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PREFACE

Every second year the Agricultural Engineering Committee of the Hungarian Academy of Sciences and the Szent István University's Faculty of Mechanical Engineering organise the International Conference series called Synergy in the Technical Development of Agriculture and Food Industry at Gödöllő, the central place of the Hungarian agricultural scientific activity.

Focusing on technical and technological development the conference discusses synergic trends between agriculture and industry, renewable energy production, education, fundamental and applied research. According to the main objective, the conference brings together experts from different geographic regions with similar scientific interdisciplinary interest and research activities and shares ideas and developments in the various fields of biosystems engineering.

During the sessions on the event which was organized during October 9-15, 2011 , researchers, scientists, engineers, experts of institutions engaged in agricultural engineering development, gave summarizing presentations of their works. Overview of the best papers covering wide range of the conference main theme is published in this issue of the Hungarian Agricultural Engineering. All the papers have been selected by the editorial board and reviewed by prominent experts. We do hope, that this unique publication can give good coverage of the conference's work and can inspire many of the Readers to take part on the next Synergy conference in 2013.

Dr. István SZABÓ
Dean

Faculty of Mechanical Engineering
St. István University

Dr. János BEKE
President

Agricultural Engineering Committee
Hungarian Academy of Sciences

DESIGN OF THE EXPERIMENTAL DRYER FOR MEDICAL & AROMATIC PLANTS

A.K. BAYHAN[1], S. BOYAR[1], M.F. CAGLAR[2],
R.C. AKDENIZ[3] and O. KAYAALP[1]
[1]Department of Agricultural Machinery,
Süleyman Demirel University
32260, Isparta, Turkey
Tel.:+902462114614, E-mail: kamilbayhan@sdu.edu.tr
and/or akbayhan@hotmail.com
[2]Department of Electronics and Communication
Engineering, Süleyman Demirel University
32260, Isparta, Turkey
Tel.:+902462111391, E-mail: fatihcaglar@sdu.edu.tr
[3]Department Agricultural Machinery, Ege University
35100, Izmir, Turkey
Tel.:+902323434400,
E-mail: r.cengiz.akdeniz@ege.edu.tr

Abstract

Today, the importance of keeping agricultural plants by means of drying is getting increase. Many research studies have been carried out on the development of drying techniques and drying characteristics of agricultural plants. In recent years, increase of usage in health and aroma therapy applications caused to increase requesting of these agricultural materials. The keeping of colour, flavour and essential oil is of great importance during drying process of medical and aromatic plants and it has priority. Based on this information, the relationships amongst the temperature and humidity level of drying air, drying speed, drying duration should be stated in most proper way.

The basic research studies on developing of drying technologies of medical and aromatic plants are priority fields. In this study, an experimental dryer having monitoring abilities for temperature, humidity and drying period of medical and aromatic plants was developed. The data gained through the laboratory experiments was evaluated and performance of experimental dryer is given.

Keywords

medical plants, experimental dryers, drying technology

Introduction

Today, the importance of keeping agricultural plants by means of drying is getting increase. Many research studies have been carried out on the development of drying techniques and drying characteristics of agricultural plants. In recent years, increase of usage in health and aroma therapy applications caused to increase requesting of these agricultural materials. The keeping of colour, flavour and essential oil is of great importance during drying process of medical and aromatic plants and it has priority. Based on this information, the relationships amongst the temperature and humidity level of drying air, drying speed, drying duration should be stated in most proper way.

Around the world, there is a remarkable increase in the consumption and usage of all kind of dried agricultural products (Reynolds, 1997). Turkey is one of the ten big producer of more than 20 agricultural products around the world even the biggest producer of some of them. Turkey supplied 36.3% of dried grape demand of the world with 300 thousand tons in 2008 (TUIK, 2010). Also in 2007, Turkey supplied 39.7% of dried fig demand of the world (TUIK, 2010). However these numbers are different in medical and aromatic products and the drug industry. Even Turkey exports these wet or dried agricultural products, unfortunately has not become the drug producer of these products yet.

For this purpose, the basic research studies on developing of drying technologies of medical and aromatic plants are priority fields. In this study, an experimental dryer having monitoring abilities for temperature, humidity and drying period of medical and aromatic plants was developed. The data gained through the laboratory experiments was evaluated and performance of experimental dryer is given in this study.

Design of experimental dryer

In order to estimate the essential parameters of dried medical and aromatic products, an experimental dryer system designed and produced. This dryer has the ability of electronically control of drying temperature and drying rate.

System consists of an electrical resistance dryer, 4 caged and continuously weighting and data accusation (Figure 1). There are 4 drying shelves having 1 m^2 capacity and located in each of the separate drying cage for experimental repetition purposes. Air heated by the electrical resistance is forced to move to the shelves from bottom by the fan. Drying shelves have independent air outlets and dryer connected to the mixing room which is located behind of the dryer system. In this outlet air capacity and velocity of the dryer are controlled manually by changing diameter of the outlet pipe with the help of clap. Moreover, dryer has property of mixing fresh air with the interior drying air.

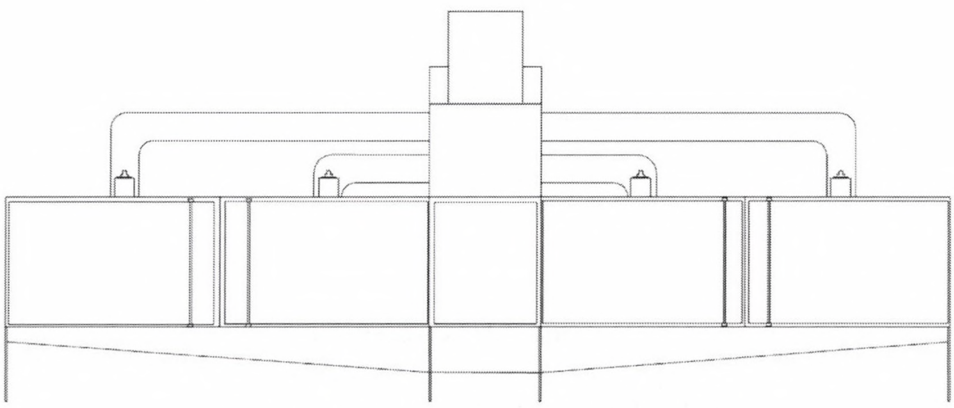

Figure 1. Schematic front view of the experimental dryer

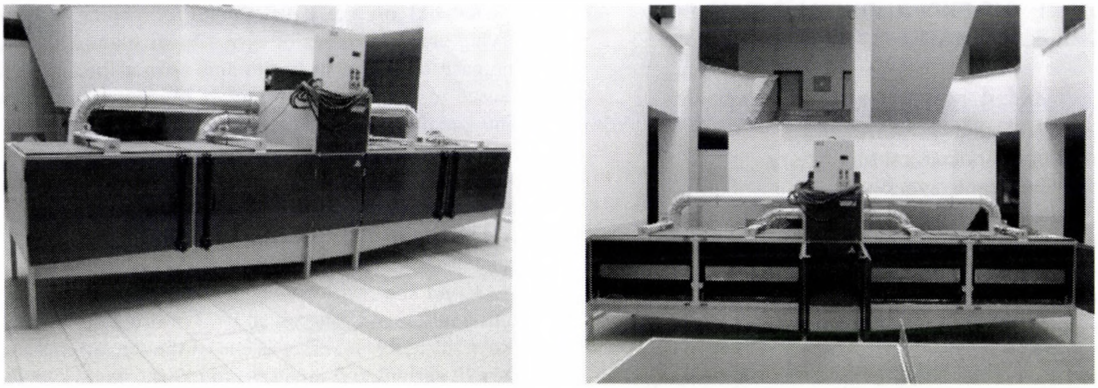

Figure 2. Outer view of the experimental dryer

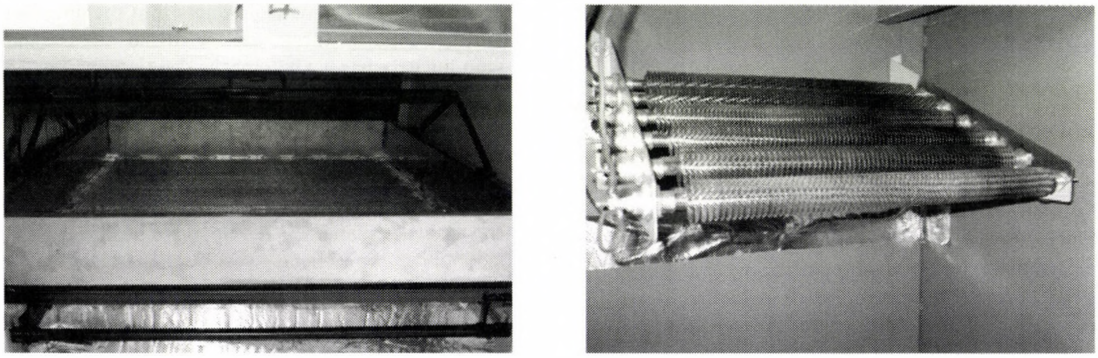

Figure 3. Shelf and heater of the experimental dryer

Micro-data loggers are located in different places in the dryer system. These data-loggers record the temperature, relative humidity and light luminance in chosen time interval continuously. Electronic drying temperature control system has the accuracy of 0.1°C between 30-60°C. Inlet air velocity is controlled by single and common clap, but outlet air velocities are controlled by four different claps for each outlet pipe, and also these four pipes attached to a main outlet pipe which has another clap. In this way; air velocity in the system can be controlled separately for each shelf or four of them together. In order to calculate drying curve exactly, each shelves weighted continuously with load-cell having accuracy as 1g. All these recorded data inputted and processed by MATLAB software.

Experimental drying system has 10 measurement points (Figure 4): 1 fresh air inlet, 1 common air outlet and 4 shelf inlets (located bottom of the shelf) and 4 shelf outlet (located in the shelf or in the pipe of shelf outlets).

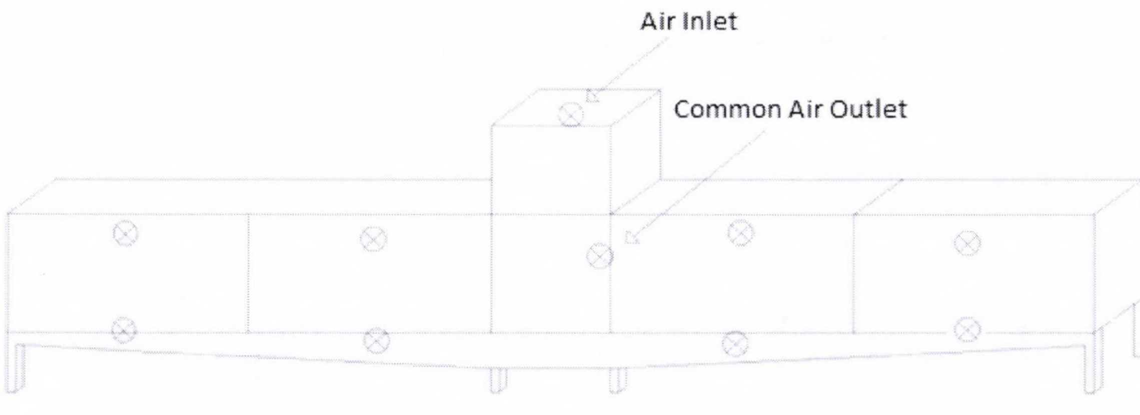

Figure 4. Measurement points

Experimental dryer system tested with Rosa damascane (Figure 5) in different drying temperature (30-50°C) and also other medical and aromatic plants such as Lavender.

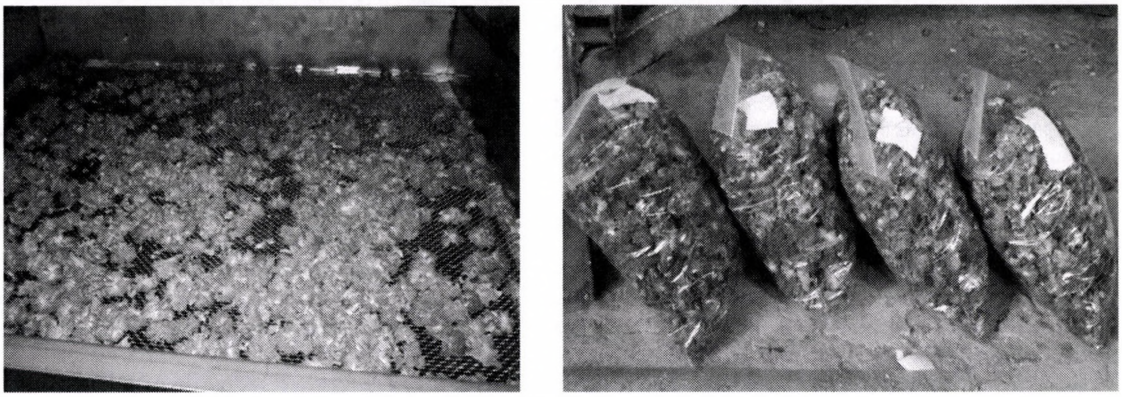

Figure 5. Rosa damascane before and after drying

Drying characteristics of agricultural products

Moisture content of agricultural products is calculated by two different methods based on wet base and dry base (Greig, 1970; Molnar, 1995; Öztekin and Soysal, 1998). Moisture content based on dry matter (X_{DB}) is calculated by dividing moisture content of product (m_M) to dry matter of product (m_{DM}) (Equation 1).

$$X_{DB} = \frac{m_M}{m_{DM}} \quad 1$$

Moisture content based on wet matter (X_{WB}) is calculated by dividing moisture content of product (m_M) to total mass of product (m) (Equation 2).

$$X_{WB} = \frac{m_M}{m} \quad 2$$

By using the relation of different values of X_{DB} and X_{WB} with respect to time drying curves are plotted in order to see end of drying. Figure 6 represents an example graph of drying characteristics of Rosa damascene in 41°C.

