposition Scope C, F and the new method Scope B, E. Scope A and D represents blade and tower deflection influencing each other. With this method more frequencies could be added to each other at the same time. The service lifetimes could be predicted more accurately this way.

4. Conclusions

Experimental and computational techniques have been used in an algorithm for describing the aerodynamic and structural study of a wind turbine. The conclusions are summarized as follows:

1. An on site wind measurement data have been used as inlet boundary condition for dynamic system analysis.
2. Natural frequencies and deflection were obtained from a finite element modeler.
3. The method of analytic frequency data superposition for determining the stress amplitudes could be a basis for lifetime estimation.
4. With computer-aided design methods the design procedures and design variables can be defined depending on the on site wind characteristics.
5. The whole model is highly dependent on material properties.
6. This model should give guidelines for wind turbine load measurement.

5. References

[1] DÖRNER, H.: Freifahrende Turbinen Windenergie. Fakultat Luft und Raumfahrttechnik, Universitat Stuttgart, 1997.

[2] GOURIERES, D. LE.: Wind power plants. Oxford: Pergamon Press.1982. pp.76-77.

[3] HABALI S. M. - SALEH I. A.: Design and testing of small mixed airfoil wind turbine blades. Pergamon Press: Renewable Energy, Vol. 6., No 2., 1995.

[4] LANDAU, L. D. - LIFSIC, E. M.: Theoretical physics – Hydrodynamics, Budapest: Coursebook Press. 1980. pp.32-38.

[5] HORVATH, G. - TOTH, L.: A numerical algorithm for wind turbine design employing finite element analysis. Paper presented at the Second International Ph.D. Conference, Miskolc, 1999.

[6] PRETLOVE, A. J. - MAYER, R.: Rotor size and mass - the dilemma for designers of wind turbine generating systems. Wind Engineering, Vol. 18 No.6, pp.317-329.

[7] SUTHERLAND, H. J. - KELLEY N. D.: Fatigue damage estimate comparisons for northern European and U.S. wind farm loading environments. Proceedings of WindPower 95, AWAE, Washington, D.C., 1995.

[8] TOTH, L. - HORVATH, G. - TOTH, G.: The use of wind energy in Hungary. Hungarian Agricultural Engineering, 1998/11.

[9] VEERS, P. S. - WINTERSTEIN, S. R.: Application of measured loads to wind turbine fatigue and reliability analysis. ASME Wind Energy Symposium, Reno, Nevada, January 6-9 1997.

[10] VEERS, P. S. - LAIRD D. L. - CARNE T. G. - SAGARTZ M. J.: Estimation of uncertain material parameters using modal test data. American Institute of Aeronautics and Astronautics, 1998.

[11] ZELDOVICH, Y. B. - YAGLOM I. M.: Higher Math for beginners. Mir Publishers, Moscow, 1987.

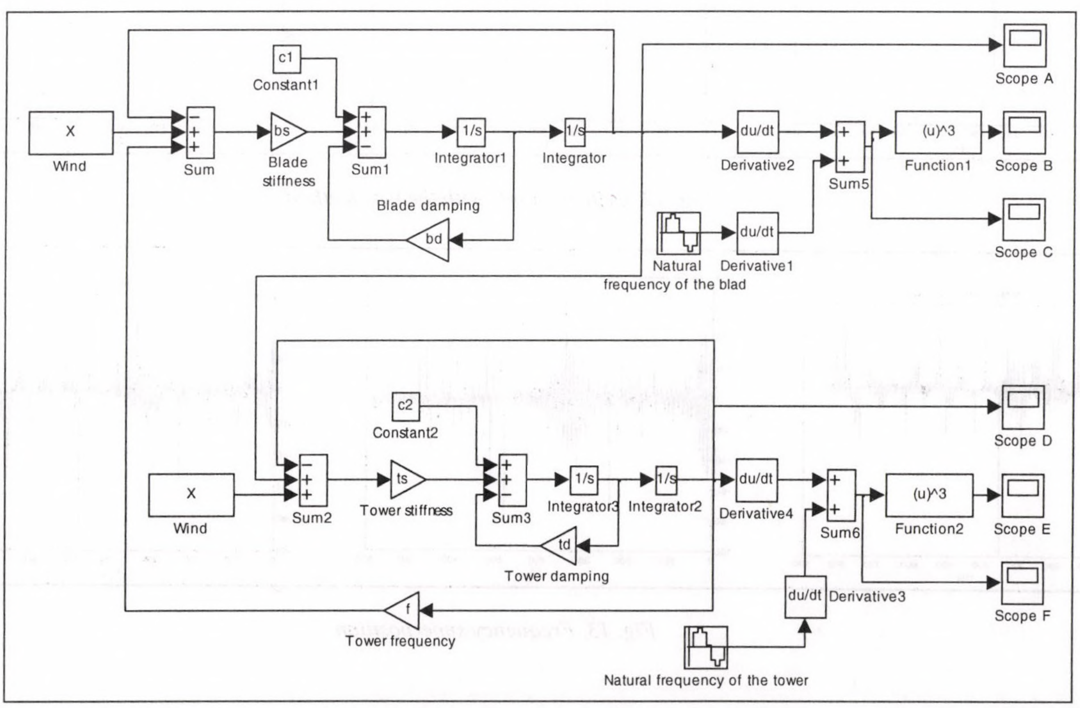


Fig. 9. Wind turbine model for frequency superposition

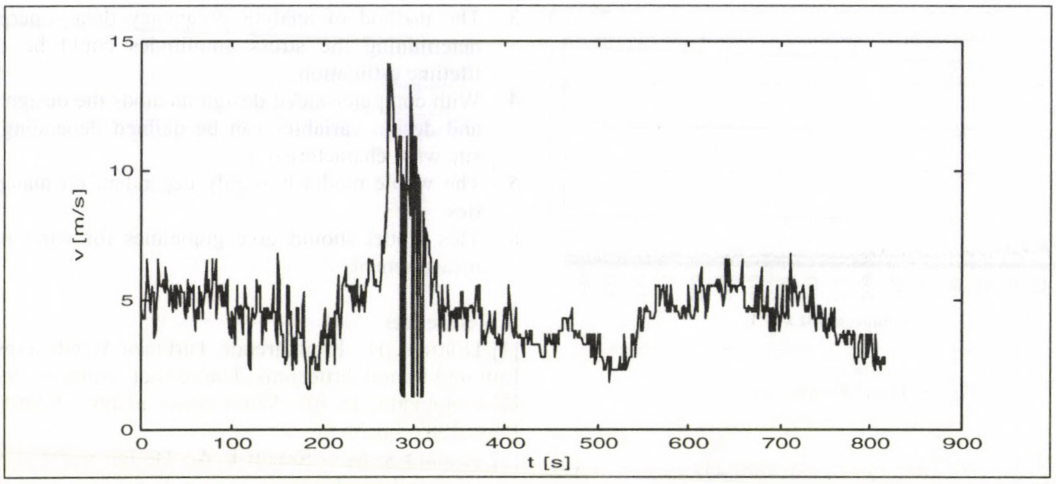


Fig. 10. Wind speed data

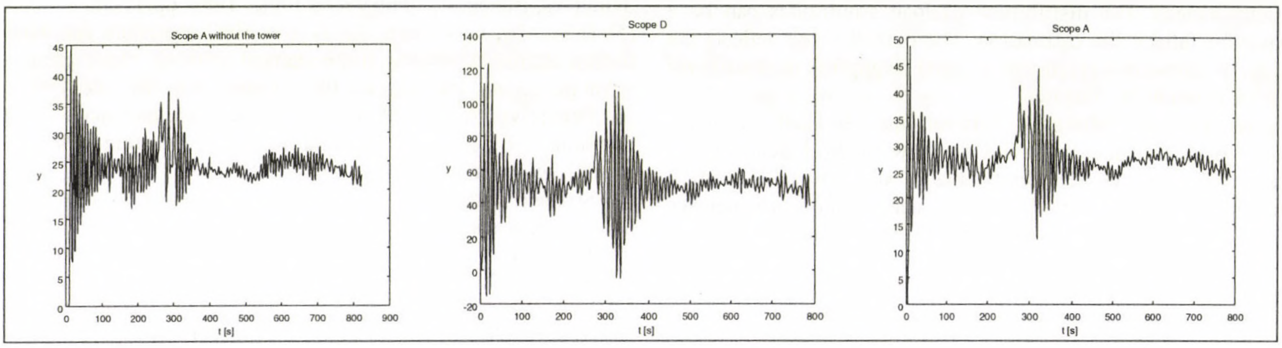


Fig. 11. Blade and tower deflection

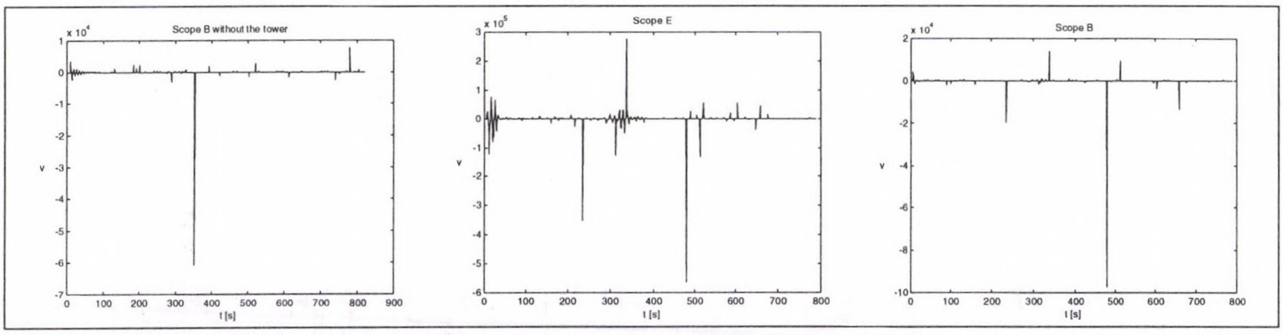


Fig. 12. Critical points with the new method

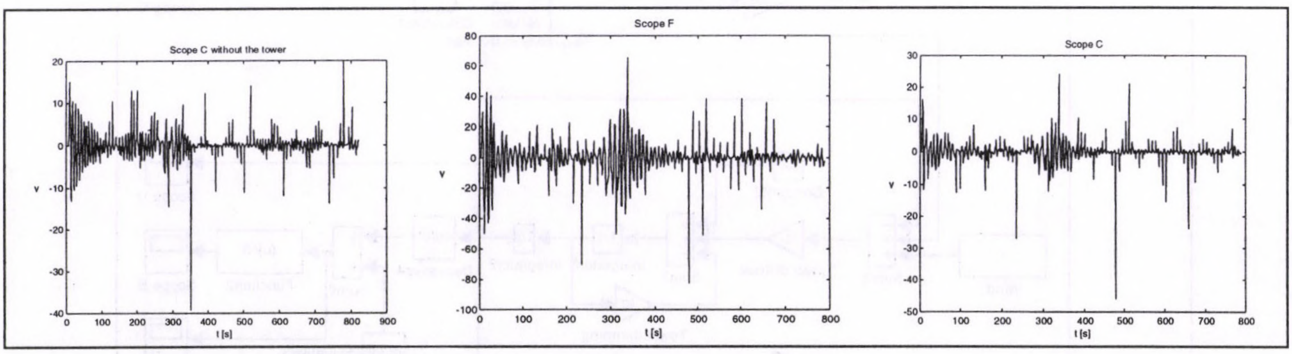


Fig. 13. Frequency superposition

DISK TILLAGE - THE DISK TILLAGE EFFECTS ON THE PHYSICAL CONDITION OF SOILS

M. Birkás
University of Agricultural Sciences, Gödöllő

Introduction

Effects of the typical operations of the disking, such as the mixing, the breaking and the loosening shallowly, on soil physical condition can be favourable vs unfavourable, depending on the soil moisture status.

During the past 100 years the disk and disk tillage as a result of the practicability has been become a tool and a process applied most often in stubble stripping and the chopping, and in primary and secondary tillage. Advantages of the disk tillage are well-known in practice much rather than disadvantages of its application (such as a diskpan compaction at a depth of the disking on wet soils, clod formation on dry soils or the dust formation during the repeated secondary operations).

The qualification of physical condition of soils started 23 years ago and the long-term trials comparing the disking with other tillage operations has been carried out since 1977 at the Department of Soil Management. The examination periods are followed the development of mechanization and soil tillage in Hungarian agriculture. The first (1976-1987) can be qualified the developing period, the second (1988-1990) as period of the changing, and the third (1991-1997) as the period of the adaptation to economic pressure. This paper calls attention to the practice presents the most important results of the disking effects on the soil physical condition.

Method of research

Researh was based on monitoring the tillage practice of 41 farms in 15 counties and 41 districts of Hungary. The qualification of soil condition min. to a depth of 70 cm cover 7,860 ha. Examinations were carried out in sugar beet, maize, winter wheat, sunflower, pea and barley fields. Soil condition was determined in the 0-70 cm layers by parallel methods: 1. Sampling from the vertical wall of soil pits according to Niekrashoff. 2. Lifting and weighing of monolits in tillage depth. 3. Measuring the soil strength with penetrometer, such as Tanakajd and Irwine-types, and a PENETRONIK-type from 1995 [1]. Purposes of the recent paper are as follows: 1. Results of diskpan compaction expansion on arable soils. 2. Summarizing the practical advantages and considerations of disking on the basis of monitoring and measuring.

Results

Diskpan compaction expansion

Seven types of compaction according to those location in soils were registered (Table 1). During the first period soils were well-loosened at least to a depth of 40 cm on 36% of examined area. This ratio was declined to 16% for the second, and to 7% for the third period, which refers to ommitting a deeper tillage for many years. Ratio of soils compacted at a depth of 26-32 cm – below the deep ploughing which was typically in Hungary – has not changed significantly during the periods, however the ratio of soils compacted at the depth of 22-26 cm has increased by 60% to the third period. An upward tendency was distincted on soils located compacted layer to a depth of 18-22 cm, that is below the depth of disking or any shallow tillage and a more frequent application of these procedures might be concluded. The occurrence of two or three compacted layers within the same soil profile indicates the expansion of compaction close to the surface in the second and in third period as well. These compaction types were determined in highest ratio on winter wheat fields where a diskpan compaction occurred 39% of examined fields in the third period.

Practical advantages and considerations of disking on the basis of monitoring and measuring

More advantages and less considerations of disk tillage are summarised in Table 2. One of the advantages of disk tillage is the applicability on dry soils. It is considerable that the dust formation can be shown an upward tendency use the disk for secondary tillage repeatly breaking the clods.