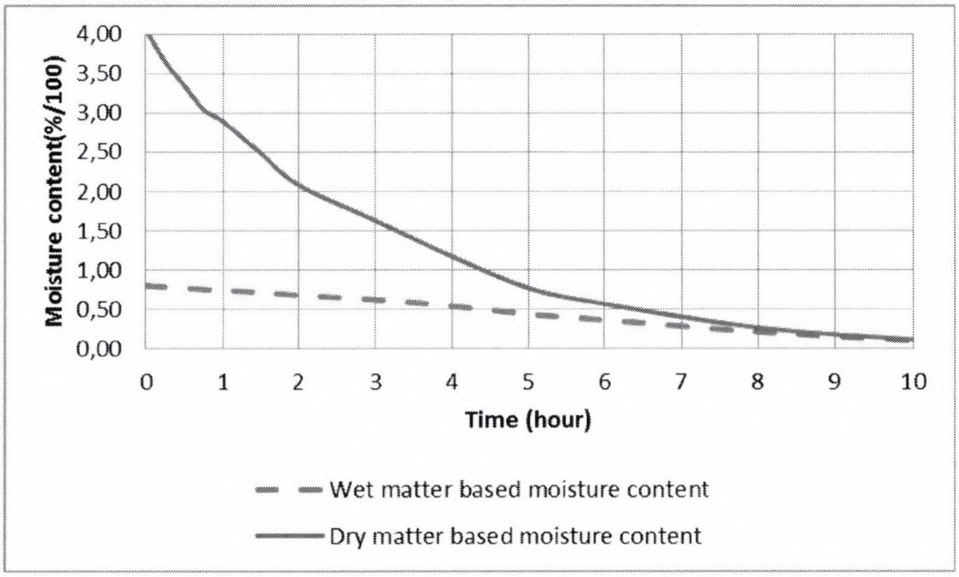

Figure 6. Drying Curves of Rosa damascene in 41°C

Also by using these drying curves, drying ratio and drying phases could be calculated. There are three phases of drying; first one is the heating and constant drying phase, second one is the decreasing drying phase and the last is the equilibrium phase (Krischer, 1963; Soysal and Öztekin, 1999; Soysal and Öztekin, 2001).

Drying ratio is also an important and commonly used parameter in drying calculations. Average drying ratio (g_{mean}, kg/m²h) is calculated by using slope of dry matter based moisture content (Equation 3) (Yagcıoglu, 1996).

$$g_{mean} = \frac{m_{Lost}}{F \cdot t} \quad 3$$

Where F (m²), is the unit drying space, t (hour) is the time and mLost is the moisture loss. Drying ratio can be plotted according to time and also % moisture content (Demir and Günhan, 2002).

Discussion and conclusions

After many experiments conducted on different medical and aromatic plants in different temperatures, it is shown that designed experimental drying system is capable to estimate optimum drying parameters and conditions mentioned. This system is capable to adjust velocity of drying air for each cage, and by this way different drying ratios in same temperature are obtained. By monitoring drying phases, end of drying (equilibrium phase) can be automatically achieved. However; in different drying air velocities, weight error is occurred. Dynamic average value method is applied to minimize the weight error.

To conclude, this developed experimental drying system for medical and aromatic plants through R&D studies is proved itself, when monitoring and automation, advanced accuracy of the device considered.

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DEFINING PHYSICAL PROPERTIES OF THE SOIL THAT INFLUENCE MECHANIZATION IN FORESTS

Tamás MAJOR
University of West Hungary,
Faculty of Forestry,
Institute of Forest and Environmental Techniques,
4 Bajcsy-Zsilinszky St., Sopron, 9400, Hungary

Abstract

In the recent years there has been a growing number of studies on soil cultivation in stumpy forests areas. However, the development and improvement of suitable soil cultivation machines is unfeasible without knowing the proper characteristics of the soils. The complex structure of soil makes it very difficult to describe its general mechanical regularities. Beyond that, the presence of stumps causes further problems to forestry. Reviewing the literature, we have found that the physical and mechanical characteristics of soils with roots are hitherto unidentified. The available scientific literature does not provide relevant information how the presence of roots affects the soil's resistance against cultivating tools.

One of our research goals was to study the physical and mechanical properties of forest soils, as well as the effect of tree roots on these physical-mechanical characteristics. We have set up correlations in order to predict soil penetration resistance.
Using mechanical and statistical methods, we have fitted a surface to the measured data points, which relates the changes of soil resistance to the diameter of the trees and to the distance from the trees.

Keywords

machine improvement, stumpy areas, soil cultivation, machines for soil preparation, penetrometer, soil resistance

Introduction

In the recent years a growing emphasis has been placed on the development of machinery providing solutions for the cultivation of stumpy forest areas (Horváth 1997, Horváth 1998). However, the development of such soil tillage machines (also called soil cultivation machines) is unfeasible without knowing the precise characteristics of the soils (Bánházi 1984, Mészáros et al. 1965, Rázsó 1958, Sitkei 1991).

Soil, being a three-phase disperse system is a mixture of solid, liquid and gaseous substances, can be charactarized with a spatially and temporally changing proportion of these components. Besides of that, the interrelation between these components is not unchanging either (Sitkei 1986). Indeed, soil can not be characterized with only one single physical or mechanical parameter. Soil cultivation machines alter primarily the physical features of the soil, while in turn the mechanical properties of the soil also have a significant reaction on the tools (Sitkei 1967, Sitkei 1981). Physical features of the soil involve textural and structural properties. Mechanical behaviour of the soil is defined by the type and extent of the deformation triggered by a distinct force (pressure, shearing stress). Regarding agricultural soil cultivation mechanical properties are of the highest importance.

Because of the inhomogenity and complex build-up of soils it is highly difficult to establish general mechanical principles for soils and to find proper mechanical parameters for characterization. The currently used paramteres for soil-characterizing do not reflect the mechanical behaviour of the soils under all possible circumstances. The relationships established from research data can not be generalized without certain restrictions (Kaifás 2006).

Regarding forestry practice the presence of roots and stumps gives rise to further problems, as these could increase the stability of the soil significantly. Reviewing the applying scientific literature we have concluded that the physical as well as mechanical characteristics of rooty soils are hitherto unknown. Our knowledge on the morphology of the root system of trees, on its arrangement in the soil and on its branching properties are all very incomplete (Csiha and Keserű 2003, Kárász 1984; Kárász 1986, Köstler et al. 1968, Majer 1958, Majer 1961). During the last decades special devices have been developed, which are suitable for soil characterization thru measuring the degree of soil compaction. Although these devices were equipped with differently shaped probes, the basic method of the measurement remained unchanged through these years (Bánházi, 2000). These mechanically-operated devices (penetrometers) record the level of the resistance required to make the probe penetrate into the soil. Mesuring soil resistance with the penetrometer is one of the most frequently applied methods nowadays to study the compaction of the soil, the depth of different compacted layers as well as the change of physical characteristics of the soil in time and space. Many researchers have concluded in their studies that soil resistance acquired with the penetrometer is a much more sensitive indicator of soil compaction than volumetric mass.

The pressurized probe can be applied in the following fields:
- examination of the effect of different soil cultivation methods and systems;
- surveying the state of soil, detecting soil defects;
- characterizing soils with different physical properties;
- measuring soil water content and soil water flow;
- monitoring long-term soil resistance changes under different cultivation systems and plant (crop) sequences.

Materials and methods

The aim of our research was to investigate the mechanical and physical properties of forest soils as well as researching the effects of tree roots on the afore-mentioned properties of the soil, that is how the resistance of the soil changes as a function of tree species, stem diameter, and distance from the stem.

As finding out the precise arrangement of the roots and their possible impact by digging up the complete root system is extremely time consuming, we have searched for a method instead which would result the required data relatively fast. It seemed evident to draw conclusions from the soil resistance measurements in order to learn about the effects of the root system.

Soil resistance was measured using the „3T System" electronic soil layer indicator, which acquires the soil's water content and compaction at 1 cm depth steps. The device indicates the water content of the soil related to the field capacity (pF 2.5) in volume percent. The compaction of the soil was determined from the penetration resistance of the probe (cone, 60°, 12,5 mm diameter) and is given in kPa unit. The device stores all the measured data which can be evaluated using a computer.

Measurement sites were assigned in the subcompartments 79/B and 80/N at the Tanulmányi Erdőgazdaság Ltd. (Sopron, Hungary). Major parameters of the subcompartments are listed in Table 1.

Table 1. Major parameters of the investigated subcompartments

Parameter	Subcompartment	
	79/A	80/B
Soil characteristics:		
- genetic soil type:	Brown forest soil with clay illuviation	Brown forest soil with clay illuviation
- physical soil type:	Adobe	Adobe
- hydrology:	Independent from water source	Independent from water source
- thickness of fertile layer:	Very thick	Very thick
Forest stand properties:		
- tree species:	Sessile oak, larch	Sessile oak, pine, hornbeam, black locust
- age [year]:	109	81
- $d_{1,3}$ [cm]:	42	28
- stems per hectare [stem/ha]:	132	480

Three stems were chosen at each of the measurement sites. Soil resistance was recorded around the assigned trees along concentric circles. The radius was increased in 0,5 meter steps until 3 meter was reached. For the sake of comparison, control measurements have also been carried out at the centre of gravity of the three stems, assuming that roots have no more influence at that point. The exact positions of the measurements have been determined (using polar coordinates) which will make a later reconstruction of the investigations possible.

Altogether eight measurement sites with 24 stems were assigned for the analysis. Experiments were designed to cover the complete diameter range of the trees of the stand. As forestry practice applies diameter at breast height to characterize stem diameter, this convention was followed (diameters at stump and at breast height can be interconverted using tables). The investigated trees were all sessile oaks.

Measurements were carried out to a maximum depth of 40 cm. Soil cultivation is basically done within this depth and the major part of the root system of trees can be found near the surface of the soil. According to Köstler et al. (1968) 65-85% of the longitudinal extension of the roots is located within the upper 10 cm of the soil. Evaluation of the measured data was done using a large number of measurements as the variance of pointwise measurements is rather high; measurement precision is greatly influenced by not-yet-rotten roots, left back from earlier loggings and by stones.

Results and discussion

The data recorded by the 3T System device was exported to ASCII files and these files were processed further using Microsoft Excel. This was followed by the statistical evaluation (correlational analysis and regression analysis) using STATISTICA software which is suitable for fitting multivariate functions and also for graphical representation of the results. The strength of the association between the variables was quantified using Pearson's correlation coefficient (r).

Figure 1 summarizes the measured data for soil resistance, variables: *var1* diameter,
var2 distance from the stem,
var3 soil resistance.

Table 2 shows the respective correlation matrix for the variables.

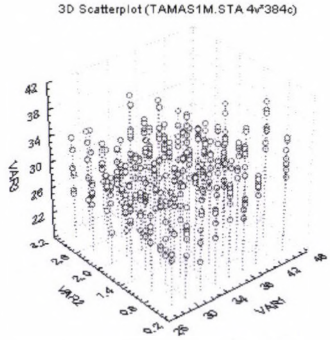

Figure 1. Values of measured soil resistance

Table 2. The correlation matrix for the whole database

	diameter	distance	soil resistance	water content
diameter	1,00	0,00	0,28	0,21
distance	0,00	1,00	-0,23	-0,19
soil resistance	0,28	-0,23	1,00	0,52
water content	0,21	-0,19	0,52	1,00

The pairwise investigation of the variables reveals that the goodness of the correlations are very poor that is there is no, or only a very weak connection between the parameters.
These results however do not preclude that some better type of correlation models could be established from the data further on.

For a better illustration of the dependence of the soil resistance from the diameter and from the distance, the soil resistance values measured at identical distances from a stem were averaged and surface fitting analysis was carried out for these average values. The correlation matrix for these average values is included in Tab. 3.

Table 3. The correlation matrix of average values

	diameter	distance	soil resistance	water content
diameter	1,00	0,00	0,40	0,20
distance	0,00	1,00	-0,49	-0,37
soil resistance	0,40	-0,49	1,00	0,62
water content	0,20	-0,37	0,62	1,00

The strating point for the surface fitting analysis was the typical second order equation of a surface. With the modification of this equation using the Rosenbrock és quasi-Newton iteration method the following equation was fitted to the data set.

$$p = a_1 \cdot r^2 + a_2 \cdot d_{1,3}{}^2 + a_3 \cdot (r \cdot d_{1,3})^2 + a_4 \cdot d_{1,3} + a_5 \cdot r^{a_6} + a_7$$

where: p [100 kPa]: soil resistance,
r [m]: distance from the stem,
$d_{1,3}$ [cm]: diameter of the stem.

The constants a_1, a_2, a_3, a_4, a_5, a_6, a_7 are the coefficients of the model. Values are summed up in Table 4.

Table 4. The coefficients of the regression model

a_1	a_2	a_3	a_4	a_5	a_6	a_7
0,077571	-0,011850	-0,000443	1,121044	0,000002	12,53775	6,555678

The value of the correlation coefficient (r) indicating the goodness of the surface fit is r=0,72213. This value can be qualified as adequate regarding the type of measured values and the surface fitting. Better values for the correlation coefficient (i.e. better model) could possibly be obtained by the further refining of measured data (e.g. using 3-period moving average models which have already been applied in economic calculations and have also become widespread in technical fields lately).

The adapted regression model does not interpret the physical relationship between the variables but is indeed capable to predict the tendency of changes and is suitable for carrying out interpolations too. While substituting the values of diameter and distance into the model function, partial equations, showing the change of the soil resistance for a given diameter and distance can be obtained stepwise.

Figure 2 depicts the fitted surface and the measured data points.

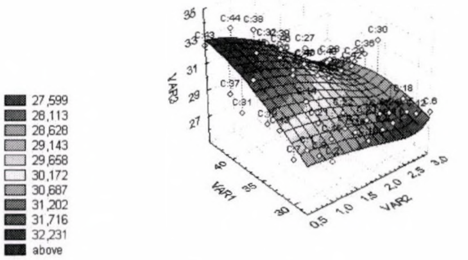

Figure 2. Connected surface

According to the measured data it can be established that around the stems in a radius of 1-1,5 meters the higher soil resistance is caused by the presence of roots. In absence of respective control locations it could not be estimated if there are any measurable differences in resistance between soils with and without roots, beyond 1,5 meters distance from the stems. In the case of stems having a diameter at breast height less than 30 cm, the influence of the root system on the change of the soil resistance could not be detected.

However, with stems having larger diameters the relation between the two parameters was not always evident either, primarily the best results have been found for single standing trees. The three-meter-sized theoretical growing space, calculated from the stems per hectare value is usually much smaller because of the natural arrengement of the trees (i.e. impact of the neighbouring trees). At these locations and at those sites with higher stems per hectare, soil reistance proved to be relatively uniform due to the evenly distributed root system throughout the soil of the whole subcompartment.

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INTERACTION OF PLANNING, MANUFACTURING AND MACHINE MAINTENANCE

Ibolya ZSOLDOS[1], József JANIK[2]
[1]Department of Material knowledge und Vehicle production, Széchenyi István University, Egyetem-tér, Győr, 9026, zsoldos@sze.hu
[2]Institute for Mechanical Engineering Technology, Szent István University, Páter K. u. 1, Gödöllő, 2103
janik.jozsef@gek.szie.hu

Keywords

Decision preparing, machine investment, machine operation and machine maintenance costs, optimum service-life, virtual machine substitution, rejection, reliability.

Introduction

We want to present in present article as a case study based on our data measured at some agricultural companies chosen representatively, that by analyzing the costs arisen during the operation cycle of high cost machines drawn into the experimental work the company management what technical-economical conclusions should consider for the sake of maximizing the profit.

We have worked out a machine operation professional user-friend system [3., 4] aided by computer in order to manage the task on company level, which doesn't need special theoretic knowledges, because after entering datum into the computer the informational parameters needed to the decision preparation are generated automatically.

The computer system is based on the theoretical work [1., 2] elaborated already earlier and is formed by the following more important mathematical connections.

1. The material flow – in general turnover energy – flow – balance equation of the company (as a system):

$$X(t_N) = X(t_0) + U(t_0, t_N) - Y(t_0, t_N) \pm K(t_0, t_N)$$

where:

- $X(t_N)$ = the condition characteristic of the system at a given tN time,
- $X(t_0)$ = the condition characteristic of the system in the starting time, in the starting time of the operation of the system,
- $U(t_0, t_N)$ = the totality of inputs flow into the system in the examined time interval,
- $Y(t_0, t_N)$ = the totality of outputs flow out from the system in the examined time interval,
- $+ K(t_0, t_N)$ = the totality of finished products ready to transportation produced in the system in the examined time interval, meaning the products and can be marked as source,
- $- K(t_0, t_N)$ = the total costs needed to operate the system respectively needed to produce products in the examined time interval which can be interpretated as swallower according to system-theory.

2. The regulating balance – equation that can show the process efficiency at same time:

$$\Delta V(t_0, t_N) = V_{Kf}(t_0, t_N) - V_{Kr}(t_0, t_N)$$

where

- $\Delta V(t_0, t_N)$ = the regulating variable characterizing the given process which can have got financial and natural characteristics, it can also be the target function expediently of the company as company profit,
- $V_{Kf}(t_0, t_N)$ = is the result of the given process (for example: motor-cycle, tractor, washing machine, etc.) in general as sources, and the elements can have got natural or financial characteristics.
- $V_{Kr}(t_0, t_N)$ = is the needed costs to maintain the given process (for example: sheets with different materials, steel and plastic rods, castings, semi-finished and finished product available in the commerce, various energy sources, etc.)

3. The specific parameter representing first of all the determination of the optimum service-life and is the basis of the appreciability according to the given technical-economical process. Where the specific cost reaches the minimum there is the maximum of the attainable profit.

$$k = \frac{V_K(t_0, t_N)}{T} \rightarrow \min imum$$

where:

- k = is the specific parameter of the given process,
- $V_K(t_0, t_N)$ = can be any member on the right side of the equation in the No.2 point, as it can be equally important specific value of both the result (source) and of the smallower (cost), but the change of them in particular,
- T = the value of such element characterizing the given process which can be determined objectively and so the specific parameter can be used correctly to evaluate to qualify respectively the company activity. So the T can be for example number of pieces, time, km, etc.
- t_0 = is the moment meaning the beginning (the operation of the system) of the given process,
- t_N = is the moment meaning the end of the system operation.

4. The transformation operator of the given process by using it the work done with a chosen so called basic machine is carried out in the computer simulation process with another machine, what can be called virtual machine practically.

$$\bar{\Delta} = \begin{bmatrix} \Delta(t_1) \\ \Delta(t_2) \\ \Delta(t_3) \\ \dots \\ \Delta(t_N) \end{bmatrix}$$

where

- $\bar{\Delta}$= is the transformation operator of the process,
- $\Delta(t_i)$-k = are the multiplication parameters belonging to the given year.

Practical experiences and results applying the model at the company

To verify the practical applicability of the model such large companies were looked for already having several year's data and were ready to take part in the experimental work, so 4 agricultural companies were chosen.

We choose with mutual agreement those machines to be drawn into the examination. These were tractors with various power, combines, ensilage harvesters, in number 60 pieces.

We put down in Table all those data composing the datum of determining the characteristic parameters according to the balance-equations and identifying the machines belonging to one-one company. It is noteworthy that the non-public data (for example the names of the companies, the names of machine manufacturing companies and types of machines manufactured by them) can occur in coded form as naming them can allude to legal questions. Taking this into account we don't make known such data neither here.

Data base and processing

The datum base consists the following main – measurable – data:
- type of the machine, its power, its naming,
- the purchase cost of the machine,
- the purchase year of the machine,
- the material cost used to repair the machine,
- the material cost used to the maintenance of the machine,
- the working hours and wage spent on maintenances and repairs,
- the different works done by the machine,
- amount of fuel, lubricant used and their costs,
- the social security contribution on wages,
- overheads,
- etc.

As a result of arranging and processing the datum [4] such parameters, indicators can be determined giving objective possibility to characterize technically and economically the given machine. During the experimental work we drew conclusions based by analyzing the machine maintenance – and machine operation characteristic curves from among parameters determined by means of measuring, grouping of more than 25.000 data. Figure 1 shows process of the data collecting and processing.

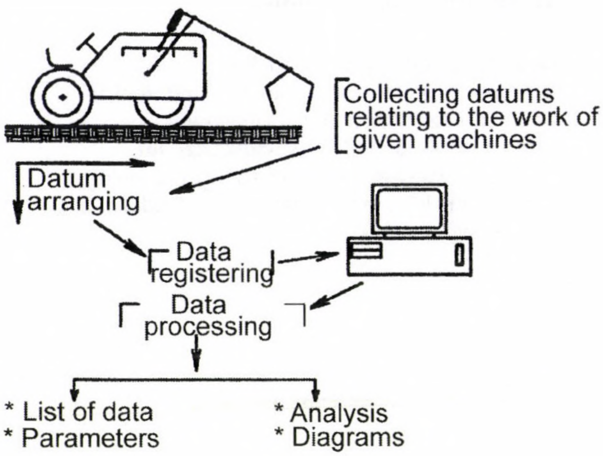

Figure 1.

Results

We indicated partly the specific machine operation costs and partly the specific machine maintenance costs in the function of the work done by them in Figure 2 and 3. We indicated the work done in nha (normal hectare) on the horizontal axis. The normal hectare is the unit indicator of different agricultural works (1 nha =25,315 KWh). We indicated the specific machine operation cost (c_{smv}) in Figure 2, and Figure 3.a, and the specific machine maintenance cost (c_{smm}) in Figure 3.b on the vertical axis.

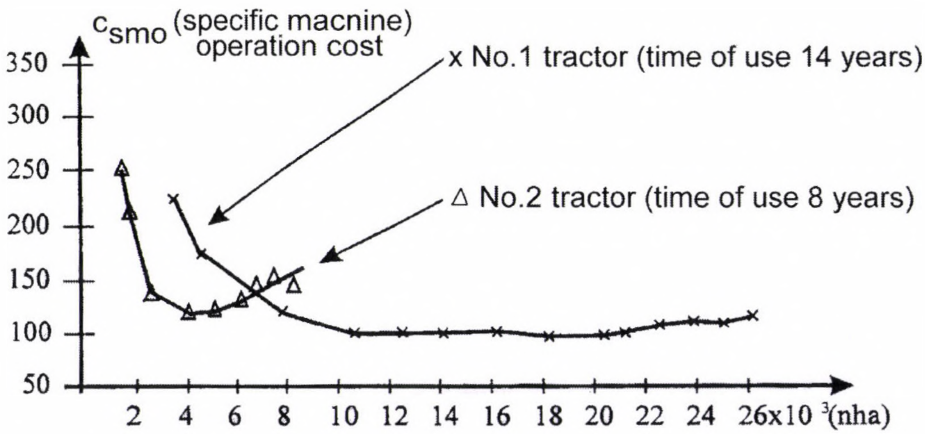

Figure 2.

The machine operation characteristics of two kinds of caterpillars made to carry out quasi-similar tasks can be seen in Figure 2, and the following conclusions can be made:
- the No.2 tractor operates with very favourable cost as reaching the surroundings of the minimum has got constant value during long time with small fluctuations (between 12 000 and 22 000 nha), and the cost is smaller than No.1 tractor,
- further advantage is for the operator that the machine with horizontal characteristic operates on optimal level for a long time and so the time of machine change is shifted to a longer period as against the No. 2 machine which reaches the minimum already at the surroundings of carrying out 4000 nha work and its further operation results profit reduction for the company,
- the No.1 characteristic machine is also very favourable for the manufacturing company because its market demand has got indisputable advantage as against the No.2 machine,
- the No.2 machine has got disadvantage to both to the operator and to the manufacturing company actually. It has got disadvantage for the operator because after starting up the specific cost reaches the minimum rapidly then increases rapidly. The operation during longer period of such machine is partly very expensive partly the incline of the curve requires quick capital mobility to change such machines.

  However it has got disadvantage for the manufacturing company because the customer will give preference to the No.1 machine.

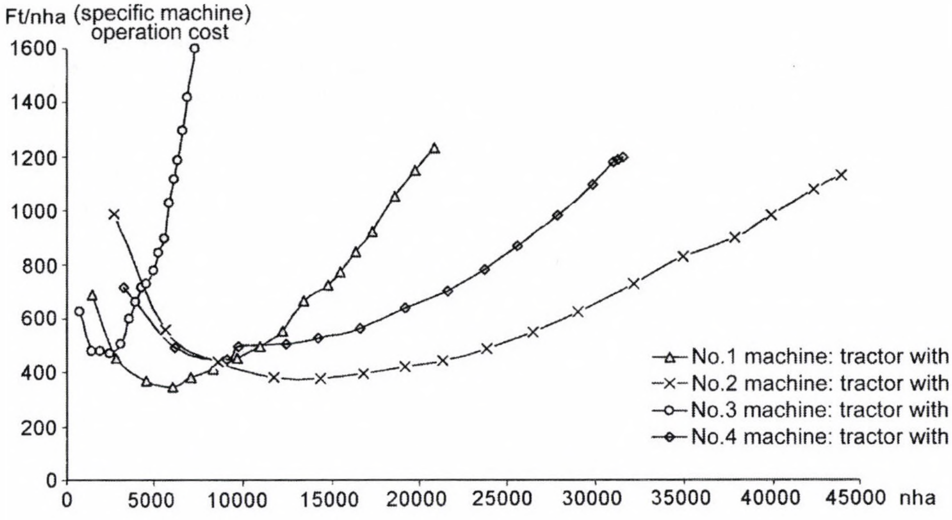

Figure 3.a.

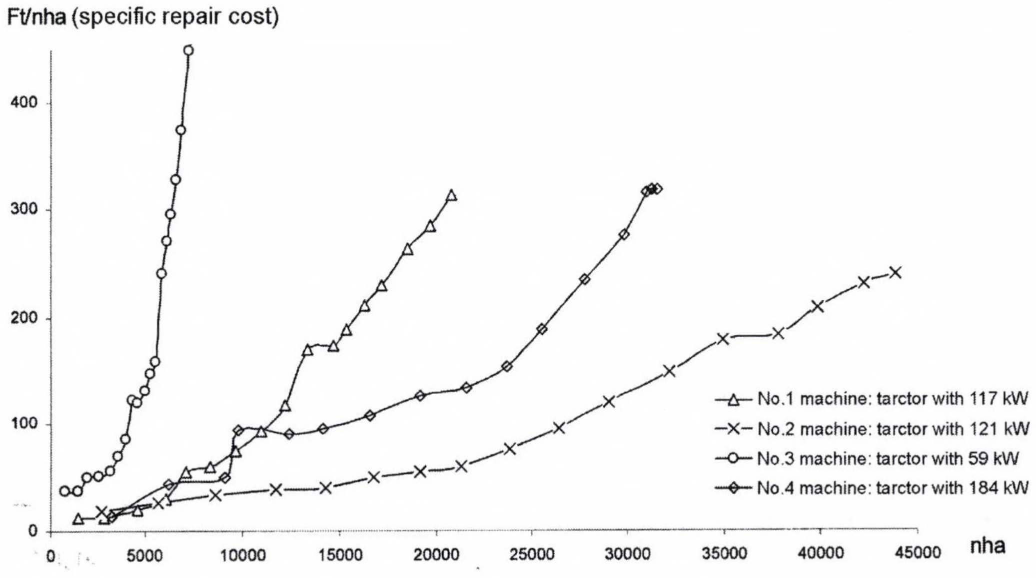

Figure 3.b.

Specific machine operation – and repair costs' characteristics of 4 pcs. wheeled tractors with various products and powers can be seen in Figure 3.

Based on taking into account the parameters the No.2 machine can be qualified as the most favourable in long period. The a figure and also the b figure support this. However the No. 1 machine can be qualified the best in short period surely that machine has got the most favourable optimal specific cost. The transformation operator ensures the more objective help how to take into account the time horizon at the investment strategy of machines performing nearly the same tasks.

We present in Figure 4 that the comparison in pairs of the No.1, No.2, No.3 and No.4, No.2 power machines shown in Figure 3 to what conclusions give possibility.

The Figure 4.a shows unambiguously that concerning the final result in case of long range operation there is no difference between the two machines, well the costs are almost the same in case of operation beyond the crosspoint (t_m) of the operation characteristics. It has to indunce thinking the investor that the basic machine requires significantly smaller investment cost than the virtual machine. The suboptimum at t_m thus calls attention sharply to the importance of the long range strategic decisions.

The Figure 4.b shows a typical case. Namely there is a definite difference between the two operation curves before the crosspoint (tm) and also after it. The economic strategy in such case is the following: if the expected operation time is not longer than t_m (it is near to it respectively) the No.3 machine is chosen, surely it can be seen well at the starting costs that the capital investment demand of the No.3 machine is significantly smaller than the No.1 machine. The savings is substantial which can be utilized favourably by the company at other profitable investment. The company decides beside the investment of the No.1 machine however in that case the expected operation time is much longer than t_m.