It also considerable that shallow disk tillage should be regarded as a yield-decreasing factor owing to generally compacted soils. In long-term trial the decrease in maize yield was 49% without fertilization and 42% in average of three fertilization levels. The yield of winter wheat was slighly decreased, such as 22% without fertilization and 16% at all fertilization levels. Because of the economical pressure, the shallow disk tillage use for primary tillage is generally preferred to deeper or soil condition improving operations in 1990s. It can be stated that the first important factor to use disk tillage for primary tillage is the lack of compaction below 16-20 cm depth, and the second to adapt to any given moisture conditions (no disking on wet soils).

Acknowledgements

This paper present results of research programs supported by OTKA-25.315, MKM-FKFK-B-20, FM-27.240/12/97, VETŐMAG 95 Ltd., and INCO COPERNICUS-PL971165

References

[1] Daróczi S. - Lelkes J. 1999. A szarvasi PENETRONIK talajvizsgáló nyomószonda alkalmazása. Gyakorlati Agrofórum, 10. 7. 16-18.

Table 1
Changing of the soil condition under arable crops during 3 examination periods in Hungary

Soil condition	Examination periods		
	1st	2nd	3rd
Well loosened to a depth of 60 cm	14	4	1
Well loosened to a depth of 40 cm	22	12	6
Compaction located at the depth of 28-32 cm	44	47	42
Compaction located at the depth of 22-26 cm	14	22	23
Compaction located at the depth of 18-22 cm	6	10	16
2 compacted layers located below 16 cm	0	3	7
3 compacted layers located below 16 cm	0	2	5
Examined area (ha)	2420	2860	2580

Table 2
Practical advantages and considerations of the disking

Advantages	Considerations
1. breaking the clods and mixing well, 2. less surface raising and less moisture loss, 3. applicability on dry soils, 4. suitability for more tillage works, 5. stubble stripping and chopping, 6. high speed and field capacity, 7. energy save tillage operation, 8. well-known (less training).	1. unsuitable for wet soils (puddling, smearing, compacting), 2. dust formation on extreme dry soils, 3. unsuitable for chopping if stubble residues were wet, 4. less efficiency for controlling the perenial weeds, 5. disk tillage is a ploughless method for primary tillage.

SOME DESIGN QUESTIONS OF VERTICAL SCREW CONVEYORS

Dr. J. Benkő
University of Agricultural Sciences, Gödöllő

The literature in this country deals with the vertical screw conveyors unduly little and they are rarely used materials conveying equipments in spite of their several advantages. Their application advantages are the economy, small space need horizontally and vertically, flexible unloading possibility (the chute can be connected at any height and angle to the housing wall circumference) as well as the light structure. A drawback can be mention that the operation of the equipment needs the presence of friction. Therefore it is not recommended for conveying highly abrasive materials.

This study deals with two important operation parameters of vertical screw conveyors: the critical angular velocity (rpm) and the convey rate including their determination. In the theoretical investigations the motion of a single grain is analysed. It can be made because different experiments proved that the application of mass point model results in negligible inaccuracies and the results can be generalised. It is especially worth to mention that the theoretical research verified the phenomenon that after a short acceleration period a steady-state material flow is evolved in the screw conveyor.

The equilibrium equations of the vertical screw conveyor for steady-state motion can be derived from the differential equation describing the actions in an arbitrary alignment screw conveyor of δ angle to the horizontal [1] by substituting $\delta=\pi/2$:

$$-g\sin\alpha-\mu_1\frac{|\mathbf{B}|}{m}+\mu_2\frac{|\mathbf{N}|}{m}\sin\beta=0, \qquad (1/a)$$

$$\frac{|\mathbf{N}|}{m}=r\omega_0^2-2r\omega_0\dot{\varphi}_r+r\dot{\varphi}_r^2, \qquad (1/b)$$

$$\frac{|\mathbf{B}|}{m}=g\cos\alpha+\mu_2\frac{|\mathbf{N}|}{m}\cos\beta, \qquad (1/c)$$

$$\sin\beta=\frac{\omega_0\cos^2\alpha-\dot{\varphi}_r}{\sqrt{\omega_0^2\cos^2\alpha-2\omega_0\dot{\varphi}_r\cos^2\alpha+\dot{\varphi}_r^2}}, \qquad (1/d)$$

$$\cos\beta=\frac{\omega_0\cos\alpha\sin\alpha}{\sqrt{\omega_0^2\cos^2\alpha-2\omega_0\dot{\varphi}_r\cos^2\alpha+\dot{\varphi}_r^2}}, \qquad (1/e)$$

where

- r convolution radius,
- m mass,
- β angle between the vector of absolute velocity and the binormal vector,
- $\dot{\varphi}_r$ angular velocity of relative motion,
- μ_1 friction coefficient between the mass point and the convolution surface,
- μ_2 friction coefficient between the mass point and the housing,
- $\mathbf{B}$ constraint force on the spiral curve,
- $\mathbf{N}$ constraint force on the housing wall,
- ω_0 angular velocity of the screw conveyor axis,
- g specific gravity.

It is noteworthy that the above system of equations is only formally different form those results published in papers [2], [3], [4], about conveying screw conveyors theory. In addition equations (1/*d*) and (1/e) are alternates rather than independent expressions.

Notations can be understood from the Fig. 1, where the line in angle α is the image of the evolved α angle helix in plane. $\mathbf{v}_k$ is the circumferential velocity ($|\mathbf{v}_k|=r\omega_0$) of the helix and $\dot{s}$ is the speed of the mass point relative to the helix ($\dot{s}=r\dot{\varphi}_r/\cos\alpha$), $\mathbf{v}$ is the absolute velocity of the mass point. $\mathbf{S}_1$ and $\mathbf{S}_2$ are the friction forces on the convolution surface and on the housing wall. $\mathbf{t}$ and $\mathbf{b}$ vectors are unit vectors of trihedral coordinate system of surface.

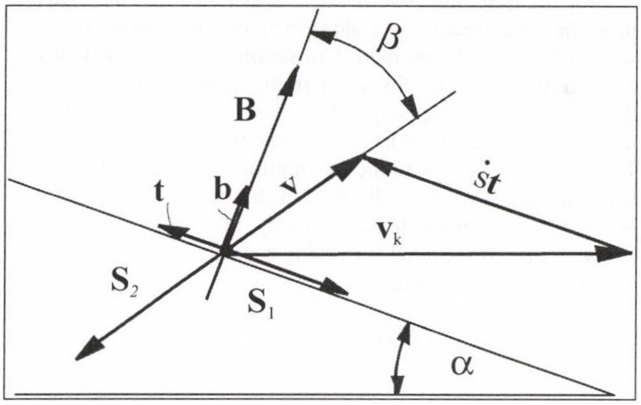


Fig. 1. velocity components of a mass point and the system of forces while the mass point is moving on the convolution surface.

Critical value of angular velocity

The conditions of the relative motion occurrence is a fundamental question of design. For the investigation the initial values $\dot{\varphi}_r(0)=0$, $\mathbf{v}=\mathbf{v}_k$ and $\beta=\pi/2-\alpha$ belonging to the start time (t=0) are substituted into equation system (1). Then $\sin\beta=\cos\alpha$ and $\cos\beta=\sin\alpha$ hold. Therefore the equilibriun equations – after substitution – are

$$-g\sin\alpha-\mu_1\frac{|\mathbf{B}|}{m}+\mu_2\frac{|\mathbf{N}|}{m}\cos\alpha=0,$$

$$\frac{|\mathbf{N}|}{m}=r\,\omega_0^2,$$

$$\frac{|\mathbf{B}|}{m}=g\cos\alpha+\mu_2\frac{|\mathbf{N}|}{m}\sin\alpha.$$

It can be concluded from the first row that the mass point moves in the direction **t** only if value of the positive sign term which is proportional to the square of angular velocity ω_0 is higher than the sum of the absolute value of negative sign terms.

After arranging and subsubstituting one obtains:

$$-\frac{\sin\alpha+\mu_1\cos\alpha}{\cos\alpha-\mu_1\sin\alpha}+\frac{\mu_2 r\omega_0^2}{g}=0,$$

and utilising the $\mu_1=\mathrm{tg}\rho$ identity results in

$$\omega_0\geq\omega_{0krit}=\sqrt{\frac{g}{\mu_2 r}\mathrm{tg}(\alpha+\rho)}. \qquad (2)$$

Hence the critical angular velocity of screw conveyor axis can be computed if the geometry and friction coefficient data are available. Determination of the critical value is essentially important for the construction and design practice because it produces the minimal angular velocity below which value the conditions for the relative motion do not exist and the screw conveying is impossible. Consequently the initial data of ω_0 must be higher than the critical value. (It is mentioned that the developed formula expresses the same as the well known critical revolution speed relationship in the literature.)

Conveying capacity of vertical screw conveyor

For the determination of the it is assumed that the material flows in concentrical layer along helixes which have the same coil pitch and different radii. Utilisation of this means that one can determine the velocity of all grains if the magnitude and the direction of the velocity of a single particle is known. Moreover, since the axial displacement of the layers are the same in accordance with the assumption all the particles moves with the same speed axially (i.e. in direction z). In short, it is enough to determine the v_z velocity of a single particle to compute the z directional conveying capacity.

The conveying capacity:

$$Q = 3.6\, A\, v_z\, \rho_h \phi \quad \text{[t/h]}, \tag{3}$$

where

A conveying cross section [m^2],

v_z conveying velocity of material in the axial diretion of screw conveyor [m/s],

ρ_h bulk mass density of conveyed material [kg/m^3],

ϕ loading (filling) coefficient.

The cross section of screw conveyor housing is $A = \dfrac{D^2\pi}{4}$, where D is the nominal diameter of the screw conveyor.

The conveying velocity

One can recognize in Fig. 1 that the axis of screw conveyor is perpendicular to the base of slope of angle α, so that the conveying velocity(v_z) is the vertical component of absolute velocity (**v**) which makes β angle to the binormal vector. As a result of the horizontal velocity component the path of the material is a helix of $\pi/2-(\alpha+\beta)$ coil pitch [1], [3].

The conveying velocity which decisively influences the conveying rate is interpreted as the axial component (v_z) of the absolute velocity (**v**). This is

$$v_z = \dot{s}\sin\alpha = \frac{r}{\cos\alpha}\dot{\varphi}_r \sin\alpha = r\dot{\varphi}_r \mathrm{tg}\alpha \text{, or} \tag{4}$$

$$v_z = \dot{s}\sin\alpha = r\omega_0 \frac{\cos(\alpha+\beta)}{\cos\beta}\sin\alpha \cdot \tag{5}$$

on the basis of Fig. 1.

According to the expressions (4) and (5) the determination of conveying velocity needs the knowledge of relative motion angular velocity ($\dot{\varphi}_r$) or the β conveying angle which characterise the direction of absolute velocity (**v**). They are computed from the algebraic equation system (1) by using a numerical procedure. On the basis of (1), (4) and (5) $v_z = v_z(\alpha, \mu_1, \mu_2, \omega_0)$, thus the conveying velocity is function of coil pitch angle, the friction coefficients and the angular velocity of screw conveyor. Due to the sophisticated implicite relationships, the computations need computer implementation.

The application software developed in our institution was elaborated primarily in order to compute conveying velocity. The program uses the revolution speed (n), nominal diameter (D), friction coefficients (μ_1, μ_2) and the s/D rate as input data from which the conveying angle (β) the angular velocity of relative motion ($\dot{\varphi}_r$) and the conveying velocity (v_z) are computed. In addition the software is applicable to make different analyses and to construct diagrams that assist the design.

As example Figs 2 and 3 are shown, where the conveying velocity curves are depicted as functions of s/D rate. In Fig. 2 the effect of friction coefficient can be analysed. The place of maxima of curves can be considered as optimal s/D rates, since the highest conveying velocities and rates belong to them which can be reached in the given conditions. The curves in Fig. 3 exhibit velocity functions for fixed friction coefficient (μ=0,6) and different revolution per minute values. Obviously, the character of curves is the same as those previously (Fig. 2) and as it was expected, the curves move upward with increasing revolution speed i.e. there are higher conveying velocities at higher rpm values.

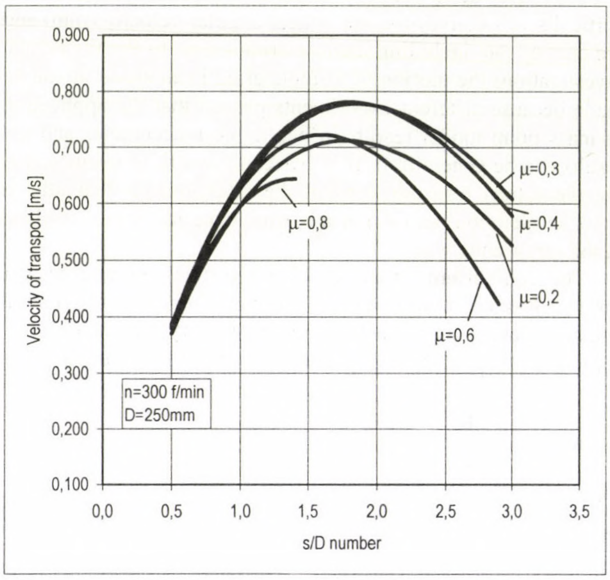


Fig 2. A szállítási sebesség változása az s/D viszonyszám függvényében különböző súrlódási tényezőknél

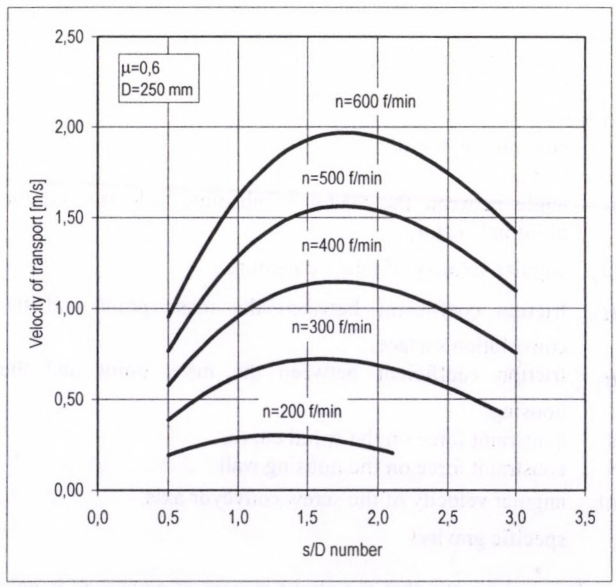


Fig 3. A szállítási sebesség változása az s/D viszonyszám függvényében különböző fordulatszámoknál

The design cannot change usually the friction coefficient, therefore the selection of the coil pitch angle and the proportional (coil pitch/diameter) rate, the angular velocity and the proportional revolution speed may result in the desired conveying velocity and the conveying rate. The diagrams similar to Fig. 2 and 3 can support this difficult course of decision-making.