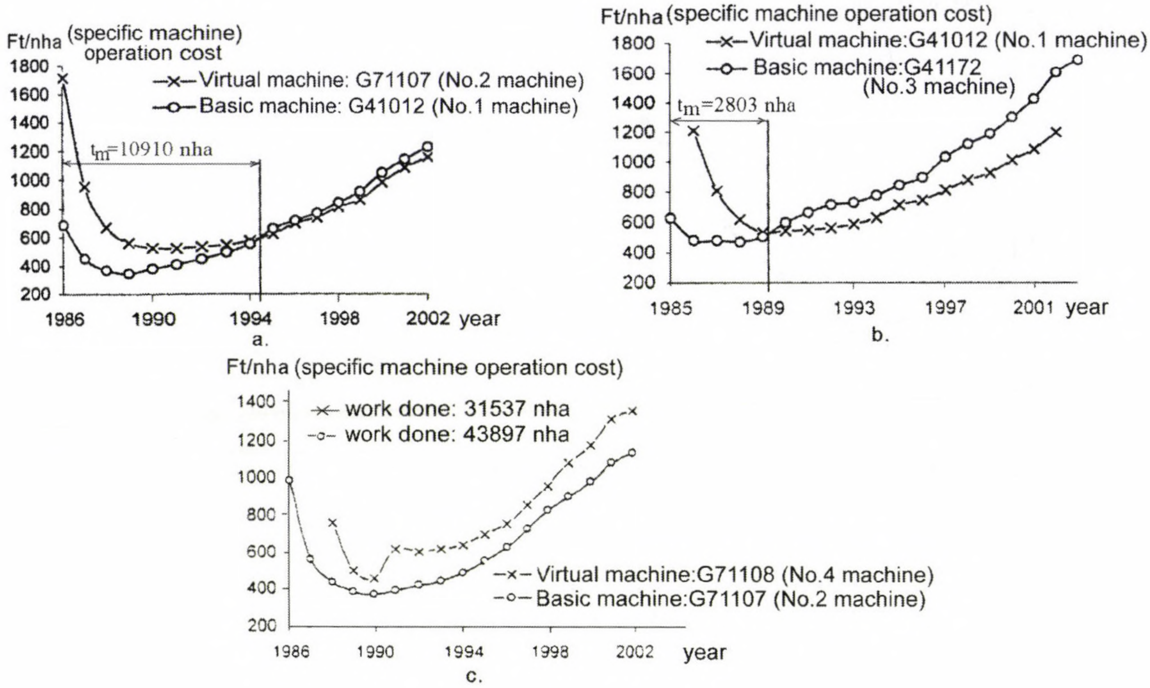

Figure 4.

The Figure 4.c shows that special case when it is evident totally that the No.4 virtual machine can't be the strategic alternative of the No.2 basic machine.

Summary

The technical-economical parameters provided by the model worked out by us prove that the working application of the Zsoldos-Janik computer machine operation professional system is established, provides objective information for the designers, manufacturers, sellers and operators of high cost machines with different types alike.

That is also natural such enormous system can't be acquainted with such detailed level which would make possible also to know the particulars, so we could only aspire to present the theoretical structure and application of the system-theoretic model.

The greatness of the company doesn't limit the application of the model that fact increases its importance , well it can be applied effectively just like in case of one-two machines, too.

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THE CHARACTERISTICS OF THE INNOVATION ACTIVITY OF THE HUNGARIAN AGRICULTURAL MACHINERY MANUFACTURERS

Árpád BAK, István HUSTI
Institute of Engineering Management,
Szent István University
Páter K. u. 1.,Gödöllő, H-2103, Hungary
Tel.:+36 28 522 044,
E-mail: bak.arpad@gek.szie.hu, husti.istvan@gek.szie.hu

Abstract

The current production of the Hungarian agricultural machinery manufacturing sector, which used to see better days, lags behind the production of the previous years to a great extent. The organisational structure of the Hungarian agricultural machinery production has totally been transformed, primarily regarding its ownership structure. The general problem of this sector is that they can only spend slight amounts on development an innovation relative to foreign-owned concerns. As a consequence, loss of market is not surprising as a bit more than one-quarter (26-27 percent) of the current total domestic market turnover derives from domestic manufacturers. The extent of market loss and the general situation of the national agricultural machinery manufacturers justify that the present of this sector must be dealt with by searching the ways-out of the crisis and make steps to develop. Our study reveals some of the results of longer research work. To help finding the way-out of the present crisis the success factors of the innovation activities of the domestic agricultural machinery manufacturers are presented and the factors that hinder innovation are also classified.

Keywords

innovation, agro-technical development, key factors of innovations

Introduction

It is an empirical fact that besides the financial constraints, other problems also prevent the national technical innovations from being successfully developed. In Hungary the total expenditure on research and development reached 299.5 billion HUF in 2009, which was 1.14 percent of GDP (= GERD indicator).It means a 12.3 percent growth relative to the previous year at current prices (Statisztikai Tükör, 2010). The share of the state of the GDP-related R&D expenditure is 0.42 percent of the total sum (state-owned research institutes and those in higher education altogether) while the expenditure of the business sector amounts to 0.58 percent of GDP. This proportion has been improving relative to the previous ones or, rather, approaches the international practice. However, approximately 60 percent of the R&D expenditure of the national business sector is realised by exclusively foreign-owned enterprises or those which are mostly in foreign hands (KSH (Central Statistical Office), 2007). In most of the developed countries the national companies spend more of their revenues on R&D expenditure than the foreign-owned ones. The high-level concentration of corporate R&D can also be observed: almost half of the expenditure derives from 17 big companies. The share of those employing fewer than 20 employees is only 12.6 percent. Unfortunately, in the sector of the national small-and medium-sized enterprises not only research and development but also the number of licenses and know-how purchase is slight, so the demand (pull) side of innovation is weak under the present system of conditions. All this is justified by the following facts:

- **72-74** percent of the segment is **inactive** regarding innovation or simply struggle to survive.
- **22-23** percent belongs to those **catching-up**, i.e. they show some initiatives in innovation that could prevail in the standard of their products and services by means of technological transfer, information and advisory institutions.
- Only **3-6** percent of companies make up the group of **promising** innovative companies (Losoncz, 2008).

According to our experience the above-mentioned facts can also hold true for **agro-technical** innovations more or less. Before the change of the regime only **27** agricultural machinery plants operated mostly "embedded" in the system of the national "agri-business". Due to this fact (among others), 60 percent of the requirements for agricultural machinery in the country were covered by these plants at a more advanced standard than the average of the former Comecon countries. During the past 15-20 years the organisational structure of the Hungarian agricultural machinery production **has totally been transformed**. Generally, the machine manufacturers operating as small-or medium-sized enterprises appear on the market with "separate" products usually not developed by themselves. Consequently, they are not price-setters, rather price takers. The product line of the companies that are successful in the international competition primarily consists of mass-produced and highly automated products. The national agricultural machinery manufacturers-partly due to their size- are not able to mass-produce in such an extent that they could compete with the West-European, American and Asian companies of huge capital power either in productivity, price or product range. A drastic innovation wave could mean a break out of this situation. Regarding **innovation**, the national agricultural machinery manufacturers also significantly lag behind as they can only spend slight amounts on development relative to foreign-owned concerns. As a consequence, loss of market is not surprising as a bit more than one-quarter (26-27 percent) of the current total domestic market turnover comes from domestic manufacturers.

In the first part of our paper the method of the empirical research is presented where the structure of the questionnaire used in the research and the process of data record are shown in details. Furthermore, of the results of the research based univariate descriptive statistics those of the success and hindering factors of corporate innovation activity are published afterwards.

Methods

Our examinations are mainly based on primary research. When formulating the research objectives, we relied on the theoretical conclusions drawn from the related specialist literature, earlier professional publications, empirical research results as well as our own professional experience. The basic objective of the research is to explore and analyse the innovation activity of the national agricultural machinery manufacturers, its results and influencing factors. Finally our objective is to have a picture of the innovation activity of the organisations involved, the special features of innovations, the partners taking part in the processes and the impact of innovation on the general situation of the companies through our examinations. Besides the brand-new or significantly developed products and technological procedure innovations, organisational features, marketing activity and the environment of the innovation are also considered. The questionnaire serving as the basis of primary research embraces three years, from 2007 to 2009. According to the estimations of experts the number of agricultural machinery manufacturing companies is between 160 and 170 in Hungary. (A great part of the enterprises are involved in more than one activity: a lot of predominantly small enterprises are also engaged in other activities besides machinery production so that is why it is difficult to define the actual number of 'agricultural machinery manufacturers' exactly). Most of the organisations that are subject to our analysis are small enterprises whose annual revenue does not reach one billion HUF. As there was not an available list on all the companies on the basis of which a pattern of probability could have been compiled, the companies that could be drawn into the research had to be defined in another way. To find the companies necessary for carrying out the questionnaire, the address list of MEGOSZ (National Association of Agricultural Machinery Manufacturers) served as a basis and the heads of this professional organisation were also consulted. In the data recording phase of the research a multi-channel approach was applied whose main points are:

- 15 machine manufacturers (hopefully the most significant companies of the sector) were questioned at personal in-depth interviews;
- 20 organisations were provided with a questionnaire sent by post requiring them to send back the material filled in;
- 9 of the 25 organisations were part of on-the spot discussion either because of the difficulties they faced while filling in the questionnaire (3 cases) or because the interpretation of the responses required further information (6 organisations).

Sample-taking cannot be regarded **representative**. However, during the research it was not our objective to draw conclusions that can be generalised for the basic population. Our basic objective was to give a thorough examination of innovation activity and to achieve it, we tried to select the organisations regarded to be suitable on the basis of preliminary professional considerations. As such a thorough examination dealing with the innovation activity of agricultural machinery manufacturers was not carried out in the past 25 years on a national level, we consider our research is **to resolve discrepancies in the professional field.**

In compliance with the general methodological requirements first of all some pilot questions were asked on the basis of which the questionnaire was finalised. Data recording took place between March 2010 and September 2010. The duration of in-depth interviews was various, typically 90-100 minutes per interview. A positive feature of them was that data providers mainly come from the senior management (chief executive officer, head of production or technical manager). In this way first-hand information on the general situation, actual projects and strategic plans of the organisation involved was gained besides the reliability of data. The atmosphere of the interviews was typically of honesty and intimacy. Some of our interviewees have already expressed their enquiry in our results. The questionnaires compiled on the basis of the interviews and sent out **by post** were also accompanied by a guide to filling in. A kind of evaluation of our preliminary work is that all the responding organisations gave answers that could be assessed. The statistical processing of data recorded by the questionnaires was carried out by using **SPSS 13.0** programme.

Results

a) Factors that hinder innovation

When examining the results (**Figure 1**) it is not surprising that most of all it is **the high cost of innovation** (3.42) that prevents Hungarian agricultural machinery manufacturing companies from their innovation activities like in the case of other companies in West Europe and other sectors of industry. Controlling innovation costs is rather problematic due to the uncertainties of the different sub-processes and their parts as unexpected costs can incur very frequently. **Lack of state and project funds** (3.08) is another significant hindering factor. However, our EU accession opened ways to innovation development sources but due to financing difficulties (slight share of own capital, credit regarded to be risky) only few agricultural machinery producers gain access to EU development funds. The **separation of financial funds within the company** (3.08) is a problem tightly linked to the previous one. A frequently made excuse is that the available funds are needed for other purposes so due to the necessity of ensuring everyday living uncertain developments are often sacrificed. High risk (2.81), taxation and its legal regulation (2.77) and the weakness of protecting intellectual property rights (2.28) are also seen as further obstacles.

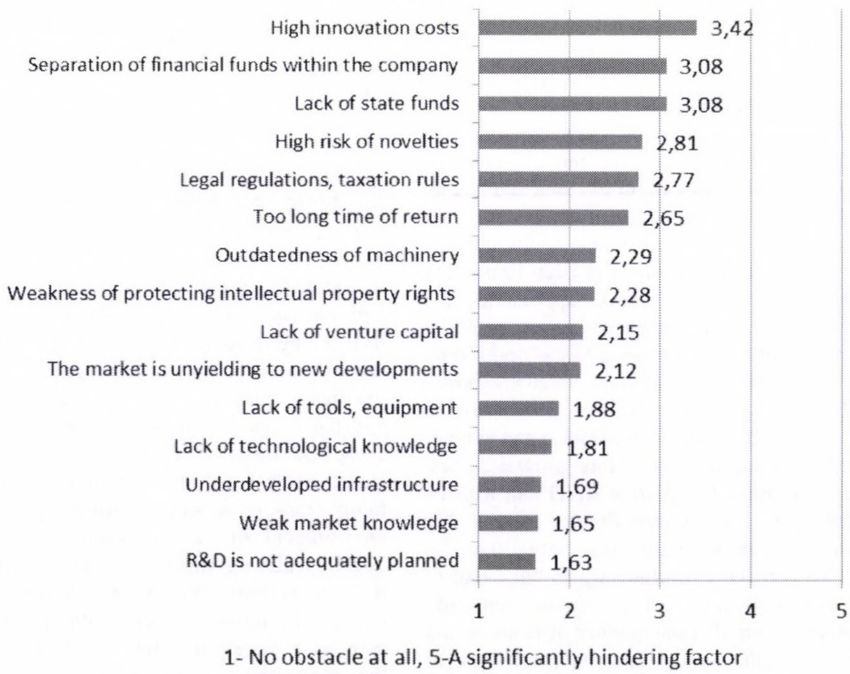

Figure 1. Factors that hinder corporate innovation (Source: own compilation)

(When looking at the gained results it can be discerned that the respondents ranked the impact of even the strongest hindering factor to be approximately 3.5. This can be due to the special nature of the scale and the questionnaire as a statement with a negative content had to be evaluated.)

We also examined the **human factors** within the hindering factors of spreading innovation separately (**Figure 2**). The results are obvious as the factors in connection with lack of professionals and training are among the five most significant hindering ones. Unanimously the responding chief executives lack of professionals and training are among the five most significant hindering ones. Unanimously the responding chief executives lack **„good vocational staff"** most typically for welding, CNC operator, mechanic and cutting positions.

Figure 2. Human factors that hinder corporate innovation (Source: own compilation)

As far as graduates are concerned, there is a more intense need for traditional agricultural mechanics with language knowledge and production technician. The absence of technical professionals can **go back to several reasons:** the pulling power of other sectors regarding labour force is a problem and, furthermore, the small and medium sized agricultural machinery manufacturers cannot compete with the wages offered by the multinationals. As a further unfavourable process it was also mentioned that for the young it still was not too appealing to find placement at an agricultural machinery manufacturer in the countryside so labour supply often cannot be provided. Our findings also reflect that **according to the chief executives the motivation of their subordinates does not hinder** innovation processes. Interviews highlight that there was no resistance experienced among the employees (including the vocational staff of workshops), what is more, they are interested in a novelty, new developments and at several places new ideas are rewarded. **The managerial approach against novelties** (1.2) was ranked the lowest of the different hindering factors. It is important to note as the literature on innovation management regards the support of the senior management as one of the key criteria of successful innovation, which, in more details, means making the necessary resources available, risk taking, creation of an atmosphere that supports creativity and an adequate system of incentives, monitoring the development process and participating in decision making at the key points most of all.

b) The success factors of innovation

In our questionnaire **the criteria of the success of innovation** were also analysed (**Figure 3**). An answer was sought to the question what factors the companies regard as the most essential ones for their successful innovation activities. Unanimously participation in **professional exhibitions** (4.32) was selected as the most significant success factor of implementing innovation. There can be two reasons why exhibitions are appreciated. On the one hand, the companies and their management can obtain first hand information on the developments of their competitors and the current market trends and it is also regarded as the primary means of marketing activities by the manufacturers as there is an opportunity of getting acquainted with new types, developments, different product and machinery (test) demonstrations in a concentrated form close to the potential customers, on the other hand. The ability of a quick technological reaction (3.93) was also regarded essential by the manufacturers in the innovation competition. The companies that are willing to take quick steps can closely monitor consumers' needs and can also overtake their competitors. Also, the ability of quickly rectifying a decision made possibly badly is important. To this end, the company must continuously monitor the newest technological solutions and the results of their competitors.

The **further professional training** of employees was ranked relatively high (3.75) among the key factors of innovation. According to our experience a great part of the national agricultural machinery manufacturers does not have strategic plans and ideas on human resources management in its classical sense. The gained results stress that the managers realised that they were somehow forced as the development of products and technologies also requires the necessity of training the engineers who develop and run them together with the vocational staff. That is why the above mentioned visits to professional exhibitions and fairs are a must together with exchanging professional points of view and organising further trainings for the employees. In some areas of vital importance such as product development, modern CAD technology and its application, optimising material content and TQM, regular updating and broadening knowledge is essential. At least organising the further trainings for SME managers and leaders is of similar importance. Courses, meetings and forums that shape attitudes, approaches and prepare the managers for managing innovation processes can help the creation of an atmosphere at work and a corporate culture that favour innovation. In the case of a small or medium sized enterprise the corporate culture must be adequate to retain the valuable employees and run efficiently as besides salary, corporate atmosphere, employee relations and those with the head of other companies are also decisive for the employee. The creation of common innovation projects **with universities and other research institutes** (3.04) came last in the system of success factors but, of course, satisfactory did not mean degradation. The weak flow of knowledge between university and corporate spheres is not only the problem of this sector, e.g. European paradox, which is not a comfort in this concrete situation. The problem is quite complex and several research was conducted in it. In our paper only the problems of the sector are highlighted. Although technology transfer offices operate at main universities whose task would be to establish and maintain contacts with companies and assist professors in creating corporate contacts but mostly their typical activities embrace keeping an eye on national and international project applications and preparing the applications of the employees of the university. It must also be noted that often the motivations of universities and those of the companies are in a conflict. The interest of the company is profit making in the short and medium run and strengthening competitiveness in the medium and long run. Further points are subordinated to these guiding principles in cooperation most of the time. The short and medium run motivations of the research institutes are mostly directed at including additional financing sources, solving a scientific problem or accomplishing the compulsory publication tasks. Universities, which themselves cope with quality capacity problems due to the increase of teachers' assignments and mainly outdated laboratory equipment, conduct their external research commissioned by a big corporation. (It is also general that part of the funds deriving from it is spent on financing „daily" operation instead of spending on research projects.) The **partnership between the competitors and development cooperations** is underranked in the sector (2.54). There are no forms of cooperation or partnerships; usually there are no agreements on cooperation, consortia and networks between the companies. In our opinion there are **still significant reserves** in this area. The partnership of companies provides further opportunities for the small and medium sized enterprises as participants to reduce their expenditure on certain areas such as technological investment, common procurement, developing foreign market relations (leaflets, advertisements, participation in exhibitions) joint marketing activity etc. besides sharing knowledge and technology transfer.

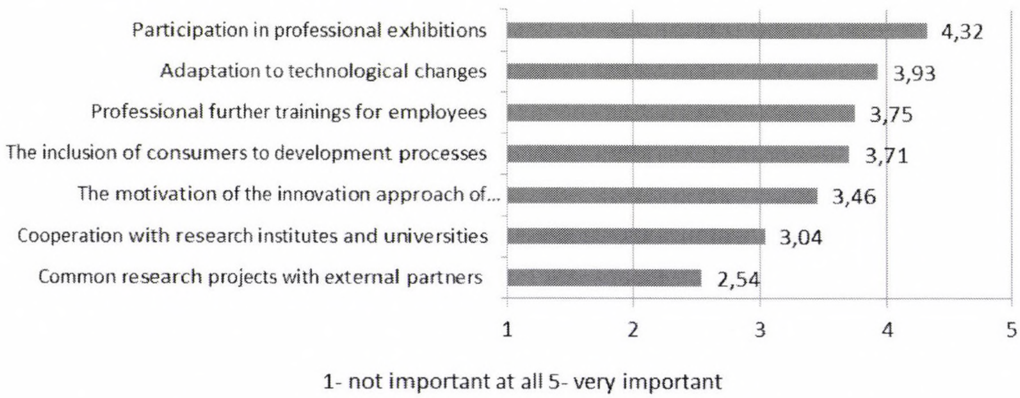

Figure 3. The success factors of innovation and R&D activity (Source: own compilation)

Conclusion

The characteristic features of the companies that were involved in the examination reflect the Hungarian conditions properly. Innovation is the key factor in catching up as it is the engine of developments. During the examination of innovation processes special attention must be paid to the market factors that especially help or hinder innovation activities. The exploration, identification and combatting these factors are primarily the tasks of the manager and our paper wishes to make a little contribution to their work.

The following must, by all means, be highlighted of the success and hindering factors of innovation explored during our analysis:

- **The high costs of innovation**, lack of financial funs within the company and the unfavourable system of state and project funds are such determining factors that can significantly limit the innovation scope of the national agricultural machinery manufacturers.
- Our examination justified the problem according to which the most acute problem of the sector is **lack of vocational employees.** Downsizing that can be experienced in the past 20 years makes it extremely difficult for the competitive agro-technical supporting industry to be established in the long run. It is obvious that the development and operation of the complicated agricultural mechanisms and technical subsystems is not viable without skilled staff. New expectations are formulated for the employees in accordance with the altered situation of small and medium sized enterprises. The single work phases require basics from several other scientific branches and besides biology and chemistry, economics, technical-technological and managerial skills are also essential. As far as the lack of vocational training is concerned, vocational schools such as educational institutions at different levels and even adult training institutions are given some tasks. Technical innovation is typically such a professional area where the halving time of knowledge is quick so there will always be a need for such training schools that impart updated and competitive knowledge.

- According to most respondents markedly one of the main bases of the **successful** innovation activity is visiting professional **exhibitions**. Manufacturers realised that machine exhibitions and fairs nowadays played the role of a complex marketing tool. They are a channel of communication through which the buyer and the seller can meet in time and space. These events can be regarded as a media surface for the manufacturers that helps companies with communication. The companies as an exhibitor can target certain groups of potential customers with their message. Moreover, they can also present their technical solutions at different machinery presentations and tests. At the same time, keeping an eye on the competitors and getting acquainted with the clients' opinion are a good way of orientation to innovation.

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SYNERGY OF INTEGRATED ENTERPRISE RESOURCE PLANNING WITH ECONOMIC RELATED GEOGRAPHIC INFORMATION SYSTEM

Krisztián KISARI, József CSERNÁK,
István TAKÁCS
Károly Róbert Főiskola, H-3200 Gyöngyös, Mátrai út 36.

Abstract

From technical and economic aspects the study examines that how the version of the most advanced GPS-based positioning system developed for agricultural is able to help the companies in the practice and how it collaborate with ERP systems. The provided data by the system make available for direct (online/offline) database building, not requiring manual recording of data, and link it to other databases, and provide a possibility for several further economic analysis based on these data. The aims of the research are:

- defining the structure of the database based on the requirements by the corporation;
- identifying and organizing the manageable tasks and methods during management, (process) monitoring, decision establishment;
- measuring the required data needed for the databases;
- describing further options and possibilities.

The study covers not only the recording the data of the machine operation, but also facilitate the optimization of production process and evaluate the possibilities helping protection of corporation property as well as installing it to ERP systems.

Objective

The authors of the examined bibliography agreed that information – similar to capital or labour (i.e. human capital) – has become a resource. Information management is not only the science of management information system, nor the technique of creating end user software, nor just informatics or system organization, but all the aforementioned jointly. Probably somewhat more than these: an approach, economic technique for economists, system organizers and engineers, whose aim is a cheaper use of information resources and making a better use of the corporate information assets. (DOBAY, 2003.)

Multi-faceted information and the smooth flow of these among the interlinked areas concerned are indispensible of creating and maintaining the economic system of a company. Information flowing within the company appears in various shape and ways, and requires differentiated management according to their characteristics. (PARÁNYI, 1999)

For a company to be competitive and successful, several resources are needed. According to ANTAL-MOKOS (1997) et al. resources are the inputs of a company's value chain that could be interpreted most widely; i. e. includes all factors that are needed in production and service activities. Such resources are labour, raw material, energy, capital and eventually information, knowledge. (KOPÁNYI, 1991; ARATÓ – SCHWARZENBERGER, 1993).

The role of information increases in each and every sector of social life, in education, in public administration, in research and development, in entertainment, and last but not least, in the economic life, production and services as well. Information as a resource is created, communicated, used, maintained, retrieved, re-used, re-wrapped, re-communicated and made available in the life-cycle of information. (CHIKÁN, 2003). RAFFAI (2006) also highlights the resource aspect of information and that information has to be produced, purchased and used similar to other resources.

Business-intelligence software can gain data from diverse sources, ensuring their plenitude and redundancy-freeness. These software can implement reports and focus on the main competencies of the company. Additionally these can proactively identify, provide priorities to and solve problems. Moreover, these can improve organizational cooperation, increase the exploitation of resources, and help in elaborating fact-based decision making methods that apply to the entire organization. Corporate proceedings become more transparent, more information is available and the consistency and accountibility of operational processes increase.

Harmonic collaboration between GPS systems and corporate information systems could play an important role in achieving, promoting and maintaining these.

In case of agricultural companies in Hungary, the I'tineris Ltd. has the biggest market share among the companies dealing with GPS technology; almost 600 companies use their system. The activities of the company cover the neighboring countries, too. In the research, the company was reviewed as software developer.

Materials and methods

Information was revealed via conducting depth interviews. The depth interviews were conducted among the leadership and the affected employees of the user company, and also the leadership of the merchandiser, service providing company.

Besides the leadership of the software developer, service provider company, the research also included leaders and nearly 30 employees (end users, operators, administrators, middle management, quality management executives) of 5 agricultural companies.

The companies that were subject to the query belong to the significant agricultural companies of the Northern Great Plain Region.

The software developer company in the survey has the most significant market share in merchandizing GPS technology.
The interviews covered 6 main areas: logistics and controlling, cost efficiency, safeguarding assets, planning, and collaboration with ERP and user support.

The responses were ranked on a scale graded 1 to 5, thus numeric values were assigned to the responses, which enabled the use of quantitative statistical methods.

Result and discussion

Based on the Figure 1 significant difference can not be found among logistics and controlling, cost-efficiency, safeguarding of assets and user-support.

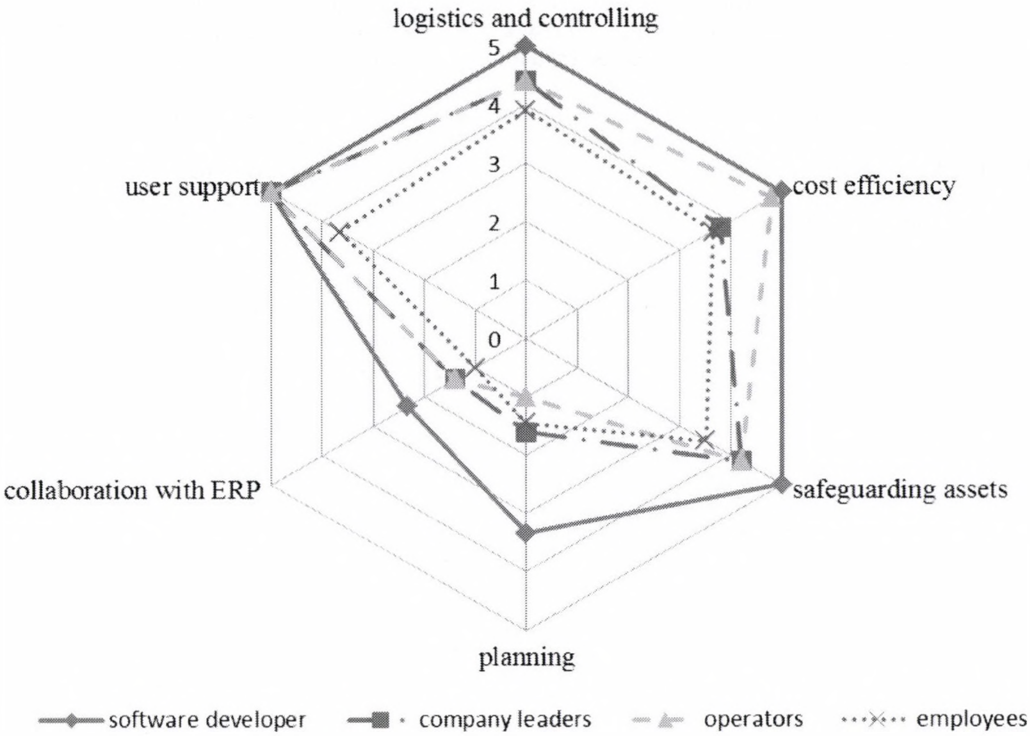
In user support, the reviewed software-developing company operates prominently. The partner companies were satisfied with them at almost every level of this area.

Differences in opinions regarding cost-efficiency are caused by the costliness of the system that can be balanced with financial support.

As it can be seen in the Figure 2, according to the results of the survey, logistics and controlling, cost-efficiency, and user support are not significantly different. This was to be expected based on the radar chart constructed from the means.

However, there is a significant difference among safeguarding of assets and logistics and controlling, since these are in different ranges.

Based on the depth interviews it can be stated that the role of the system in logistics and controlling does not come to an end by checking the execution of the delivered task; it continues having an effect in the optimization of the activities, too.