It is noteworthy, that the results do not give a good account of the current design practice. It is well known that the design engineers choose the s/D rate around 1, which corresponds near computed optimum values at quite low rotation speed values (100…200 rpm).

References

[1] BENKŐ J.: Particle model for description of operation of screw conveyors. Bulletin of the University of Agricultural Sciences, Volume 1, Gödöllő, 1995-1996.

[2] BÉLAFALVI J.: Függőleges szállítócsigák. A+CS, 27. évf. 6. sz. 1982.

[3] BÖTTCHER, S - GABLER, H.: Untersuchungen zur Antriebsleistungs-berechnung senkrechter Schnecken-förder Fördern und Heben 32. 1982. (6).

[4] RADEMACHER, F. J. C.: On the Characteristics of vertical screw conveyors for free flowing bulk material. VDI-Forschungsheft 592, VDI-Verlag, Düsseldorf, 1979.

[5] THÜSING, H. - FINK, M.: Die Förderschnecke als stetiger Senkrechtförderer für Schütt- und Stückgut. Fördern und Heben, 1958. (5).

[6] VIERLING, A - EPHREMIDIS, CH.: Untersuchungen zum Fördervorgang bein waagerechten Senkrechtförderer. Fördern und Heben, 7. k., 1957. (9).

FUZZY LOGIC APPLICATION IN THE ARABLE SITE DETERMINATION OF AGRICULTURAL CROPS

Cs. Fogarassy - Cs. Gyuricza - K. Kocsis
University of Agricultural Sciences, Gödöllő

Introduction

Originally the „Fuzzy Logic" has emerged as a profitable tool for the controlling of subway systems and complex industrial processes, as well as for household and entertainment electronics, diagnosis systems and other experts systems. Although Fuzzy Logic was invented in the United States the rapid growth of this technology has started from Japan and has now again reached the USA and Europe also.

Fuzzy Logic is still booming in Japan, the number of letters patent applied for increases exponentially. The main part deals with rather simple application of Fuzzy Control. Fuzzy has become a key-word for marketing too.

In Japan Fuzzy-research is widely supported with a huge budget. In Europe and the USA effort are being made to catch up with the tremendous Japanese success.

Fuzzy Logic is basically a multi valued logic that allows intermediate values to be defined between conventional evaluations like yes/no, true/false, black/white, etc. Notions like rather warm or pretty cold can be formulated mathematically and processed by computers. In this way an attempt is made to apply a more human-like way of thinking in the programming of computers. Fuzzy Logic was initiated in 1965 by Lotfi A. Zadeh, professor for computer science at the University of California in Berkley.

Method

First, we shall look at the fitness of Fuzzy Control in general terms.

The employment of Fuzzy Control is commendable...

- for very complex processes, when there is no simple mathematical model
- for highly nonlinear processes
- if the processing of (linguistically formulated) expert knowledge is to be performed

The employment of Fuzzy Control is no good idea if...

- conventional control theory yields a satisfying result
- an easily solvable and adequate mathematical model already exists
- the problem is not solvable

Now let's look at some examples where Fuzzy Control actually has been applied.

- not well structured marketing and economical systems, solve different sociological tasks and algorithms;
- to recognize, identify body(s) and situation(s);
- at diagnostic systems;
- to regulate and control for not exactly definable or in time changing complex systems.

I. Fuzzy Control

Fuzzy controllers are the most important applications of *Fuzzy* theory. They work rather different than conventional controllers; expert knowledge is used instead of differential equations to describe a system. This knowledge can be expressed in a very natural way using *linguistic variables*, which are described by *Fuzzy sets*.

II. Theory of Fuzzy

First we consider a set X of all real numbers between 0 and 10 which we call the universe of discourse. Now, let's define a subset A of X of all real-numbers in the range between 4 and 7.

$A = [4,7]$

We now show the set A by its characteristic function, i.e. this function assigns a number 1 or 0 to each element in X, depending on whether the element is in the subset A or not. This results in the following figure:

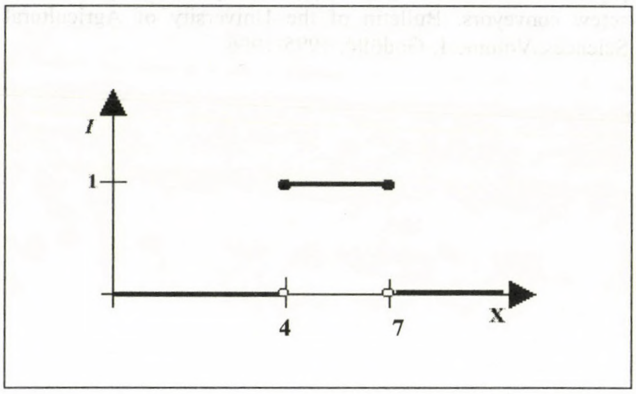


Fig. 1.

We can interpret the elements which have assigned the number 1 as *The elements are in the set A* and the elements which have assigned the number 0 as *The elements are not in the set A*.

This concept is sufficient for many areas of applications. But we can easily find situations where it lacks in flexibility. In order to show this consider the following example:

In this example we want to describe the set of young apple trees. More formally we can denote B = {set of young apple trees}. Since - in general - age starts at 0 the lower range of this set ought to be clear. The upper range, on the other hand, is rather hard to define. As a first attempt we set upper range to, say, 15 years. Therefore we get B as a crisp interval, namely: B = [0, 15].

Now the question aries: why is a tree on his 15th birthday young and right on the next day not young? Obviously, this is a structural problem, for if we move the upper boundof the range from 15 an arbitrary point we can pose the same question. A more natural way to construct the set B would be to relax the strict separation between young and not young. We will do this by allowing not only the crisp decision YES, it is in the set of young trees or NO, it is not in the set of young trees but more flexible phrases like WELL, it is belongs a little bit more to the set of young trees or NO, it is belongs nearly not to the set of young trees.

The next figure shows how a fuzzy set allows us to define this question. In our example we coded all the elements of the universe of discourse with 0 or 1. A straight way to generalize this concept is allow more values between 0 and 1. In fact, we even allow infinite many alternatives between 0 and 1, namely the unit interval I = [0, 1]. The interpretation of the numbers now assigned to all elements of the universe of discourse is much more difficult. The number 1 assigned to an element means that the element is in the set B and 0 means that the element is definitely not in the set B. All other values mean a gradual membership to the set B.

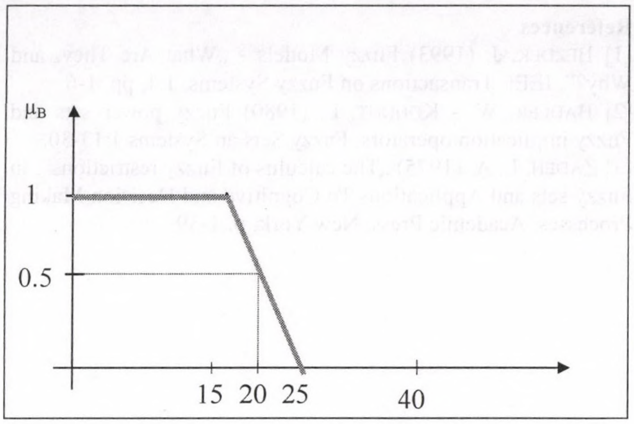


Fig. 2.

This way a 20 years old would still be young to degree of 50 percent.

IV. Basic operation on Fuzzy Sets

Similar to the operations on crisp sets we also want to intersect and unify *Fuzzy sets*. In his first paper about *Fuzzy sets*, L. A. Zadeh suggested the minimum operator for the intersection and the maximum operator for the union of two *Fuzzy sets*. These operators coincide with the crisp unification, and intersection if we only consider the membership degrees 0 and 1. To clarify this we show a few examples.

Let „A" be a *Fuzzy* interval between 4 and 7 and B a *Fuzzy number* about 3. The corresponding figures are shown below:

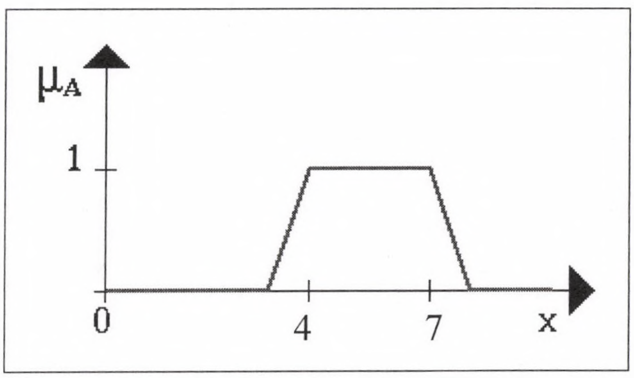


Fig. 3.

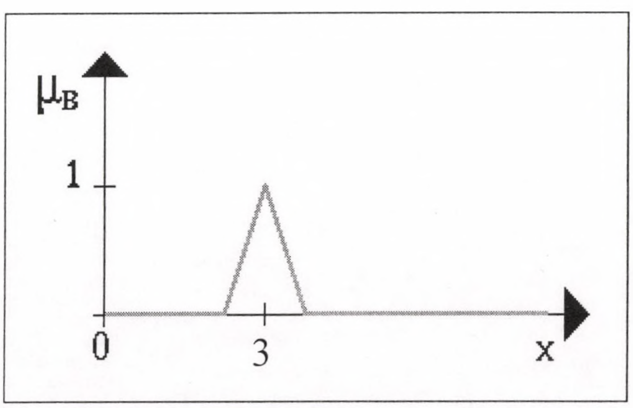


Fig. 4.

Results

So called „AGRO FUZZY"

To determine the regional distribution of the different agricultural crops is a very hard task. In classical mathematics we could not solve this problem, because it is necessary to take into consideration a lot of different agro-ecological factors.

Till now, the agricultural experts first examined the attributes of critical producing area, after they selected which is good or bad for specified crop. The basic problem is, the great number agro-ecological effects, which influence the production level, are not described by mathematical method, because we could not characterize these effects conventional evaluation like true or false. Therefore in this case it is necessary to use the *Fuzzy set* too. The explanation figures are shown below.

The next figure shows one of the basic sets. We gave an optimal value set (it was A in the example), and two not optimal *Fuzzy sets* with values (sets B).

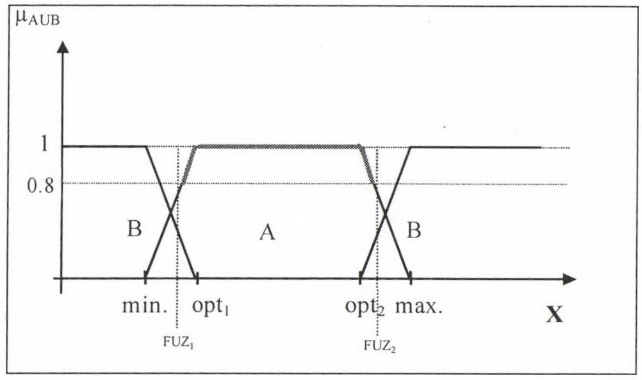


Fig. 5.

A = fuzzy set of the optimal parameters
B = fuzzy sets of the non optimal parameters
$A_{(X)} \geq B_{(X1)}$;
$A_{(X)} \leq B_{(X2)}$;
$(FUZ_{1,2})$ = fuzzy set of the really optimal parameters (at μ=0.8)

The unify set, if the probability is 80%, will be the area under the thick line. In this case this figure illustrates the optimal temperature values for miscanthus production.

In our study, about the energy crops, we created five different *Fuzzy sets* for one crop. With the help of ArcView program we could determine the regional distribution of the crops in the function of crop's ecological demands.

The five *Fuzzy sets* determined an optimal region for specified crop production. For a planting decision there is no need to examine every agricultural area if we know the place where the crop gives an optimal production result. The first step is to give the necessary *Fuzzy sets* and we next is to make a selection for optimal areas on the map with the help of ArcView or MapInfo programs.

Summary

Originally the „Fuzzy Logic" has emerged as a profitable tool for the controlling of subway systems and complex industrial processes, as well as for household and entertainment electronics, diagnosis systems and other experts systems.

To determine the regional distribution of the different agricultural crops is a very hard task. In classical mathematics we could not solve this problem, because it is necessary to take

into consideration a lot of different agro-ecological factors. Till now, the agricultural experts first examined the attributes of critical producing area, after they selected which is good or bad for specified crop. The basic problem is, the great number agro-ecological effects, which influence the production level, are not described by mathematical method, because we could not characterize these effects conventional evaluation like true or false. Therefore in this case it is necessary to use the *Fuzzy set* too.

References

[1] BEZDEK, J. (1993) Fuzzy Models - „What Are They, and Why?", IEEE Transactions on Fuzzy Systems, 1:1, pp. 1-6.

[2] BADLER, W. - KOHOUT, L. (1980) Fuzzy power sets and Fuzzy implication operators, Fuzzy Sets an Systems 4:13-30.

[3] ZADEH, L. A. (1975) „The calculus of Fuzzy restrictions", in Fuzzy sets and Applications To Cognitive and Decision Making Processes, Academic Press, New York, p. 1-39.

THEORETICAL AND PRACTICAL RELATIONSHIPS FOR COMPETITIVE COMPARISON OF DIFFERENT POWER MACHINE SYSTEMS

L. Magó Ph.D. student
University of Agricultural Sciences, Gödöllő

It is the optimal power machine park considering the technology and economy requirements what serves as a basis of the efficiency, realising higher profit and contributing the long term prosperity of the business. Making use this issue one should decide from which machine types of which manufacturers would be aggregated the machine park. Therefore procurement should be made with examining the possible widest market of power machines so that the power machine, power machine park would have the most favourable economy characteristics.

There have already obtained results in the field of optimising agricultural machine park and achieving economically effective power machine park by this both in our region (*Acsai-Csáki-Varga*, 1973; *Kubas*, 1972) and in wider region (*Wissing*, 1986; *Malinnikov*, 1985).

In my work the method of linear programming was used based on the sowing plan of a model company and the optimal power machine park was aggregated from the products of agricultural machine manufacturers of three regions such as East-Europe, Middle-East-Europe and West-Europe. Two distinct machine families were considered from the latter region. The families were compared on the basis of their technology and economy properties.

It is emphasised that the results of the investigation, the qualification of the machine families are formulated on the basis of the procurement and usage costs of the applied power machines and implements. Occasionally, the machine selection is influenced by several technical, technology and economy factors such as trade, credit condition, available services, operation reliability etc. which may modify the machine qualification hierarchy presented.

Optimising power machine parks of machine families

Throughout the investigation a standard sowing plan is employed and the power machines of the different machine families are compared in completing the same operations.

Table 1.
Basic data of sowing plan

autumn barley	150 ha
spring barley	150 ha
autumn wheat	750 ha
sunflower	300 ha
maize	900 ha
silage maize	300 ha
alfalfa	100 ha
total	**3000 ha**

Among the power machines the tractors are grouped according to power classes and the self-propelled harvest machines according to their jobs. As an example a machine type is selected to each group in order to detail the machine usage costs (FMMI 1998, [6]).

The power machines applied in the model:

East European power machines

Serial number Description

Tractors

1. 0-60 kW **MTZ 550**
2. 60-100 kW **MTZ 1025**
3. 100-140 kW **T 150**
4. 140-180 kW **K 700 A**

Transport vehicles:

5. ZIL 4514

Self-propelled harvest machines:

6. Sugar beet harvester **Kleine SF-25**
7. Forage harvester **CLAAS Jaguar 800**
8. Cereal harvester-thresher **DON 1500**

Middle, East European power machines

Serial number Description

Tractors

1. 0-60 kW **ZETOR 6211.2**
2. 60-100 kW **ZETOR 102.45**
3. 100-140 kW **ZETOR 162.45**
4. 140-180 kW **RÁBA 250**

Transport vehicles:

5. **RÁBA K.19.188**

Self-propelled harvest machines:

6. Sugar beet harvester **Kleine SF-25**
7. Forage harvester **CLAAS Jaguar 800**
8. Cereal harvester-thresher **CLAAS 228**

NEW HOLLAND type power machines

Serial number Description

Tractors

1. 0-60 kW **FIAT 45-66 S**
2. 60-100 kW **FIAT F 130 DT**
3. 100-140 kW **FIAT 180-90 DT**
4. 140-180 kW **FIAT G 210**

Transport vehicles

5. **RENAULT M 210.15/D**

Self-propelled harvest machines

6. Sugar beet harvester **Barigelli B/6**
7. Forage harvester **New Holland FX 450**
8. Cereal harvester-thresher **New Holland TX 66**

JOHN DEERE type power machines

Serial number Description

Tractors

1. 0-60 kW **John Deere 6200**
2. 60-100 kW **John Deere 6810**
3. 100-140 kW **John Deere 7810**
4. 140-180 kW **John Deere 8300**

Transport vehicles

5. **Mercedes-Benz 1820**

Self-propelled harvest machines

6. Sugar beet harvester **Kleine SF-25**
7. Forage harvester **Hesston 7700**
8. Cereal harvester-thresher **John Deere 2258**

In the case of some harvest machines of the machine families no typical power machine was found in the given region in which case a known and reputed harvest machine type was selected as substitution.

The procedure of optimisation

For the given type machines:

- the operation jobs
- the periods
- the volume of the works

- the number of the operated machines
- the performance of the machines
- and the machine application costs

are determined.

After processing the content of the data system the limiting conditions and the object function are compiled applying the machine need variables. Such way the mathematical model is constructed which is applied and optimised on a computer.

The optimisation is based on the principle of linear programming. The computations can be carried out with the *Excel 7.0* program package which is considered today an everyday application software.

As the result of optimisation the number of the power machines necessary to carry out the arable land operations in the given month is determined. The power machine need plan is made for the whole duration of production. Based on this the optimal power machine park is recommended.

The aggregated optimal power machine parks of different machine families can be seen in Table 2.

Analysing the differences of the suggested machine aggregates a similarity is found in the piece number distribution of the different power class machines (apart from a few alterations). It can be stated that the characteristic number distribution in the 1st and 2nd power categories is an increasing rate, and the same can be stated in the 3rd and 4th power classes with lower number of machines. The 1st power category machine of New Holland family is out of this distribution which has a lower performance rate comparing to the other category power machines. Thus higher number of machines can complete the given job due to the lower operation cost of the lower power tractor. This is also the reason for this type of tractor exposes much higher efficiency than the 2nd category tractor of the family so that the lower performance class power machine of the family proves more advantageous in the given job.

The next „out of rule" result is found in the Middle-East-European tractor family where the 4th category power machine has less favourable efficiency than that of the 3rd category power machine due to its higher performance than rated. Consequently, the job were assigned to the the power machines of the 3rd performance class.

The distribution of the transport and harvest machines can be considered identical, the only deviation comes from the less capacity of the DON harvest machine.

Based on the specific operation cost of optimal machinery aggregates the **yearly cost of application of optimal power and implement machine park** is countable:

- The yearly cost of application of East European machine park is **517** thousand ECU/year
- The yearly cost of application of Middle East European machine park is **572** thousand ECU/year
- The yearly cost of application of New Holland machine park is **557** thousand ECU/year
- The yearly cost of application of John Deere machine park is **547** thousand ECU/year

On the basis of the cost comparison the advantage of the East European machine family can be recognized. This is followed by the two West European and the Middle East European ones.

The purchase investment costs of the optimal power machine parks of families are

- The procurement cost of East European machine park is **985** thousand ECU
- The procurement cost of Middle East European machine park is **1298** thousand ECU
- The procurement cost of New Holland machine park is **1702** thousand ECU
- The procurement cost of John Deere machine park is **1668** thousand ECU

On the basis of the procurement cost comparison it can be stated that this characteristic is the most favourable for the East European machines. This is followed by the Middle East European machines and the two West European ones. One cannot neglect the fact that the length of application time is different for the different machines of the power machine families. Based on the opinion of professionals and the practical experience that this is 10 years in average for the West European power machines and 6 years for the Middle East European machines and only 4 years for the East European ones considering 1000-2000 operation hours yearly. If the procu-

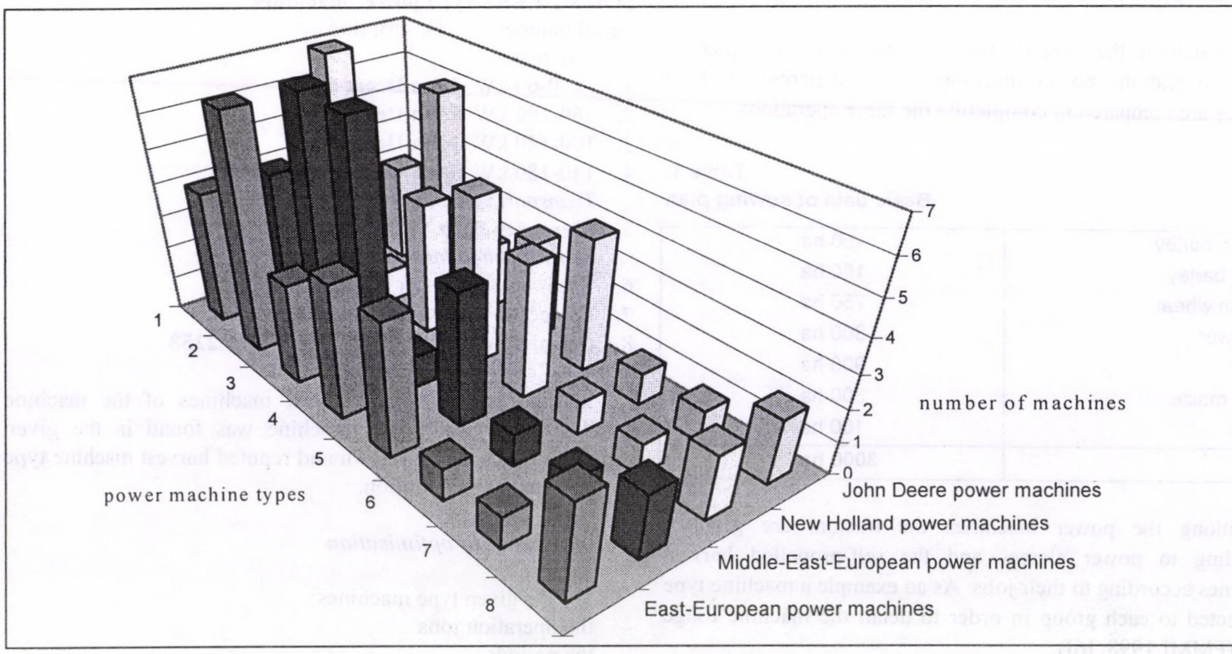


Fig. 1. The distribution of the different recommended machine parks

Table 2.

Number of power machines of East European machines

Machine type	1. MTZ 550	2. MTZ 1025	3. T 150	4. K 700 A	5. ZIL 4514	6. Kleine SF-25	7. CLASS Jaguar	8. DON 1500
Recommended number	4	7	3	4	4	1	1	3

Number of power machines of Middle East European machines

Machine type	1. Zetor 6211.2	2. Zetor 102.45	3. Zetor 162.45	4. Rába 250	5. Rába K.19.188	6. Kleine SF-25	7. CLASS Jaguar	8. CLASS 228
Recommended number	4	7	7	1	4	1	1	2

Number of power machines of New Holland type machines

Machine type	1. FIAT 46-66 S	2. FIAT F 130 DT	3. FIAT 180-90 DT	4. FIAT G 210	5. Renault M 210.15	6. Barigelli B/6-4×4	7. New H. FX 450	8. New H. TX 66
Recommended number	7	1	4	5	4	1	1	2

Number of power machines of John Deere type machines

Machine type	1. John D. 6200	2. John D. 6810	3. John D. 7810	4. John D. 8300	5. M.B. 1820	6. Kleine SF-25	7. Hesston 7700	8. John D. TX 66
Recommended number	3	6	2	3	4	1	1	2

rement costs presented previously are related to 6 years duration of life the following values are obtained:

The purchase investment costs of the optimal power machine parks of families for 6 years duration of life

- The procurement cost of East European machine park is **1052** thousand ECU
- The procurement cost of Middle East European machine park is **1298** thousand ECU
- The procurement cost of New Holland machine park is **1021** thousand ECU
- The procurement cost of John Deere machine park is **1013** thousand ECU

In this case already it can be seen that the West European machine families expose a minimal advantage to the East European machine family and the Middle East European machine family is ranked to the last place.

In my investigation the comparison of different optimal machine parks was carried out. It was experienced that the performance rates of the power machines selected into the performance categories may distort the examination results. Efforts should be made to eliminate them. It can be stated that the power machines offered by the different manufacturers and the optimal machine park aggregated from them have different technical, technology and economy characteristics. Those values greatly influence the economy of the operating agricultural companies.

The examination carried out this way determines the operation characteristics of the optimal machine park instead of an individual machine examination. This can be advantageous both for the operating and manufacturing companies because this way it is not the characterisation of a given power machine in a given job but the information on a whole machine family in a complete production technology what is obtained.

References

[1] ACSAY F. - CSÁKI CS. - VARGA GY.: A vállalati géppark és géphasználat matematikai tervezése. Akadémiai Kiadó. Budapest, 1973. (Mathematical planning of company machine park and machine application)

[2] HUSTI I.: A mezőgazdasági gépesítés ökonómiája. Szakmérnöki jegyzet, Gödöllő, 1985. (Economy of the mechanisation of agriculture)

[3] KUBAS P. *et al*: Matematikai módszerek a mezőgazdasági vállalatok tervezésében és vezetésében. Mezőgazdasági Kiadó. Budapest, 1972. (Methods of Mathematics in the company planning and managing)

[4] MAGÓ L. - HUSTI I.: A növénytermesztő gazdaságok optimális gépparkjának kialakítása. Gazdálkodás, agrárpolitikai és vállalkozási tudományos folyóirat. 1998. XLII. évfolyam 6. szám, p. 56-65 (Aggregating optimal machine park of plant production companies)

[5] MALINNIKOV A. E.: A gép- és traktorpark összetételének és kihasználásának optimalizálása különböző kritériumok alapján. Szb. Naucs. Trud. TSzHA, Moszkva, 1985. (Optimising machine and tractor park composition and utilisation on the basis of different criteria)

[6] *Mezőgazdasági gépek ára és üzemeltetési költsége 1998-ban.* Mezőgazdasági Gépüzemeltetés 1998. 1. sz. FM Műszaki Intézet. Gödöllő, 1998. (Prices and operation costs of agricultural machines)

[7] WISSING P.: Az optimális gépkapacitás meghatározása a növénytermesztés területén. Kooperation, Berlin, 1986. (Determining optimum machine capacity in the plant production)

FEM ANALYSIS OF STATIONARY AND ROTATING FRAME OF THE MOUNTED REVERSIBLE PLOUGH

T. Illés - I. J. Jóri - Gy. Kerényi
Technical University, Budapest
L. Vései
Kühne Rt., Mosonmagyaróvár

Introduction

Ploughs are determining machines of agriculture. It was a long development through which we reached the modern reversible plough starting with simple spade-stick. The oldest memory of Cultural activity of human dates back to about 8000 years. The Mesopothanian Uruk-Varka clay-tables that contain the oldest drawings of ploughs are 5000 year old. [*Lammel*, 1963]

The modern ploughs have been developed on the basis of experiences of these 5000 years. We expect these modern ploughs to fulfil the following demands.

- When ploughing every ploughbody should cut out furrows with the same cross-section.
- We should be able to adjust the work-depth according to the requirements, but the variation of depth and width (stability) should remain under 5%, 10% respectively.
- Ploughbodies should ensure proper turn over (ploughing) and the required pulverizing. The ploughed furrows should tilt tightly against each other, so that the coverage and mixing of organic materials should be adequate.
- Ploughbodies are required to leave no big clods behind, the ploughing should be smooth.
- Ploughbodies should leave behind a vertical, smoothly cut, non-collapsed furrow wall to avoid compression of the soil.
- The bottom of the furrow should be plane (parallel to the surface), because this way the local cumulating of water can be avoided. [*Bánházi - Koltay - Soós*, 1984]

The requirements of plough design

Ploughing is one of the most important operation of agriculture, besides it requires the most amount of energy as well, since ploughing loosen the soil, turns over the soil, mix the soil and pulverize the soil at the same time. The ploughbody changes the mechanical properties of the soil, simultaneously the soil puts force onto the implement. [*Bánházi - Koltay - Szendrő - Vener*, 1978] When designing an agricultural implement knowing the magnitude and location of this force is a fundamental requirement. The soil can be considered as such a complex and complicated structure, the exact description of which cannot merely be given by means of some simple parameters.

Just like in every case of design problems, also this time determining the magnitude and type of the acting load is the first problem to solve. Turning, loosening, mixing the soil, and pulverizing the soil could be examined separately, as independent operations, which means determining the loads separately at each operation. However the theory of superposition leads to an incorrect solution as for the loads, since the effects of one operation on the other operation should also be considered. [*Boltizár*, 1972; *Barta - Jóri - Salamon*, 1979; *Rázsó*, 1958; *Fenyvesi - Borsa*, 1985]

The above listed requirements came from ploughing, while they should be completed with the requirements of production and the market. For instance a basic demand of the market is that the product should be cheap but high quality at the same time. Quality means on the first place reliability and good working, that is the high standards designed and produced product should be tested before introduction into the market. In case of ploughs – since they are basically built of a frame structure and operating elements mounted on it –, reliability means operation without breaking and in accordance with agricultural and technical requirements. Normally these are related to normal operation. It is in contrast to the above statements, that nowadays the manufacturers do not have the time to spend years with development, new products and ideas should be put into market as fast as possible, otherwise rival companies take over. Because of the competition on the market there is no possibilities to thorough testing and examining the occasional modifications.