Source: Own construction

Figure 1. Average values of factors according to the depth interviews

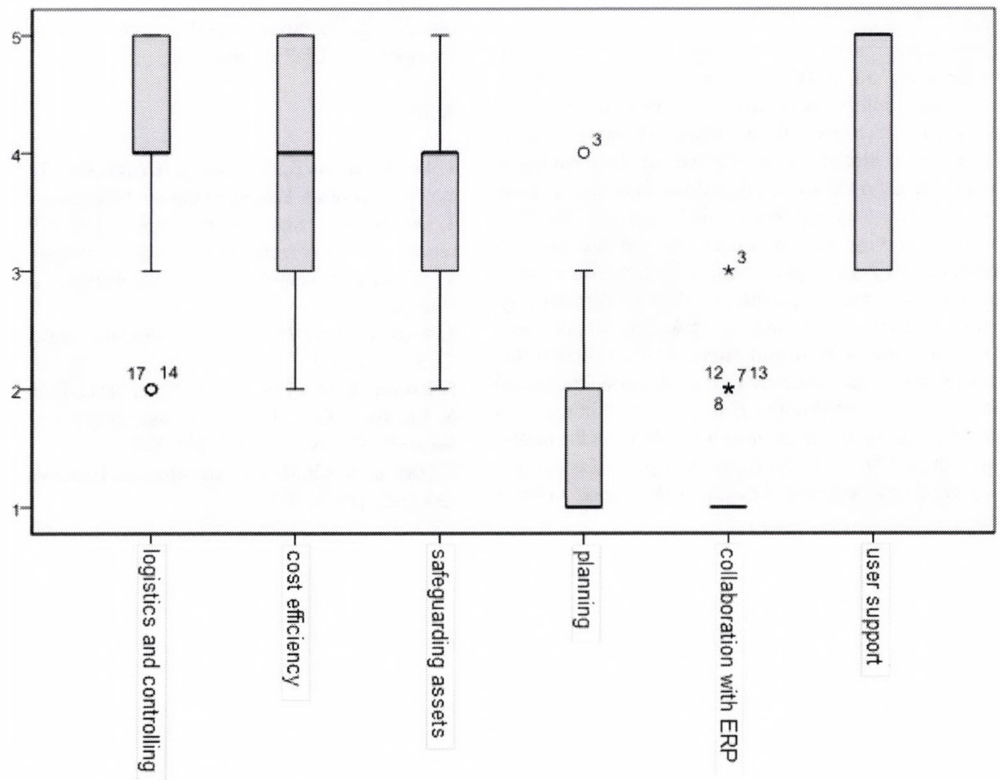


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Figure 2. Boxplots of factors

During a fulfillment-examination there is the possibility of making quality and quantity examination beyond the yes-no results. These options can further increase the efficiency of the operation since the process can be analyzed in a causal relation. An interrupted process can be analyzed precisely, and the knowing the exact phase and state of things facilitates the termination.

Quality analysis of the activities performed offers further opportunities for the company to have its processes in grip and have a complete control over them; since the quality of the work done significantly relates to the quality and value of the product produced.

With the help of the information provided by this system, the optimal transportation and driving route can be analyzed, which could result in significant cost-reduction. Quality analysis is an option in the case as well, thus the problems revealed during these examinations can be solved in the short-run. This way the company can decrease the possible losses to the minimum; the losses which would come from deficiencies and not accurately done activities. Thus the profit can be maximized.

Opportunities provided by the system include the use of working hours, and optimization of working within the boundaries of the legal framework. In this case notions of effective working hours, ignition off, ignition on (ACC), and obligatory resting time has to be mentioned. The aim is to increase effective working hours to the maximum whereas decreasing ignition off and ignition on (ACC) to the minimum, so that obligatory resting time comply with the legislative provisions. Optimal resource usage can be defined when all these conditions are fulfilled.

Regarding the safeguarding of assets especially the protection of the presence of devices that does not mean preservation of their conditions. With the introduction and spread of the opening sensor of the fuel system that is to be developed, if continuing its development for the inner defense, a higher standard could be reached in this field, too.

Both figures depict very well the significant differences, especially in planning and collaboration with the ERP system.

Based on the depth interviews it turns out that the difference in fields of planning has its roots in the alternatives that the software developer companies already have worked out to completely maintain the planning functions, but in order to proceed, a closer cooperation of the partner companies would be needed. That does not only mean observing the machines through the supplier system and introducing a company owned fuel station system, but a complete insight into the production data of the company. Knowing these, company leadership excludes this opportunity. Because if several companies would improve this system to the level of planning that would mean that all production data would get into the same hand, production data of several companies would be stored at the same server, thus it would raise the matter of trust, which should be observed from the aspect of economic moral, or in several case are treated by the leadership as a matter of principle.

In our opinion a feasible result of these is that in the case of Hungarian agriculture companies in the area of ERP systems breakthroughs were born mainly in leadership decision support systems. Two significant companies are on the market: Agrovir and Agroorg. The sum of the software-users of these companies does not reach up to the half of partners of the GPS software-developer company examined in our survey. Based on these the conclusion can be drawn that nowadays in Hungary the joint usage of GPS systems with decision support systems is not typical, even though the opportunities of collaboration among these systems are given and would result in numerous advantages.

The cooperation of these two segments is in progress. There are several examples of partial data transfer. Still GPS technology offers numerous possibilities apart from the above mentioned unexploited by the present decision support systems.

When conducting the research we brought up, that it could become an ERP for e.g. service provider companies. It records the activities done, can print operation log form and route-sheets, thus it could also prepare an invoice or its records of expenses could serve as a base of internal accounting.

Conclusions

As a result of the developing technical equipment companies possess ever more precise devices, which could mean a huge advantage on the market compared to the competitors who are not able to keep up, but could also pose hidden dangers.

Fear of the new and lack of trust often occurs during the innovation procedures. These have to be learnt to handle in the right way, because they can provide opportunities for the company to emerge and cope with the market leaders.

As the query shows, it is a continuously and dynamically developing program; moreover they are in a really good relation with their partners. Great opportunities lie in these which when used effectively not only supports the work of the companies and makes them successful as GPS systems, but could also take over the role of an ERP system.

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THE MOST IMPORTANT TASKS IN THE MANAGEMENT INFORMATION SYSTEMS

Imre KOVÁCS[1] István SZALKAI[1], Katalin BÁNOS[2]
[1]Szent István University,
Institute of Engineering Management,
E-mail: kovacs.imre@gek.szie.hu
[2]Szent István University,
Faculty of Economic and Social Sciences
Páter K. u. 1., Gödöllő, H-2103, Tel.:+36 28 522-000

Abstract

Management Information Systems (MIS) are an integral part of the overall management system in a purposeful organization and form parts of tools such as, enterprise resource planning (ERP) and overall information systems (IS).

The use of information technology tools and methods in agricultural mechanization accelerated. The application of ERP systems widespread in many areas of economy is not yet generally used in the agriculture. Agriculture and farmers face a great challenge in effectively manage information both internally and externally in order to improve the economic and operational efficiency of operations, reduce environmental impact and comply with various documentation requirements. The analysis of decision processes, as well as information modeling for field operations is not a new approach. Decision-making is an important aspect in farm management information system. As a part of meeting this challenge, the flow of information between decisions processes defined as realizing a decision must be analyzed and modelled as a prerequisite for the subsequent design, construction and implementation of information systems. This paper defines the roles of the farmers and the communication specifics associated with the various planning, decision and control processes in the farm management information system.

Keywords

planning, decision-making, farm machinery management, agricultural technical development, FMIS

Introduction

The information technology developed very quickly last 10-15 years. Thanks to this development there are available more foolproof and heavy-duty computers, quickly and more trusted local reds not only for the industrial and commercial but if the agricultural users. One of the most eye-catching changes is the wide permeation of the Enterprise Resource Planning (ERP) and the fast development of the integrated, customizable and ready to use information systems. These modern systems are able to influence positively the organizations and give excellent tools to their managements. [4].

The ERP systems map the economic processes of the enterprises with the tools of informatics. These systems work with separated but functionally related modules. There are two types of mapping. The first one is the type of one's own developing. This is very expensive; therefore it is used when the economic process is very individual. In the case of the agricultural mechanization it is recommended to use the second type, with standard software. In this case a software developing company makes modules for consolidated economic processes and these are available for license-fee. [6]

The goal of the present paper is to introduce – on the basis of tasks of the farm machinery management – the linking points and possibilities, which support the management with existing IT applications. We would like to give a base that we can integrate efficiently the tasks of the farm machinery management into the FMIS systems.

Methodology

The paper deals with the mechanization of agricultural enterprises. Although this activity is important, it is only a part of the farming, therefore it cannot be operated separately [5]. Its main tasks are the planning, the execution and the management of the optimal machinery stock for the production. The withdrawal of machines from the production and theirs secondary reutilization is also an important task of the machinery management. All the above mentioned tasks take part strongly in the execution of the goals of the enterprise, and also some classical management functions are recognizable in them.

These tasks can be realized more efficiently with the ERP systems, which give the methodological background of our paper.

The Farm Management Information System

If farmers are to prosper in this turbulent economic environment they must manage their productive resources more efficiently and become more effective business managers. Innovative computer-based management tools have the potential to increase the quantity and quality of information available for decision making. Used in conjunction with modems, computers will soon provide the opportunity for remote farm businesses to access new sources of management information through connection to the Information Communication Technology (ICT).

Information and decision making process are inseparable. A system for providing information is vital to a business decision making process. Farm decision makers use information from a wide range of sources, but, one of the most valuable sources of specialized information about the farm operation is provided by a farm record system (FRS). A FRS can include financial and production record types. It may be as simple as a basic cash book, or so large and complex that it requires the processing capabilities of a computer to maintain it efficiently.

A computer-based system is conceptualized primarily as a management tool. It is a system of hardware and software elements capable of supporting a FRS and performing analysis on the data. The adoption and use of a computer enables farm businesses to operate a larger number of record types, and perform more extensive and complex analysis than would be possible using manual procedures alone.

The farm management information system (FMIS) is conceptualized as a FRS that provides information to support farm business decision making. If a FRS only provides information to individuals or organizations outside the farm business, then it is not a FMIS.

Farm management information systems (FMIS) are an integral part of the overall management system in a purposeful organization and form parts of tools such as enterprise resource planning (ERP) and overall information systems (IS).

FMIS differs from regular information systems because the primary objectives of these systems are to analyze other systems dealing with the operational activities in the organization. In this way, FMIS is a subset of the overall planning and control activities covering the application of humans, technologies, and procedures of the organization.

Fig. 1 shows the conceptual decomposition of the different management systems in an organization.

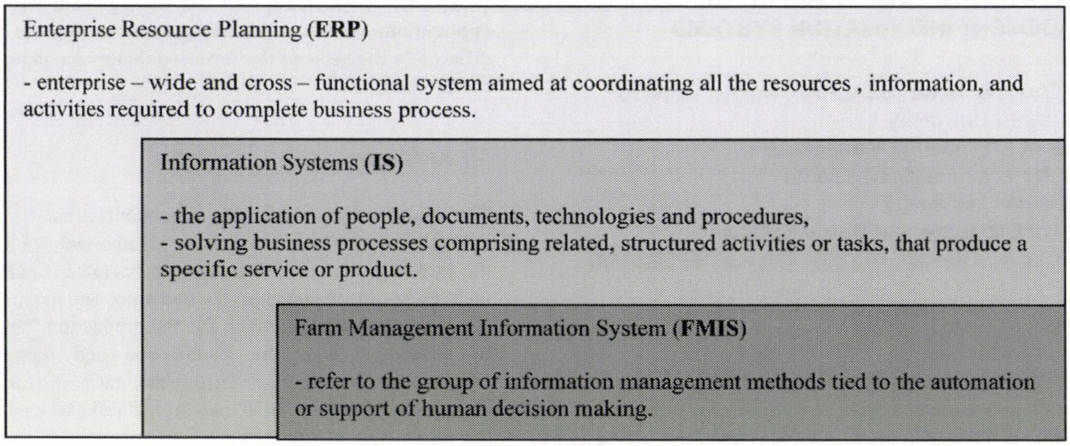

Figure 1. Concept of farm management information systems
(Source: Lewis, 1997)

By following this conceptual framework and notation, a FMIS is defined as a planned system for the collecting, processing, storing and disseminating of data in the form of information needed to carry out the operations functions of the farm. [8]

The Fig. 2 shows the perceived boundaries of the proposed farm management information system.

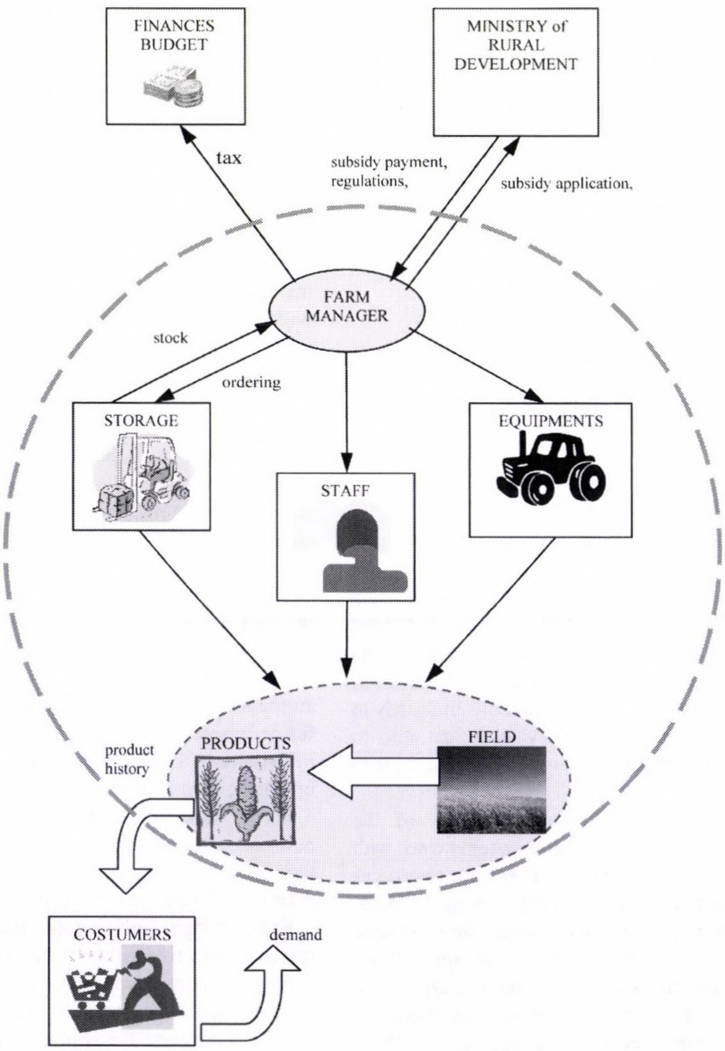

Figure 2. The components of the farm management information systems
(Source: Sirensen, 2010)

The central entities in the proposed system include the farm manager, the fields, the products and production input. The Government and the consumer as external components are included since the system is very much influenced by these entities. [1].

Results

Activities of the planning and decision making

The first stage of the asset management is the phase before the supply. From the functions of the machinery management the main accent is focused to the planning and decision making. [6] During the planning we put the goals. We plan also the future needs of machinery. We can decide about the next steps on the basis of the comparison of the needs and the existing production capacities.

The needs of tangible assets mean the quantitative and qualitative consistence of the tools, which make possible the maximal utilization of the natural and economic capabilities of the enterprise. To give an exact definition is quite difficult. Even so all enterprises should know what would be the optimal quantitative and qualitative consistence of the tools in their conditions. This planning task receives the information from the data of production. With their help we are able to plan the operations of the production technology. We can get the information from the Farm diary and the Field recording. In this stage of the planning it occur the selection, the modification and the adaptation of the operations, the accumulation of the plans of the different productions. With the accumulation of the above mentioned plans we can plan the supply of materials and the immobilization of capacities. There are many solutions to the execution of the technological operations. But we have to take into the consideration, that every solutions have different conditions. [3].