To get over the market pressure processes and methods are to work out, which firstly can simulate the loads during operation, secondly can make it possible to analyse the designed structure for functionality and strength, thirdly no manufacturing is required for doing analyses.

The current home practise

At the moment the design process of ploughbodies is the following. The parameters of the soil and the acting loads on the operating implement during ploughing are quite hard to deal with mathematically, but on the basis of the vast amounts of measurements available some characteristic values can be considered. According to the results of the measurements the acting loads on the body during ploughing can be dealt with as below.

The distributed load on the body is replaced by a concentrated force with arbitrary direction, the acting point and magnitude of which can be determined by the experimental formulae made according to the measurements processing the characteristic parameters of plough and share, and the properties of the soil. The magnitude contains the dynamic property of the load, too. [*Krasznicsenko*, 1965; *Bernacki - Haman*, 1972; *Gill*, 1968; *Sitkei*, 1967]

According to the foreign and domestic practice the design of plough has been done according to the tradition and experience so far. This method has been supported by the fact, that because of the complicated structure the elements of the body cannot be designed properly, secondly the weaknesses of the structure can be revealed by a experimental machine made for functionality analysis. Also because of the needing time for the production of the experimental machine and the prototype the time for designing should be reduced.

Therefore in case of ploughs and other agricultural machines, experimental machines and the prototype production with experiments have a significant role. Series production of nowadays' plough starts only after plough having been redesigned, strengthened many times, and prototypes having been tried out. However this design method reveals only weak points of the plough – because the breaking and deformation occurs there –, and there is no information of the places with peak strength deserve. The requirements of functionality and ploughing quality can be tested and checked, and the effects of the possible modifications can be predicted.

A non-moral but frequently-used method of plough-design is using the ploughbody of a rival company or one of our former body as a base for reshaping. The essence of this method is to select a good performing, reliable body. First we work out the computer model of the selected plough, and by means of the program we determine the moments of inertia and sectional modulus of the whole plough, in different planes connected to the bending planes. After this we build our own new structure according to our experience and according to the idea, that the moment of inertia and sectional modulus should be proper in the examined cross-sections of the constructed implement. The method is based on the assumption that the new plough will work in identical environment, so the acting loads will also be identical. The big advantage of this method is that it does not require really big-performance computer modelling system, since the above mentioned services are contained in almost every software.

This method however is mostly suitable for reshaping of an existing product, which serves the reduction of production and material expenses. This type of designing neither supports using materials and building units that differ from those of the former structure, nor aims reaching uniform stress distribution. So with using this method we cannot handle the new materials and parts that are to build in, also since having determined the moment of inertia of the whole plough in one plane we do not have information of the distribution among the supporting elements. Consequently we know neither the load on the supporting elements, nor the materials stress deserves. That is why this method of plough designing also requires producing experimental machine or prototype, and experiments. The aim of these experiments is identical to the above mentioned, and the disadvantages, too. As a result products designed by this method will not use up properly the stress-bearing capacity of the material, and the stress distribution in the supporting elements will not be uniform.

Possibilities provided by computers

These shortcomings can be corrected by systematic using of computer aided designing systems. By means of the system we design the structure, which is based on the traditions and experiences. This model is naturally a simplified one, which does not contain subtle details of the structure in this first approach. After this we make the FEM net, which should be properly denser in the neighbourhood of the points that seem dangerous. Then we can define the loads and initial conditions. By means of the examinations having appropriate information we can modify the design. [*Borsa - Papp*, 1981; *Borsa - Papp*, 1982; *Váradi*, 1998; *Varga*, 1998; *Mouzen - Neményi*, 1998]

Finally by means of the stress map resulted by the analysis we can choose the appropriate material for each beams. And if necessary at the weak points we can strengthen the examined structure; for instance in case of examinations of prototypes we can weld casual supporters on the frame, but „material-build-in" and „material-out-take" (material-rearrangement) can be used successfully, which neglects the use of high alloyed steels. For rearranging materials in a quick and effective way we need a properly flexible modelling system, by means of which we can carry out the alterations in the cross-sections, and the redesign of the structure. This method has the advantage over the others, that it makes possible to manufacture a product that has no unnecessary material built in, that is checked for stresses, that has supporters which has uniform stress distribution.

Since the results of the prototype experiments can be reproduced by FEM analysis, the number of the necessary experiments can be considerably reduced, and these can be considered as final test.

By means of the analysis we can examine the behaviour of the product in cases of different loads, therefore the seasonal problems, like an autumn test cannot be carried out in the spring, can be solved in a simple way.

The shortcoming of the method is merely that the loads are determined by the experimental formulae. Also we have not had the chance to simulate the loads in a way, so that the fluctuation of the magnitude of the real load, and the type of the changes. According to our assumption this method is perfect for a start. Thus we tested the applicability and effectiveness of the method in the process of a particular design.

A concrete example

The pictures below show the stress distribution diagrams of a 4 beam member of a recently developed family of reversible ploughs. During designing we examined the possibilities of different structures of several frames.

At first we examined a frame with no extra supporter built of closed-profile beams (Fig. 1). According to the results of the analysis there are two regions in the main frame on which the shares are mounted, where the stress exceeds the yield stress. One zone is located between the second and the third shares, while the other zone is between the first and the second shares and even extends over the flaps created for the angle-adjusting spindle.

According to the stress map the structure should be strengthened. This could be done in two ways. In the first case we weld supporting beams next to the main beam, while in the other case we changed the cross-section of the main beam and the location of the joining points each closed-profile beams.

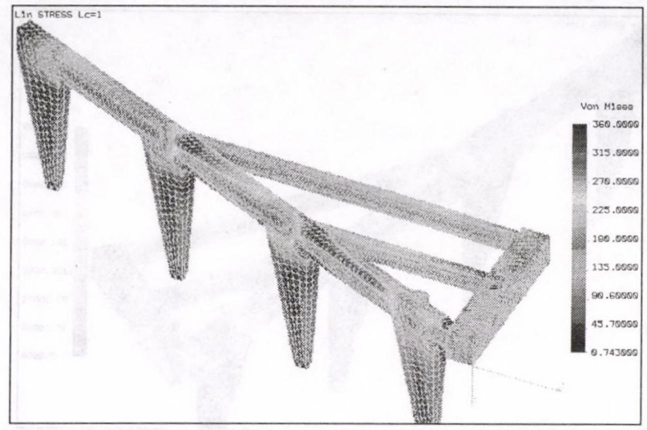


Fig 1. Stress map of frame without supporters (HMH)

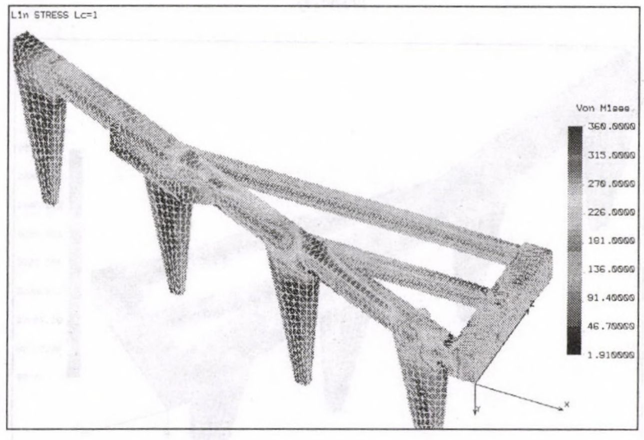


Fig 2. Stress map of frame with closed-profile supporters (HMH)

We worked out two possibilities for the first solution (with supporters). In the first case we made a closed-profile supporter beam, while in the other case we used U-profile supporters.

The picture of the frame with closed-profile supporter is shown in the Fig 2. In the case of this solution the former zone is concentrated at the joining points of the supporter and the shares, which are modelled with the pyramids, at this places the stress exceeds the yield stress. The zones mentioned before are unchanged.

When strengthening the frame by U-profile beams the results are shown in the Fig. 3, thus we can say that the stress map of the zone between the second and the third shares became favourable, the peak-stress in the former solution became smooth. There are no changes at other parts of the structure.

As for changing the joins and cross-sections we examined two structures.

As the Fig. 4 shows we increased here the cross-section of the main beam without welding any supporter-beams to the structure. As it is shown in the pictures the stress at the places which were dangerous before does not reach the yield stress. However this alteration reduces the applicability and utilisation of the frame, so the structure could bear bigger loads without any point of the structure reaching the yield stress.

A better solution can be achieved with locating the joins at the proper places and in the proper number. This alteration is shown in the Fig. 5, which uses the same amount of material as the that of the Fig. 1, and the production costs are also the same, apart from the solutions shown in the Figs. 2 and 3.

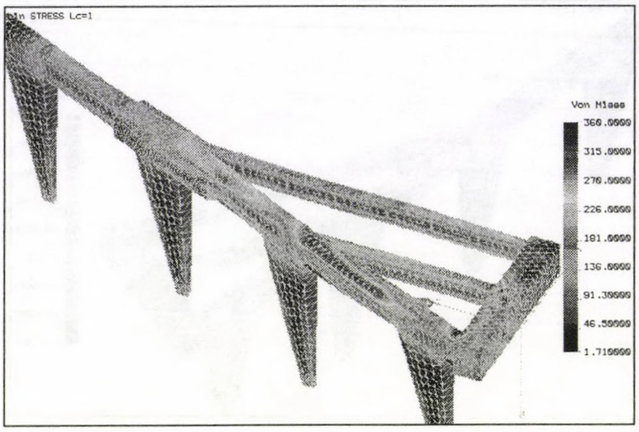


Fig 3. The stress map of the frame with U-profile supporter (HMH)

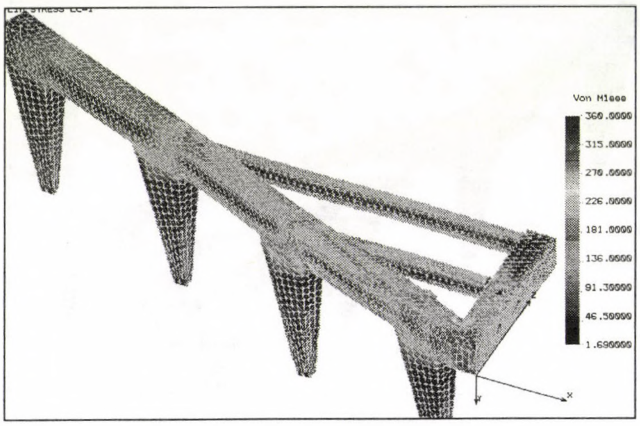


Fig 4. Stress map in the case of increasing the cross-section of the main beam (HMH)

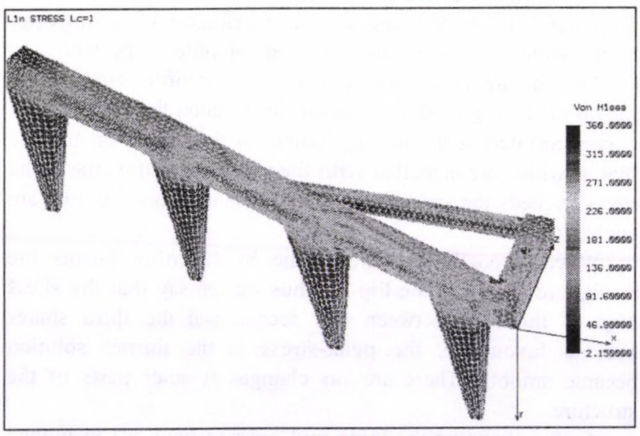


Fig 5. Stress map in the case of increasing the cross-section of the main beam and decreasing the length of the cross bar (HMH)

Conclusions

As it is shown in the instance the FEM analysis has a great significance even if we use the static model determined by the literature in a way, that we determine point loads in three directions according to the measurements, and we use this as the three component of the general force. As for the location of the acting force we accept the recommendation of the literature. By means of even this simple model the design work can become much more effective and economic, because with using the FEM analysis it can be easily decided whether a structure that looks perfect becomes perfect beside which exact parameters, and the success of the necessary alterations can be predicted. Besides it is naturally of great significance that the prototype is adequate for stresses. Also nowadays most of the agricultural machines are over-dimensioned to assure reliability and quality work. So even with using this simple model we can achieve and exceed the design quality of the domestic market. Naturally the competitiveness is greatly influenced by the profit. To get bigger profit we should design machines, which really uses up the reserves of the material, and avoid useless material-build-in. This is in contrast with making the manufacturing cheaper and easier. But using CAD these two aspects can simultaneously be taken into account effectively.

The experimental machine shown in the Fig. 6. has been manufactured, and plough experiments has been executed on it. It is clearly recognisable in the picture that firstly the machine was manufactured in the way shown in the figure 1., and later this got strengthened.

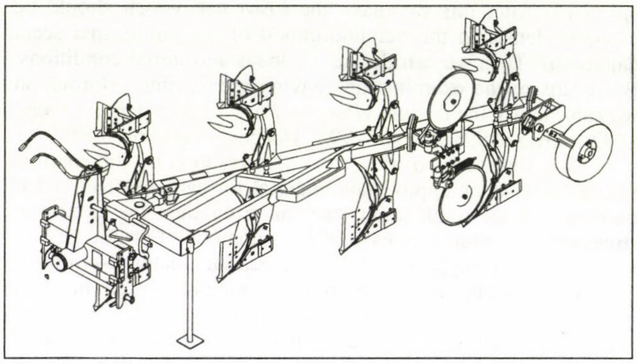


Fig 6. The experimental machine

References

BÁNHÁZI - KOLTAY - SOÓS: A szántóföldi munkagépek működésének elméleti alapjai. Mezőgazdasági Kiadó, Budapest, 1984

BÁNHÁZI - KOLTAY - SZENDRŐ - VÉNER: Szántóföldi munkagépek. Mezőgazdasági Kiadó, Budapest, 1978

BARTA - JÓRI - SALAMON: Talajművelés. MÉM Műszaki Intézet, Gödöllő, 1979

BERNACKI - HAMAN: Grundlagen der bodenbearbeitung und pflugbau. VEB Verlag Technik, Berlin, 1972

BOLTIZÁR PÁL: Mezőgazdaság gépesítése. Tankönyvkiadó, Budapest, 1972

BORSA - PAPP: Mezőgazdasági gépek vázszerkezeteinek szilárdsági ellenőrzése véges elemek módszerével. MÉM Műszaki Intézet, Gödöllő, 1981.

BORSA - PAPP: Végeselemek módszer alkalmazása a mezőgazdasági gépészeti tervezésben és ellenőrzésben. MÉM Műszaki Intézet, Gödöllő, 1982.

FENYVESI - BORSA: Fajlagos talajellenállás meghatározására szolgáló mérőeszközök szántóföldi vizsgálata. MÉM Műszaki Intézet, Gödöllő, 1985.

GILL: Soil dynamics in tillage and traction. U. S. Goverment Printing Office, Washington, 1968

KRASZNICSENKO: Mezőgazdasági gépszerkesztők kézikönyve. Műszaki Könyvkiadó, Budapest, 1965

LAMMEL KÁLMÁN: Eke és szántás. Mezőgazdasági Kiadó, Budapest, 1963

MOUAZEN - NEMÉNYI: Finite element prediction of soil loosening and forces acting on a medium-deep subloiler. Hungarian Agricultural Engineering/10.

Rázsó Imre: Mezőgazdasági gépek elmélete. Tankönyvkiadó, Budapest, 1958

SITKEI GYÖRGY: A mezőgazdasági gépek talajmechanikai problémái. Akadémiai Kiadó, Budapest, 1967

VÁRADI KÁROLY: Tartószerkezetek Gyakorlati jegyzet, 1998. őszi félév

VARGA LÁSZLÓ: Tartószerkezetek előadás jegyzet, 1998. őszi félév

CAVITATION AND TRANSIENT PROCESS OF GEAR PUMPS

Dr. S. Török - Z. Bártfai
University of Agricultural Sciences, Gödöllő

Abstract

Pumps operating on the base of volume displacing theory are sensible very much for the boost pressure. Cavitation occurs when the pressure inside the pump is lower then the critical pressure in the inlet chamber. In order to avoid the mentioned disadvantageous phenomenon during operation of gear pumps, computer aided research activities have been run by the author at the Systems Engineering Department of the Gödöllő University of Agricultural Sciences.

Introduction

Pumps operating on the theory of volume displacing are sensible for the boost pressure. Because of this one of the must important parameter that the operator must keep in mind is the boost pressure. The reason why the pressure is to be controlled is the phenomenon of cavitation. In the case of cavitation the leakage increases with an undesired degree.

If the value of the absolute pressure inside the pump fall below the pressure value of saturated steam gas or stem will segregate. Noise and erosion are some unfortunate outgrowths of cavitation. These happen because of the turbulent flow of the liquid carried by the pump. The vortexes flake off periodically and the cavity holes collapse. If the cavitation is so serious some parts of the pump that are in contact with the flowing liquid can abrade. This results a rapid smash.

Investigations have been performed at the laboratory of Systems Engineering Department. One of the aims of this investigation is studying the affect of cavitation on the critical value of boost pressure (p_{skr}) as function of temperature as well as pump r.p.m. The other purpose is to record and display the transient effects come into being at different boost pressures. The investigations have been carried out with the use of a hydraulic measuring bench designed and built by a team of the mentioned department. The author is one of the team members.

Type of test pump is TGL 10859, nominal size is 16.

Discussion

Studying Fig. 2 – a diagram of volume flow versus pressure – the definition of the critical boost pressure can be understood easily. Critical boost pressure belongs to the point of the volume curve where the value is lower by 2-3% than the volume value of geometric delivery. I the followings I describe the measuring activities I have carried out for the successful determination of the characteristic curve. Fig. 1. shows the hydrostatic measuring bench and its elements.

Elements of the hydrostatic measuring system:

The system is divided into three main parts:
I. Hydraulic supply unit
II. Hydro-motor circle
III. Pump circle

1.	Hydraulic supply unit	500 TE 40-160
2.	Thermostat	AVTB 3N 3252
3.	Flow-stabiliser	3 FRM 10-20/50L
4.	Measuring-turbine	HB 15/2-250
5.	Hydro-motor	12.5 TGL 10860
6.	Torque-meter	0-50 Nm
7.	Pressure-gauge	213. 100. 25
8.	Pressure-gauge	213. 100. 250
9.	Choke-valve	MG 10G
10.	Oil-water heat exchanger	OHV-315
11.	Magnet filter	MS 63
12.	Thermostat	AVTB 3N 3252
13.	Choke valve	MK 20 G
14.	Manual stopper	A20 TGL 21575
15.	Hydraulic pump	16 TGL 10859
16.	Pressure-gauge	213.100.250
17.	Pressure-gauge	213.100 +1.5/-1
18.	Pressure stabiliser	DB 101-30/3154
19.	r.p.m transmitter	4.660
20.	Piston measuring motor	A2F 10R 4P1
21.	Oil-water heat exchanger	OHV-315
22.	Oil tank	

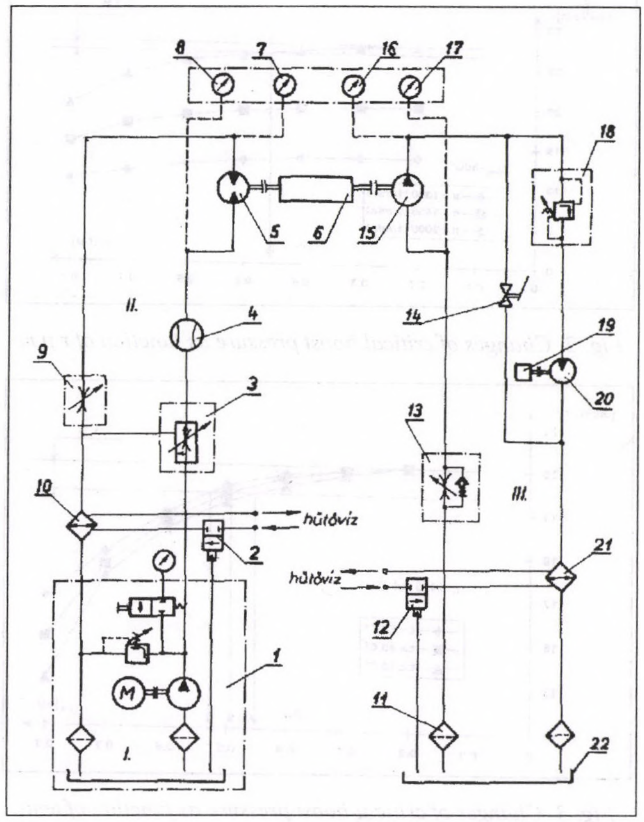


Fig. 1. Hydrostatic measuring bench

The mentioned investigation consists of the several main steps. First the characteristic curves were recorded. The r.p.m. of the gear pump -placed in the motor circle (II.)- was adjusted with the help of a flow stabiliser (3). After than the vacuum (p_s) was increased inside the boost inlet chamber. Otherwise during this process the boost pressure is decreased by the choke valve connected in the hydraulic system before the pump (15). In every adjusted choking stage the volume-flow of the pump was recorded with the help of an axial-piston constant hydro-motor (20). This hydro-motor is the so called measuring hydro-motor.

For the determination of the volume flow the following equation can be applied:

$$q_v = \frac{q \cdot n_m}{1000} \quad [\frac{dm^3}{min}]$$

q : Specific liquid deglutition of the measuring hydro-motor (9.4 cm^3/revolution)

n_m : r.p.m. of the measuring hydro-motor (min^{-1})

After having a curve recorded, the next (constant) value of the r.p.m shall to be adjusted and the same measuring process can be performed again. Studying Fig. 2 carefully it can be seen that increasing the r.p.m the boost pressure is also higher (value of the vacuum is lower).

Fig. 3 shows the results of an other investigation. The main steps of this measuring process are summarised in the followings. During the examination the rated r.p.m. was constant. The temperature of the test liquid (oil) was changed and adjusted to the value of 30 °C, 40°C and 50°C. Three diagrams of volume-boost pressure (p_s) were recorded in this way. All the setting actions of the measuring bench were carried out likewise in the previous test series. The critical boost pressure was determined by plotting.

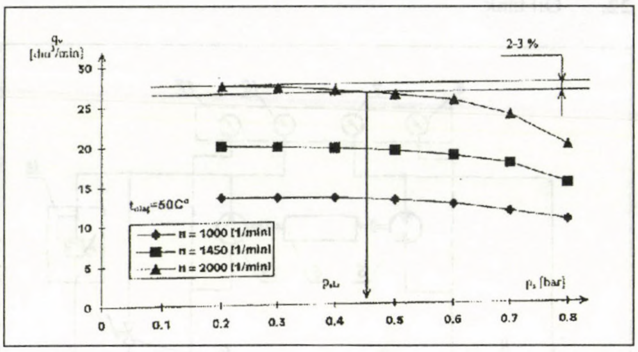


Fig. 2. Changes of critical boost pressure as function of r.p.m

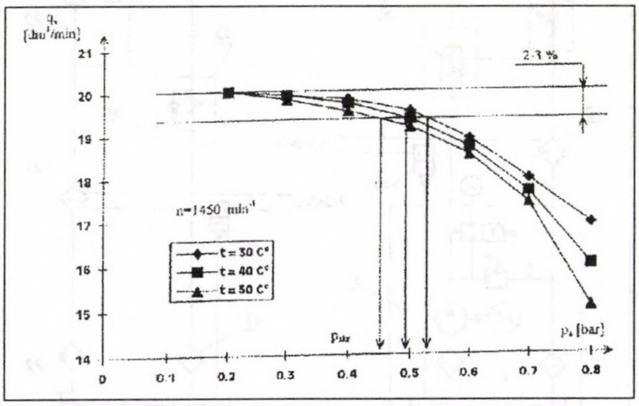


Fig. 3. Changes of critical boost pressure as function of temperature

As it derives from the diagrams in the case of higher oil temperature the vacuum is lower. The explanation of this phenomenon is very simple. The absolute value of saturation oil-vapour pressure increases if the temperature is higher. In the practice this means that pumping a warmer oil the probability of cavitation in the hydraulic system is higher. I have examined the changes of the transient incidents at several boost pressure (vacuum) values.

The must important elements of the applied measuring system are described below:

- strain gage pressure sensor,
- opto-electronic revolution signal device,
- amplifier,
- PCL-718 computer measuring card,

This system is able to take and proceed 40 000 signal sample. This measuring method gives the possibility for studying very rapid changes of the pressure existing in the hydraulic system. In Fig. 4 shows pressure fluctuation versus turns of the pump-axle. In this case the examined gear pump operated without cavitation. Here the pressure fluctuation during one turn of the pump-axle is determined by the number of teeth (z=10).

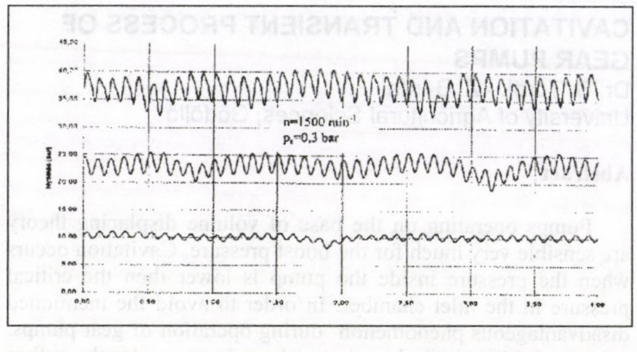


Fig. 4. Transient incident without cavitation

Studying the diagram carefully some tendencies can be realised. For example increasing the pressure of the pump, the amplitude is also higher. In Fig. 5 the examined pump operates at the beginning of cavitation. As it can be seen the cavitation holes collapses periodically. Fig. 6 shows the transient incident with a completely developed cavitation.

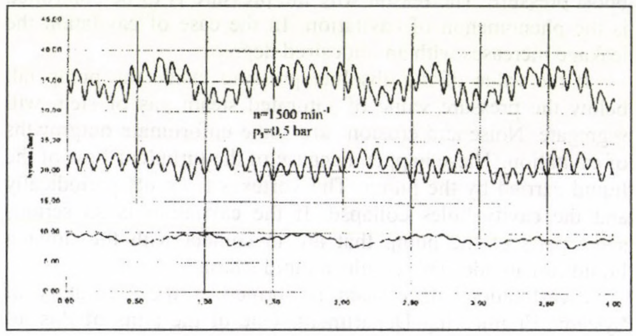


Fig. 5. Transient incident at the beginning of cavitation

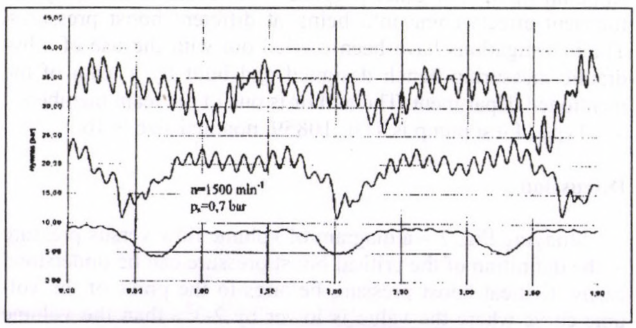


Fig. 6. Transient incident with cavitation

Summary

Pumps operating on the base of volume displacing theory are sensible very much for the boost pressure. Cavitation occurs when the pressure inside the pump is lower then the critical pressure in the inlet chamber. The most important purpose of determination of the critical boost pressure is to avoid cavitation by ensuring a lower pressure during operation.

If the r.p.m. is higher, cavitation comes into being sooner as it can be seen in Fig. 2 This is why the diagram plotting must be started with the curve belongs to the highest r.p.m. Cavitation also happens sooner if the oil temperature is higher.

Fig. 4, 5 and 6 show transient incidents appearing on the delivery side. It is clear from the diagram that in the case of cavitation the tendency as well as the height of the pressure curves change significantly.

CONTRIBUTION TO THE VERIFICATION OF THE TWO-VARIABLE ENERGETIC FUNCTION

(OTKA T 016 124)

Dr. I. Bölöni - Dr. Z. Bellus
Hungarian Institute of Agricultural Engineering

Summary

Once again it was justified by means of hammermill in grinding barley, corn and wheat that

(1) the specific grinding energy requirement ($kWh \cdot t^{-1}$) is a two-variable function of the specific superficial grinding energy consumption ($kWh \cdot cm^{-2}$) and of the specific grist surface increase ($cm^2 \cdot g^{-1}$),

(2) the grinding speed ($cm^2 \cdot g\text{-}1 \cdot s^{-1}$) is a linear function of the quotient of the useful grinding power input (kW) and of the momentary load quantity (kg), if the specific superficial grinding energy demand ($kWh \cdot cm^{-2}$) remains constant.