The agricultural production processes within arable farming involve transformation processes that are realized by biological processes taking place in the course of the growing season. The processes are regarded as an autonomous system, which is basically independent of decisions made by the farmer. In contrast to this, the intervention realized by labour and machinery during the plant growing process is dependent on decisions made by the farmer and termed an operation. [2].

The supply of tangible assets means the proportion of the effectively extant and the theoretically wanted assets. Essentially it refers to the relation between the extant assets and the theoretically optimum of needs of assets. [5] The goal of the present analysis is to define in which fields are lack of assets or over-mechanization. The registry modules of assets have the needed information about the parameters of the tools (in the stock taken) and their relation to the workers. [7].

The decomposition of information processes attributed to the planning and execution of field operations is based on the management functions ranging from strategically to operational planning, execution control and evaluation, and a number of underlying processes. All planning levels have to be included in a generic FMIS as it is necessary to know what kind of information the system has to be able to handle. Farmers cannot have separate systems for each management level. All levels utilize information produced in the other levels. The integration of all planning levels is pivotal to the usefulness of the FMIS. The Fig. 3 shows the basic management processes which are identified within the agricultural plant production cycle.

In view of supply of assets it can be transpired how many and what kind of assets are needed to reach the optimal stock of tools. In this phase those possibilities must be taken into accounts which are really available. Generally it is true, that not the ownership of tools is important for the enterprises but their availability in the required quality and quantity, just in time. The associations of traders and wage-workers of machines help us with their databases to calculate the conditions of the use of the occurrent lease-work. The most important parameters for the calculations are the type, the needed quality, the place, the time and the volume of the tasks. After the calculations can we receive offers from the suppliers about the conditions of the lease-work.

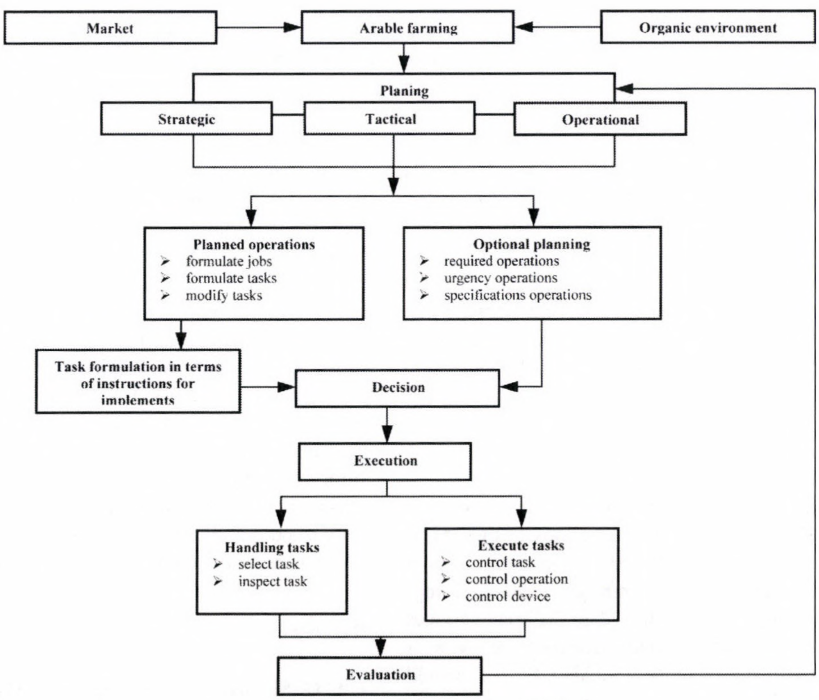

Figure 3. The basic management processes which are identified within the agricultural plant production cycle

Plan generation and execution must be linked in a system monitoring effects of actions, unexpected events and any new information that can attribute to a validation, a refinement, or a reconsideration of the plan. Plans must be presented conditionally, so that supplementary knowledge from observations, farm databases, sensors, can be incorporated in order to revise plans. It should be noted, that although that the concept of farm databases is an important issue in the modeling of a FMIS, it is not within the scope of the paper. The pursued concept, in principle, does not make any difference between information in a database and the information present in the memory of the farmer. It is all available information which can be drawn upon and where the distribution of the available information between a physical database and the memory of the farmer depends on the degree of automated decision-making and as such, the degree of explicitly formulated information storage. [2].

The actors are defined as information operatives or as the entities which are capable of processing information by way of the explicitly defined decision processes. The defined actors include farm managers, machine controllers, external services, etc. A close coupling of the actors with the decision processes exists as the actors are the executers of these processes in terms of deciding which actions to take in relation to the execution of activities defined as operations (goal-specific work as required by the relevant production system) and tasks (the physical implementation of the operation in terms of resources). The decision processes are influenced by a number of factors including strategies (the farmers preferences for a specific production form), triggers (weather conditions determining the planning and initiation of field operations), and timing (the degree of time-critical decision-making, where the operational decision-making is more time-critical than strategic decision-making). The information used in the decision process is the required information for making a rational decision, whereas the information produced by the decision process comprises the planning, guidance and control information used for actual implementing the specific decision.

Table 1. Planning levels and aggregated information flows in arable farming

Planning levels	Information required	Information provided
Strategic planning or design of the production system: Design of production system for a period of 3-5 years specifically the machinery system and selection of types of crops	Possible production levels and price developments Operations demands Possible work methods Available machinery on the market Costs	Number and dimensions of machines Machine capacity Labour requirement Crops selected
Tactical planning: Setting up a production plan for a period of 1–3 years	Availability of land, buildings and equipment External/internal standards	Crop plan Machinery replacement Fertilizer/chemical application plans Maintenance plans Labour budget
Operational planning: Determining activities in the coming cropping cycle, within the coming season	Internal/external standards Maintenance plan for land, buildings and equipment	Required operations Optional operations Urgency operations Specifications operations
Scheduling: Work scheduling setting up formulations of jobs. Planning the implementation of work in the short-term.	Required operations Optional operations Urgency operations Soil and crop status Weather forecast Workability criteria Availability of labour and equipment Operations specifications	Work plan for planned operations indicating: Starting time Duration work Sets required Deviation from plans/schedules Realized work time Realized capacity

Table 1 shows the framework for the different decision levels together with the main parts of the information flows required by the decision process or produced by the decision process. By specifying in detail the information provided and the information required for the information handling processes, the design and functionalities of the individual information system elements can be derived. This has involved explicitly specifying tacit knowledge of the farmer as way to extend the FMIS design into automated decision-making.

Summary

The user-centric information flow models propose the implementation of effective managerial functions to the FMIS, but at the same time, they expect the farmers to be ready to adopt new working habits and perhaps also undergo further training. According to the modeling farmers can utilize different services more efficiently and they are able to outsource some of the tasks they had previously performed themselves. Also, farmers would be able to gain increased insight into their production processes and would able to evaluate the performance of the chosen technology. This would lead to better process control as well as an improved capability of documenting the quality of farming to markets and administration.

In the study we have been examined the most important tasks of the mechanization management on the basis of the management functions. It is concluded that the important functions (planning and decision making) can be supported by farm management information systems. But instead of isolated solutions we need to link them. In this paper we gave the theoretical base of this. The presented information flow models are aimed to function as the basis for Farm Management Information System design. It is able to derive functional features needed in the FMIS from the model diagrams. The information flow diagrams describe the system interface features of such a FMIS which gives support to farmer's core task.

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DETERMINATION OF THE DISCRETE ELEMENT MODEL PARAMETERS OF GRANULAR MATERIALS

I. KEPPLER[1], L. KOCSIS[2], I. OLDAL[1] and A. CSATÁR[2]
[1]Department of Mechanics and Engineering Design,
Szent István University
Páter K. u. 1., Gödöllő, H-2103 Hungary,
Email: keppler.istvan@gek.szie.hu
[2]Hungarian Institute of Agricultural Engineering
Tel.: +36 28 522042

Keywords

granular material, drying, discrete element model calibration

Abstract

Engineers working on the field of agriculture, food- or pharmaceutical industry or in the architecture frequently met problems arising from the special properties of granular assemblies. The practicing engineer has to know how granular materials behave so as to be able to examine and control their mechanical behavior. The design cost of the processes can be greatly decreased if we are able to model properly the given mechanical phenomena.

From the mechanical point of view, two different type of material models can be established. The discrete element method (DEM) where the physical parameters of the interaction between the distinct grain particles (the so called micromechanical parameters) are modeled, and the continuum model, where the whole granular assembly is modeled as a continuum. At our Department and at the Institute there is an ongoing research on developing a method for determining the micro mechanical parameters of granular assemblies by carrying out measurements of the macro mechanical parameters and by modeling the same measurements using discrete element method.

Introduction

Most of the raw materials and crops in agriculture are treated and stored in form of granulates. The prognosis of the mechanical interaction between the particulate material and tools or containers during the various procedures is absolute necessity in every aspect of efficient agricultural processes. The practicing engineer has to know how granular materials behave so as to be able to examine and control their mechanical behaviour. The design cost of the processes can be greatly decreased if we are able to model properly the given mechanical phenomena. The mechanics of granular assemblies is one of the most complicated area of engineering mechanics, because the description of the behaviour of large number of particulate materials is a quite complex scientific problem.

The Discrete Element Method (DEM) is a fairly new proceeding to model the mechanical properties of bulk materials. By the use of DEM, the model problem is solved by applying and solving the equation of motion on each singular particle of the bulk material assembly. The discrete element model facilitates to trace the contact forces between the particles of the bulk material. From this we can get information also to determine the damage of the components of agricultural product [Fenyvesi 2002, 2003]. The wide range of applicability of DEM is detained by the fact that we have to determine the values of different micromechanical properties related to the interaction between the individual particles in order to model the mechanical process. The method of this micromechanical parameter determination is often called as calibration procedure. In this paper, we use oedometric test to calibrate the micromechanical parameters of sunflower seeds.

Strength characteristics measurement by odometer

The measurements had been carried out in the material testing laboratory of the Hungarian Institute of Agricultural Engineering. For the strength characteristics measurement an Instron 5581 universal material testing equipment was used (Fig. 1). This equipment is able to load 50 kN uniaxial tension and pressure. The corresponding crosshead displacement size is 2 meter. The cross-head speed range could be set between 0.001mm/min and 1000 mm/min (speed accuracy is 1%, the position accuracy is +/− 0.02mm). The equipment has three certified load cells which have 0.5% accuracy of the measured value in three different load ranges: from 0.025 to 5 N, 5-500 N and from 500 to 50,000 N. The equipment is controlled by a computer, the electronic sampling frequency is 500 Hz and the A/D converter is 32 bits.

Figure 1. The Instron 5581 materials testing equipment

For the investigations by odometer we produced a 80 mm high, 100 and a 200 mm diameter steel tanks with an inserted plunger in the upper part. By this plunger we loaded various crops (Fig. 2).

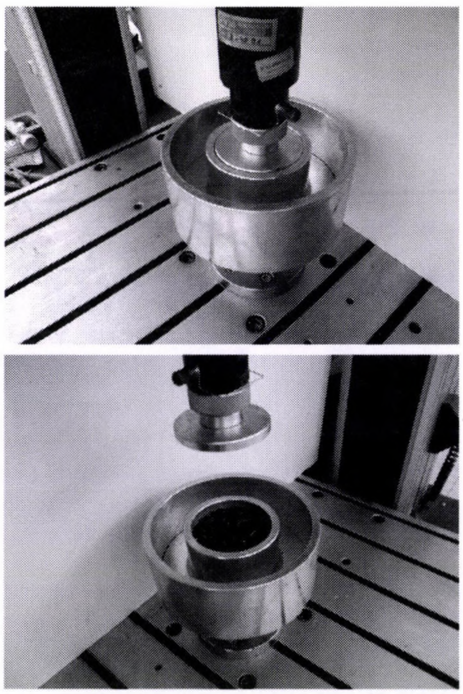

Figure 2. The steel tank with an inserted plunger

The machine settings were as follows:
- Pre-load: 100N
  corresponding crosshead displacement was 25 mm/min,
- Load: till 30000 N
  corresponding crosshead displacement was 500 mm/min.

For mass of the investigated crops we used a Kern-572 laboratory balance with 0.1 g precision. Mass of the samples were x grams. For the moisture content determination a Dicky John made by GAC ® 2100 type device was used. The Fig. 3. shows as an example the results of the sunflower investigation by odometer.

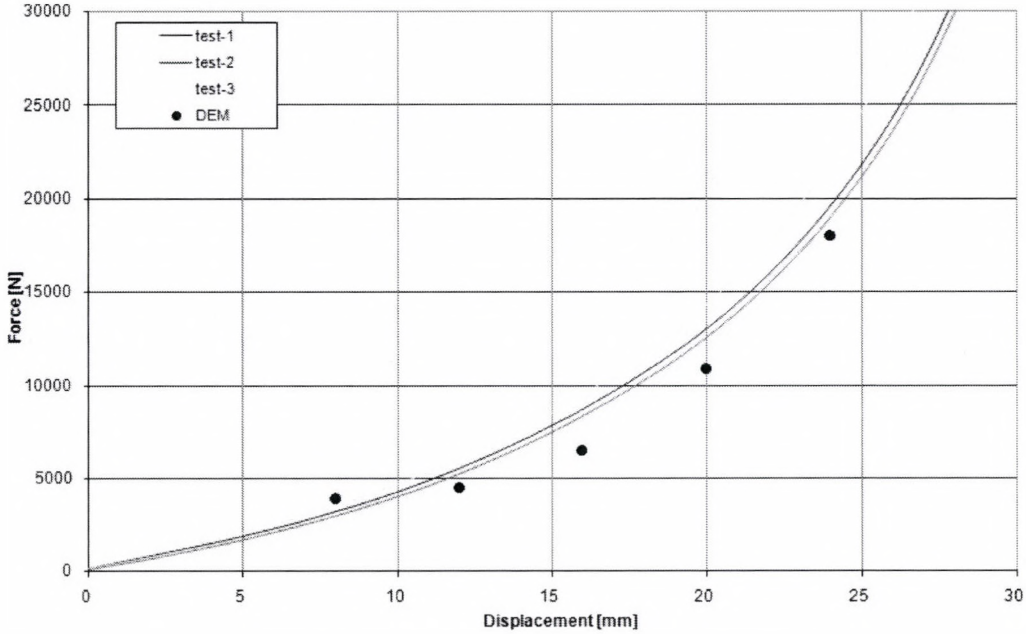

Figure 3. Results of the sunflower investigation

Discrete element simulation

The Discrete Element Method (DEM) is a fairly new proceeding to model the mechanical properties of bulk materials. By the use of DEM, the model problem is solved by applying and solving the equation of motion on each singular particle of the bulk material assembly.