Preliminaries

In the former years (1995, 1996, 1997) elaborating the OTKA project T 016 124 we have been continuously dealt with the investigations of the relationship of the specific superficial grinding energy requirement ($kWh \cdot cm^{-2}$) and of the grist specific surface increase ($cm^2 \cdot g^{-1}$). At last a two-variable energetic function was achieved which contained the specific grinding energy consumption ($kWh \cdot t^{-1}$) as a second variable.

New examinations

In this paper the results of grinding tests carried out by means of a hammermill, type Zenith Junior (P=5,5 kW) are made known in case of comminuting barley, corn and wheat during 1998.

Investigations were implemented in cooperation with the Department of Agrarenergetics and Food Machinery, GATE, Gödöllő, Hungary. The main point of the instrumentation of the mill was the application of an electrotensometric weighting device by which the mass variation of grist produced could be registered in function of time. The electric motor power input was determined by help of a two-wattmeter's measuring set, – always in stationary operation when the grist or feed flow rate was kept constant. The grist fineness characteristics (particle mean size, specific area etc.) was stated by means of a Ro-Tap vibrating sieve set.

Results of investigations

The most important data measured are shown in Fig. 1 - Fig. 2 - Fig. 3.

In Fig. 1. The relationship of the e_s ($kWh \cdot cm^{-2}$) specific superficial grinding energy demand vs· Δa_g ($cm^2 \cdot g^{-1}$) grist specific surface increase is demonstrated in case of three different steady specific grinding energy requirements:

e_{g1} = 2,9…3,5 $kWh \cdot t^{-1}$ ≅ constant 1.
e_{g2} = 4,0….6,0 $kWh \cdot t^{-1}$ ≅ constant 2.
e_{g3} = 7,5…13,0 $kWh \cdot t^{-1}$ ≅ constant 3.

It is noted that the specific grinding energy requirements were calculated by deducting the electric-, mechanical and air friction power losses first.

Fig. 1 shows a first grade hyperbolic relation of the specific superficial grinding energy demand ($kWh \cdot cm^{-2}$) and of the grist specific surface increase ($cm^2 \cdot g^{-1}$), if e_g ($kWh \cdot t^{-1}$) ≅ constant, justifying our former findings (1995, 1996, 1997):

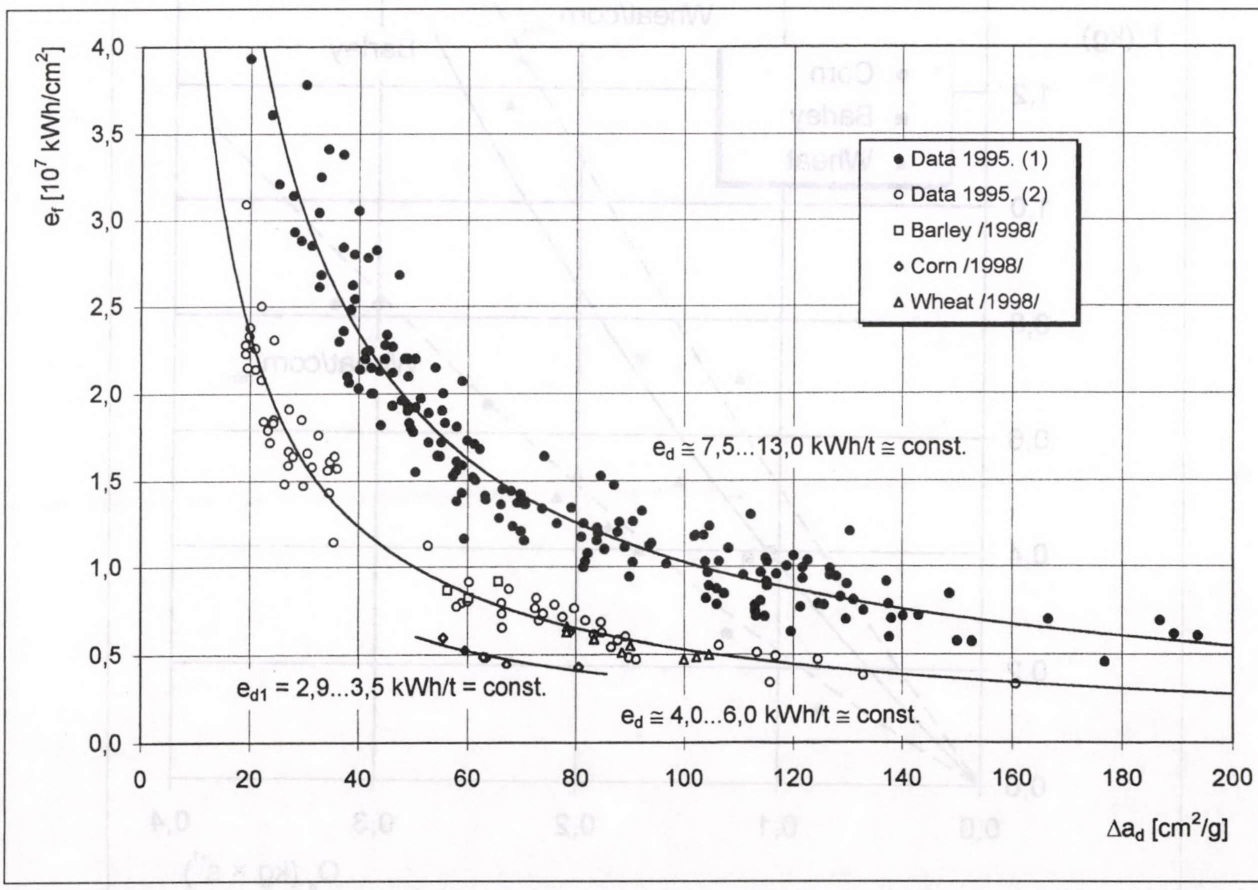


Fig. 1. Experimental relationship of e_s ($kWh \cdot cm^{-2}$) specific superficial grinding energy demand and of Δa_g ($cm^2 \cdot g^{-1}$) grist specific surface increase, if e_g ($kWh \cdot t^{-1}$) specific grinding energy consumption remains constant

$$e_g = C \cdot e_s \cdot \Delta a_g \tag{1}$$

which is a hyperbolic paraboloid's (saddle surface) function, but revolved by 45° around the perpendicular axis of the coordinate system.

The conversion factor: $C = 10^{-6} \cdot t \cdot g^{-1}$.

In Fig. 2 the progressive correlation of the load quantity (L: kg) – that is under comminution in the grinding chamber momentarily – and of the feed flow rate (Q: $kg \cdot s^{-1}$) is to be seen that was hardly researched up to now (1962, 1989). According to this diagram the double increasing of the feed flow rate needs more than twice as much enlargement of the load quantity!

In Fig. 3 the linear relation of the grinding speed (c_g: $cm^2 \cdot g^{-1} \cdot s^{-1}$) and of the specific grinding power input (P_g/kW) : (L/kg) is to be found. Namely after having measured the load quantity (L) and determined the feed flow rate (Q_g) the grinding time (t_g: s) became to be calculated:

$$t_g = L/Q_g \tag{2}$$

and also using the grist specific surface increase ($cm^2 \cdot g^{-1}$) (1964):

$$c_g = \Delta a_g/Q_g \tag{3}$$

The mathematical relation of the specific grinding power input (Pg/L: $kW \cdot kg^{-1}$) and of the grinding speed (cg: $cm^2 \cdot g^{-1} \cdot s^{-1}$) can be derived from Eqn. (1) by subsituting Eqn. (2) and (3) and the standard definition of e_g ($kWh \cdot t^{-1}$) specific grinding energy demand:

$$c_g = \Delta a_g/t_g \tag{4}$$

so that

$$P_g/Q_g = C \cdot e_s \cdot \Delta a_g \tag{5}$$

$$P_g = C \cdot e_s \cdot Q_g \cdot \Delta a_g \tag{6}$$

$$P_g = C \cdot e_s \cdot L/t_g \cdot \Delta a_g \tag{7}$$

and

$$P_g = C \cdot e_s \cdot L \cdot \Delta a_g/t_g = C \cdot e_s \cdot L \cdot c_g \tag{8}$$

i.e.:

$$P_g/L = C \cdot e_s \cdot c_g \tag{9}$$

Well, the linear correlation that is to be seen in Fig. 3, is true, if e_s ($kWh \cdot cm^{-2}$) specific superficial grinding energy consumption remains constant. Nevertheless it seems from the graph that values of e_s ($kWh \cdot cm^{-2}$) are almost steady for grinding barley, corn and wheat:

$$e_{s\,(w+c)} \cong 0{,}5 \cdot 10^{-7} \cdot kWh \cdot cm^{-2} \cong \text{const.} \tag{10}$$

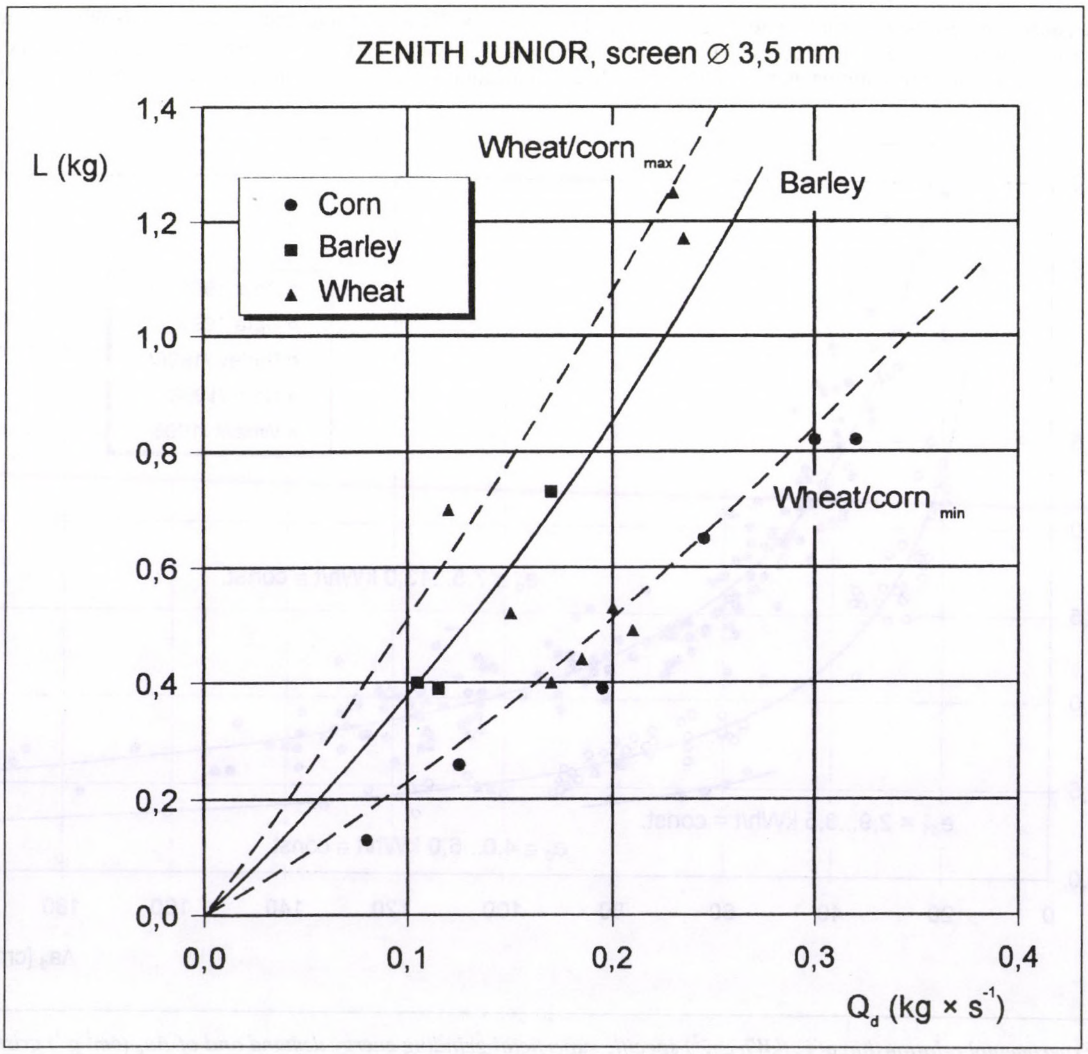


Fig. 2. The momentary load quantity (L) being in the grinding chamber vs. Feed flow rate (Q_g)

while

$$e_{s\,(b)} \cong 0.86 \cdot 10^{-7} \cdot kWh \cdot cm^{-2} \cong constant \quad (11)$$

This way e_s ($kWh \cdot cm^{-2}$) specific superficial grinding energy demand looks like to be a characterising physical property of the feed grain ground. It is to be named as "specific grinding resistance" of the given grain variety. Its reciprocal value makes the already several times searched "specific grindability" of the material but expressed by physical units:

$$\nu_{w+c} \cong 2{,}0 \cdot 10^3 \; m^2 \cdot kWh^{-1} \quad (12)$$

$$\nu_b \cong 1{,}16 \cdot 10^3 \; m^2 \cdot kWh^{-1} \quad (13)$$

which is nothing else than the newly created surface of the grist using up 1 kWh energy input.

References

[1] BÖLÖNI, I. 1962: A kalapácsos daráló üzemállapotát meghatározó jellemzők összefüggései. Mezőgazdasági Gépesítési Tanulmányok, Mezőgazdasági Gépkísérleti Intézet, Mezőgazdasági Kiadó, Budapest, No 8, 1-71 p.

[2] BÖLÖNI, I. 1964: The Required Power Input of Hammermill, Acta Technica, Budapest, Tom. 45., Fasc. 3-4, 327-344 p.

[3] BÖLÖNI, I. 1989: A kalapácsos daráló aprítási mechanizmusának egyes kérdései. Járművek, Mezőgazdasági Gépek, Budapest, I. rész: Vol. 36, No 2, 41-48 p. és II. rész: No 3, 88-92 p.

[4] BÖLÖNI, I. 1995: "Takarmányaprítás fajlagos felületi energiaigényének és a darafinomságnak az összefüggése" c. OTKA téma részjelentése, FM Műszaki Intézet, Gödöllő, 1-53 p.

[5] BÖLÖNI, I. 1996: A fajlagos felületi darálási energiaigény és a darafinomság kapcsolatának modellezése. C. OTKA téma részjelentése, FM Műszaki Intézet, Gödöllő, 1-46 p.

[6] BÖLÖNI, I. 1997: "A két-változós energetikai függvények kísérleti igazolása takarmányaprításban" c. OTKA téma részjelentése, FM Műszaki Intézet, Gödöllő, 1-34 p.

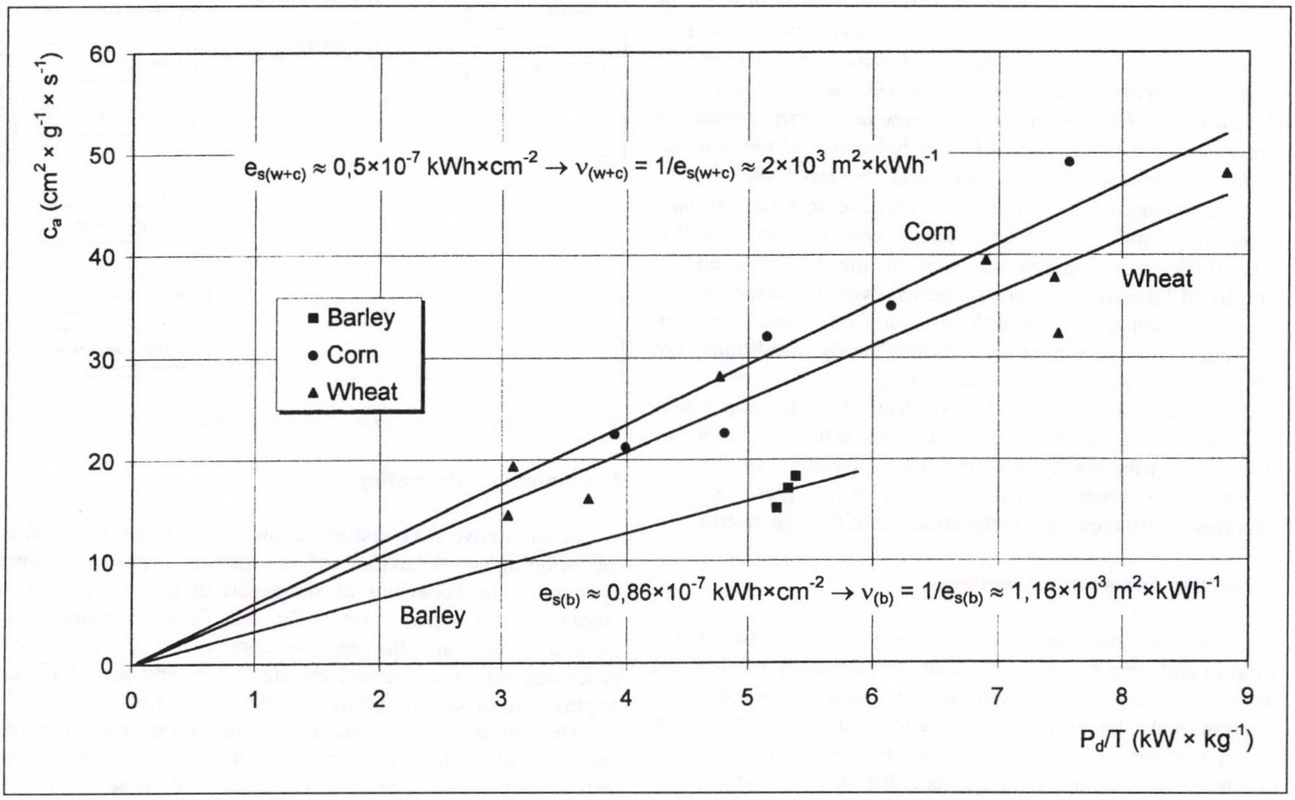


Fig. 3. c_a ($cm^2 \cdot g^{-1} \cdot s^{-1}$) grinding speed vs. P_g/L ($kWh \cdot kg^{-1}$) specific grinding power input

DEVELOPMENT OF TRIBOLOGICAL TEST-RIG FOR DINAMIC EXAMINATION OF PLASTIC COMPOSITES

Dr. G. Kalácska - L. Zsidai
University of Agricultural Sciences, Gödöllő
Dr. M. Kozma
Technical University, Budapest
Dr. Patrick De BAETS
University of Gent, Belgium

1. Introduction

As it is well known, the basic failure process of machine elements is the wear and friction. To avoid and reduce the losses, there are some useful methods e.g. heat-treatment, surface coatings, lubrication, and appropriate material selection. Nowadays the latest becomes more and more important taking the new engineering plastics into consideration.

The relatively advantageous wear behaviour of engineering plastics in abrasive conditions gives new possibilities for design, construction and maintenance of agricultural machines as well. The basic of technical development and proper material selection is the knowledge of tribological behaviour of the plastics. However, these processes are partly known for conventional metallic materials, the behaviour of the new up-to-date engineering plastics, composites, are less known.

The replacement of traditional metallic materials usually needs tribotesting of the operational systems. In most cases it is very difficult and expensive way of the investigation, so simplified laboratory test are suggested even by standards, too. These examinations (traditional pin on disc, pin on cylinder…etc) are carried out during steady conditions, not taking the dynamic effects (acceleration, force, directions…etc) into consideration. That's why we decided to develop a new dynamic test-rig, which gives possibilities to model of dynamic systems in tribo-testing giving better correlation of the real operation of machine elements. This study gives a short overview of tribotesting and the structure of the new testrig.

2. Friction and wear test methods

One of the main aspects of tribometry is the investigation of friction and wear processes by means of laboratory tribo-testing devices. Reviewing the results of wear tests published in the international tribo journals over a period of 13 years, it has been found that approximately 50% of the reported wear tests were obtained with laboratory test rigs and that only 17% of the wear tests were performed with actual machine elements. These data clearly illustrate the great importance of laboratory tribotesting devices. It was indicated previously that in recent years accurate general-purpose tribometers equipped with sensitive recorders and analyzers have been developed in research laboratories. In combining such tribometers with the new powerful surface analytical tools, it is possible to study the elementary friction and wear processes in detail. It should be emphasized, however, that the **application** of these tribometers is **useful mainly for investigations of the system structure** – as for instance the changes in the properties of the system components due to wear processes. As a consequence of the concentration on the structural aspects, from a systems point of view the engineering „use-function" is frequently degenerate in tribometric models.

In Fig. 1 the main parameters relevant to tribo-testing are compiled. In the central part of the figure the elements, i.e., the material components of the test system are sketched. In most cases the test system consists of two solid specimens (1), (2) together with the lubricant (3) and the atmosphere (4). The inputs of the test-system are given by the operating variables compiled on the left-hand side of Fig. 1. Through the action of the operating variables on the test-system elements, friction and wear processes occur. For the description of these tribological processes the tribometric characteristics compiled on the right of Fig. 1. have to be measured. Supplementing these tribometric characteristics, surface characteristics of the specimens (1) and (2) have to be determined.

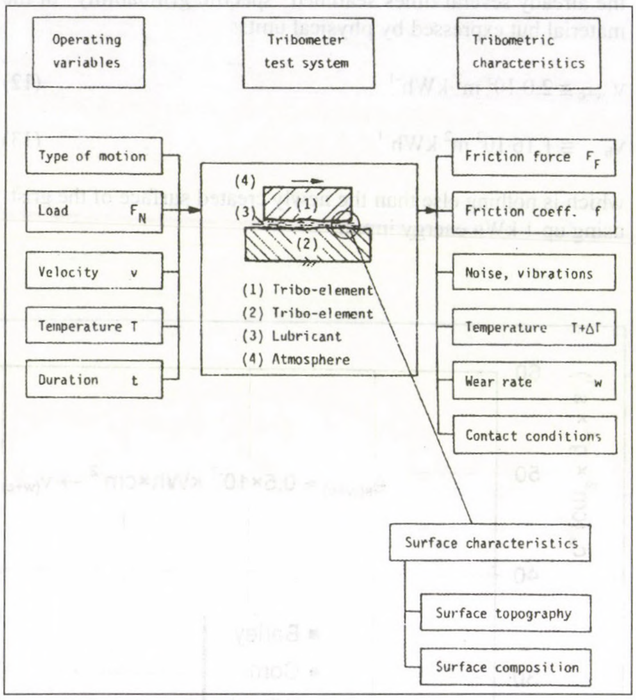


Fig. 1. Characteristics and parameters relevant to tribo-testing

3. Simulative tribo-testing

In simulative tribo-testing an attempt is made to simulate the tribological behaviour of a practical tribo-engineering system, or the behaviour of some part of it, by means of a laboratory test system. Obviously, this field of tribometry is extremely difficult due to the complexity of tribological processes, its numerous influencing factors and the additional requirement of an appropriate „simulation criterion".

The starting point in simulative tribo-testing should be the collection of available data on the practical system (PS) and the test system (TS). For the collection of these data and „casehistories", the tribo-sstem data sheet (published elsewhere) can be conveniently used. Based on these data, the conditions for simulative testing may then be specified. From a formal systems point of view, the procedure of simulative tribo-testing requires:

1.A similarity of the functions of PS and TS, i.e.:
- similarity of the inputs and the outputs
- similarity of the functional input-output relations

2. A similarity of the structures of PS and TS, i.e.:
- similarity of system elements
- similarity of system element properties
- similarity of tribological interactions

In trying to fulfil these conditions, first the materials, the lubricants and tne atmospheric environment should be chosen to be identical in both PS and TS. Then the geometrical and contact conditions of the test system should be adjusted to those of the practical system, taking into account the problem of appropriate scale factors. Finally, the operating variables should be adjusted in order to obtain the same tribological interactions in the test system as in the practical system. Clearly, simulative tribo-testing as outlined in these few sentences is an extremely difficult task and a generally accepted procedure is not yet available. In order to obtain at least a kind of guideline, some of the main aspects of simulative tribotesting, will be discussed briefly here, considering as a starring point a **pin-on-disc tribometer test system**, shown in Fig. 2. For the task of simulative tribo-testing, the test system shown may be applicable for pure continuous sliding with the materials (1), (2) identical with those of the practical system. The conditions of dry or- lubricated sliding should be realized with the atmosphere and lubricant identical to those in the practical system. Then the important „system-independent" properties of the elements, including chemical composition, elastic modulus, hardness, viscosity, etc. will inherently be identical in PS and TS. This system method useful for steady testing.

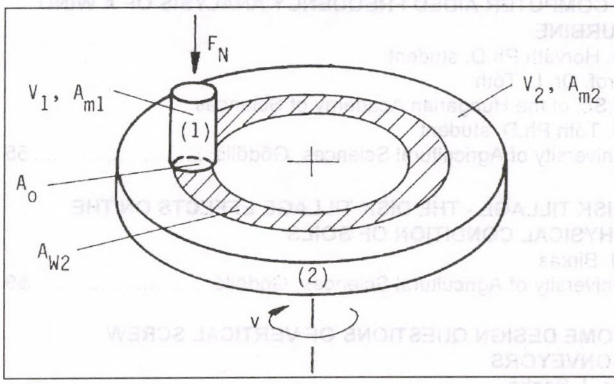


Fig. 2. Geometrical characteristics of a „pin on disc" tribotesting model system

4. Dinamic pin on disc testrig

The structure of new test-rig can be seen on Figure 3. This test system gives more flexibility and possibility of the identification of PS during modelling in laboratory environment.

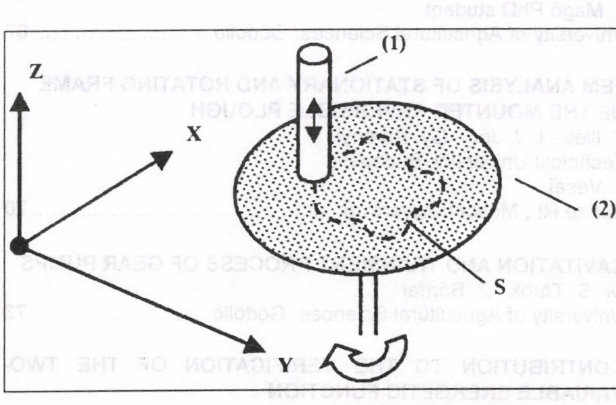


Fig. 3. Schematic vie of dynamic pin on disc tribo-testrig

$S = f(x; y)$
$x = f(t)$
$y = f(t)$
$F_N = f(z; t)$

Dynamic movement and normal load of the test specimen are controlled by PC and by means of robot technics. Fig. 4. shows a photo of the real testrig.

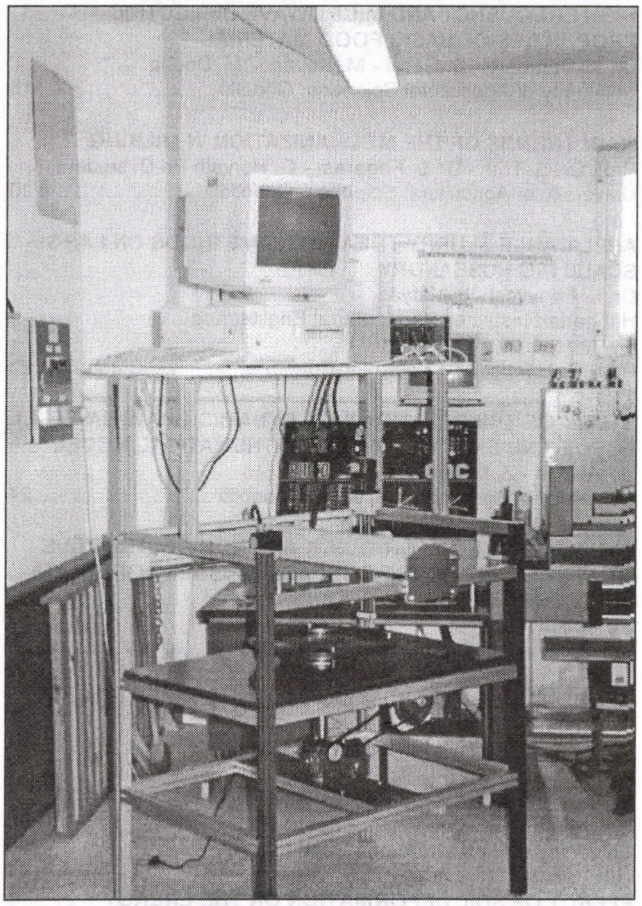


Fig. 4. Dynamic testrig

The development of this testrig is part of more OTKA and OMFB project and essential for further tribological investigation of plastics and composites taking into more relevant effects into account. This publication is performed in the frame of Hungarian-Flamish scientific and technological cooperation (OMFB TéT B-9/98, Ministry of the Flamish Community).

References

[1] CZICHOS H.: Tribology. A systems approach to the science and technology of friction, lubrication, and wear. Elsevier, 1978

[2] VALASEK I.: A tribológia szerepe az üzemfenntartásban. MOL Rt. Fejlesztési Igazgatóság, Budapest. 1994.

Contents of N° 12/1999

CONTENTS OF THE "Mezőgazdasági Technika" periodical of the year 1999.

MEZŐGAZDASÁGI TECHNIKA
2100 GÖDÖLLŐ, TESSEDIK S.U.4.

N° 1.

N° 2.

N° 3.

N° 4.

N° 5.

N° 6.

N° 7.

N° 8.

N° 9.

N° 10.

N° 11.

N° 12.