For the simulations we used the EDEM discrete element software.

For the discrete-element simulation we created the model of the odometer (Fig. 4). Hertz-Mindlin contact model was used for calculation of the contact forces between the particles. In the Hertz-Mindlin contact model the normal force between two particles contact can be determined by the following relationship:

$$F_N = \frac{4}{3} E \sqrt{R} \delta_n^{\frac{3}{2}}$$

where E is the elastic modulus of particle, R is the radius of curvature and δ_n the indentation in the contact point. While running the calculations we have to use a F_d^D damping factor to reduce oscillations of the numerical calculations. The value:

$$\left|F_n^D\right| = 2\sqrt{\frac{5}{6}} \beta \sqrt{s_n m} v_{rel}$$

where m is the mass of the particle, and v_{rel} is the normal component of the relative velocity,

$$\beta = \frac{\ln c_r}{\sqrt{\ln^2 c_r + \pi^2}}$$

s_n is the normal stiffness of the compression in the contact point of the granular material. During the simulation the used time step has a great impact on the stability of the numerical model. When the value of the time step is too big it may cause disintegration of the model because of the program calculated big change of compressive strength between two steps. That's why we selected for the simulation the 25% of the Rayleigh-type time step:

$$T = 0{,}25 T_R = 0{,}25(0.163\nu + 0{,}8766)^{-1} \pi R \left(\frac{\rho}{G}\right)^{\frac{1}{2}}$$

Table 1. Mechanical properties of the particles

Shear elasticity modulus	$G = \frac{E}{2(1+\nu)} = 11$ MPa
Poisson coefficient	$\nu = 0.4$
Density	$\rho = 759\ \mathrm{kgm^{-3}}$
Collision coefficient	$c_r = 0.6$
Friction coefficient	$\mu_s = 0.6$
Rolling resistance coefficient	$\mu_r = 0.01$

As first simulation result approximate discrete-element mechanical parameters of the sunflowers were determined. We started the discrete element simulation to study the odometer investigations based on the data of Table 1 and particle shape Fig. 5. The shape of particle – according to our view – is not necessary to be exactly equal to the original shape of the particle. It is sufficient to use different shape from the spherical symmetry. The results of the calculation are indicated by points in the Fig. 3. Comparing the results of the measurement and the results of the simulations in the diagram the differences are acceptable at higher compression values. Therefore we can say that the data of mechanical properties of the particles in Table 1. ensure adequate accuracy for the discrete element model of sunflower seeds.

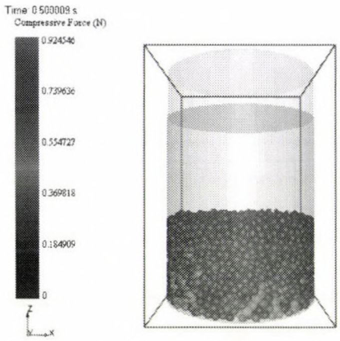

Figure 4. Discrete element model of the odometer

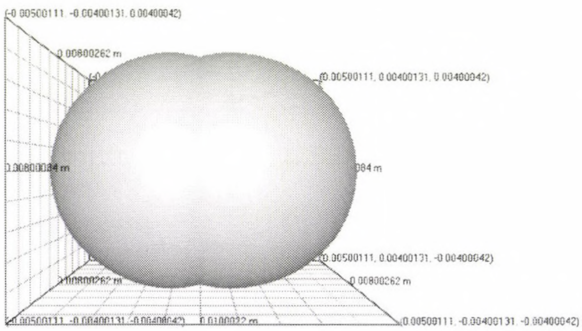

Figure 5. Model of a single particle

Results and further work

A relatively new method used for modelling the mechanical behaviour of granular assemblies during drying processes is the so called discrete element modelling technique. In this model we describe the granular assembly as the collection of large number of small rigid bodies, and the modelling process of the assemblies' behaviour is based on solving the equations of motion of this large number of particles directly. The question that arises from the practical use is how we can determine the parameters which affect the interaction between the particles: the coefficient of static- and rolling friction, coefficient of restitution, Young modulus and Poisson's ratio of a given (in some cases very small) particle.

We started to develop a procedure based on measurement and numerical simulation of the measurement for determination of micro-mechanical parameters of agricultural grains by discrete element model. The first step in the procedure is the bulk material measurements by odometer. We carried out the laboratory investigations by wheat, corn, barley and sunflower seeds. We developed discrete element model for odometer measurements and we determined the micro-mechanical parameters of sunflower seeds (Table 1).

Thereafter, we will carry out the discrete-element calculations in case of other three types of grain. We will investigate by sensitivity analysis the obtained parameter results of the model. After the shear test [Balássy, 1993] measurement, we will also verify the adequacy of the parameters by comparison of the simulated shear test results – where the micromechanical parameters were used as the result of the odometer investigation – and the obtained results of the shear test measurements.

The method will be applied later for determining the velocity distribution of granular materials moving in mass flow driers.

Acknowledgements

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DETERMINING PRESSURE RELATIONS OF VEGETABLE OIL PRESS USING DISCRETE ELEMENT METHOD SIMULATION

Bernát FÖLDESI, János Péter RÁDICS,
Kornél TAMÁS, István J. JÓRI
Department of Machine and Product Design,
Budapest University of Technology and Economics
Muegyetem rkp. 1-3., Budapest, H-1111, Hungary
Tel.:+36 1 463-3511,
E-mail: Radics.Janos@gt3.bme.hu

Abstract

The plant oil extraction is a process with high energy consumption. During the process major part of the kinetic energy transforms into thermal energy. The material receives a very significant amount of heat, which is able to modify the quality of the plant oil. This is why the precise determination of the thermal relations is important to recognize disadvantageous constructions. With the support of discrete element method it is possible to examine the mechanical and thermal relations plus deduce the extracted oil chemical attributions.

Introduction

In case of an oil press with worm shaft from the temperature aspect we determine two basic methods; the cold and hot pressing method. Using cold pressing procedure over the clarity of oil seeds there is no need for any further treating. According to experiences cold pressing provides good quality, in case of canola it is possible to get oil with low phosphor content, which does not require any further processing to produce biodiesel. If during the extraction the temperature of the oil increases too high, then it is necessary to perform additional treatment because of the high phosphor level.

Materials and methods

DEM (discrete element method) is a discontinuous numerical method based on molecular dynamics. It was developed and applied for analyzing rock mechanics by Cundall in 1971 It is the most proper way to simulate the behaviour of materials consisting of seeds.

The examined OKB-1 oil press machine has a complex geometry. On the shaft there are three different worms with different shapes. After the worm shaft the solid material leaves through a tight slot and the oil leaks through the press basket.

It is important to differentiate those sections where the geometry of the seeds would deform significantly, because the elements in the simulation cannot be deformed (Cundall, Hart 1992). In this model every seed is simulated as a ball, so we cannot study them at their highly deformed state with this material model.

The simulation develops from the simple built model into a more complex one. This method is reasoned because it is important to make sure of the realistic properties and effects of the simulated processes. The examination of the realistic behaviour is only possible with evolutionary developments (Donzé 1999).

First model:

The first model is simple and one sectioned screw geometry which contains the surface models of the casing, the shaft, the closing covers at the two ends and the helicoids (Figure 1.).

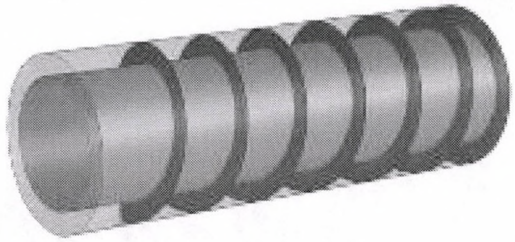


Figure 1. The model for the first simulation

The built model has nearly the same dimensions like the first section of the real machine. The size of the balls which simulate the seeds, was chosen to ensure that at least two balls positioned into radiant direction without overlapping each other (Bojtár, I., and K. Bagi 1989). The size of the particles matches the seeds in reality (Table 1.). Because of the chosen diameter it is possible to run the simulation with fewer elements but still being accurate. During the pressing process the slot at the end of the machine causes the highest resistance on the material. This generates reacting pressure against the flow of the material (Ugural, A. C., and S. K. Fenster 1987). This pressure in this simplified model is replaced by a static closing cover at the end.

Table 1. Model parameters

Property	Value
Gravitational acceleration	$9.81\ ms^{-2}$
Angular velocity (shaft and worm)	π rad•s^{-1}
Angular velocity (closing cover)	π•2^{-1} rad•s^{-1}
Ball diameter	7 mm
Material density	500 kgm^{-3}
Damping coefficient	0.14
Normal stiffness (ball-ball and wall-ball)	2•10^{3} Nm^{-1}
Shear stiffness (ball-ball and wall-ball)	2•10^{3} Nm^{-1}
Global friction coefficient	0.1

The aim of our analysis is to get data about the longitudinal distribution of pressure by rotating the shaft and the helicoid parts of the model.

Second model:

The second model could simulate the continuous material flow. In this model the closing plate effects constant dynamical resistance (servo wall). The function of this wall is to ensure the constant particle flowing, additionally produce the constant pressure to the particles.

The model with servo mechanism opens the door to the research of the constant material stream. The difference between the previous model and this one is the data of material stream. The resulted speed of the servo wall is $v_{sw} = 5.7 \cdot 10^{-3}$ ms^{-1} , that means $\tilde{V}$= 28.2 cm^{3}s^{-1} material stream. Because the displacement of the servo wall in one second is less than 1 percent compared to the longitudinal dimension could be static. It means that the results of these two models are very similar.

Third model:

The third model geometry was improved by giving thickness to the worm. This model contains the surface models of the casing, the shaft, the closing covers at the two ends, the worm modelled by two helicoids and a small surface to close the end of the worm (Figure 2.).

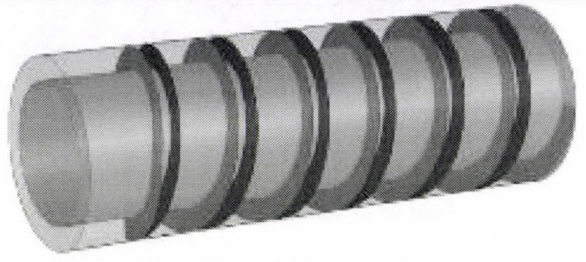


Figure 2. The geometry of the second simulation

The closing cover at the end of the model has to resist the pressure. This surface was set to be dynamic and have a constant resistance against the material. So it allows the particles to have volumetric flow. This servo wall keeps the given pressure value with 5% inaccuracy.

The second model has nearly also the same dimensions like the real machine. But the material properties are not the exact properties of the real seed. The same test material parameters were used as by the first and second simulation (Table 1).

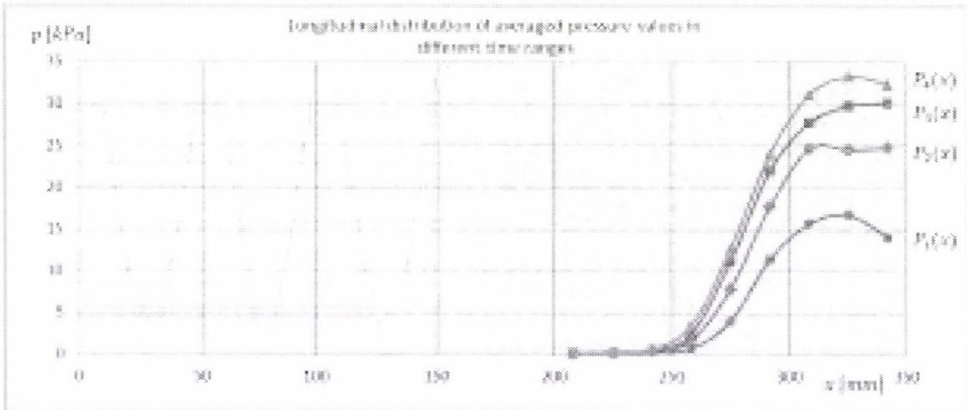
Basically the simulations were set to calculate the longitudinal distribution of pressure on the casing and evolved heat by friction in the material. But because of unexpected results the analysis focused on the pressure values.

Result and discussion

First simulation:

The value of pressure which effects on a surface is calculated from the sum of the normal forces at the contacts between the surface and the walls. During the simulation the software checks all of the contacts in the model in every time step and selects those which contact the surface. Then it is able to determine selected section by summarising the normal forces then dividing with the size of the area. The pressure was determined on the surface of sections. Because of the fluctuating behaviour of these values the final data were determined by averaging for 5000 time steps. To get detailed view of the process, the data were measured in four different time ranges. The time range of the averaging process cannot be comparable with the temporal difference between the starts.

By analysing the pressure we can see that the significant increase starts just at the beginning of the last thread. The increase continues monotonous to the end of the thread. The pressure between the worm and the closing cover in spite of expectations is not constant (Figure 3.). It fluctuates around a value which was calculated at the end of the worm.



Figurte 3. The longitudinal distribution of the averaged pressure in different time ranges

Besides this fluctuation is small enough to adduct with constant longitudinal distribution. At the last thread the bordered pressure increment is caused by the property of the discontinuous material. At fluids the longitudinal distribution is more uniform because their press transmitting attribute is better. Moreover the fluids can induce flow at the slot between the worm and the casing. According to the longitudinal distribution of the pressure we can realize that the most loaded part of the model. Probably the biggest quantity of heat is evolved in this section. But we can see that the compressed material fills only three threads of the helicoid(Figure 3.). Firstly it makes unsure that the same characteristic would be seen at a totally filled model but as the pressure highly increases at the last thread and it does not have a significant effect on the other two threads we can safely declare that similar characteristic would be formed by a totally filled model.

Second simulation:

To compare longitudinal pressure in the first and the second model we present these on Figure 4. It shows that the similarity is significant, because the distributions are the same, but on the second function the values of the pressure are higher. Due to the inaccuracy of the second simulation we are not able to draw a conclusion.

Third simulation:

New simulation was started with the new geometry but using the same properties like in the previous simulations included the pressure of the servo wall (closing cover) which was 25,46 [kPa]. After the accumulation process the volumetric flow rate could not increase and started fluctuating about zero. Because of the thickness of the worm it was expected to gain lower values in the volumetric flow but not zero. To examine this extreme decrease, different worm thicknesses were set with static closing cover. Basically the thickness is defined by an angle which gives the degree of rotation of the second helicoid from the first one. This theory is illustrated in Figure 6. at the cross-section. The summary of the results are seen in Figure 5.

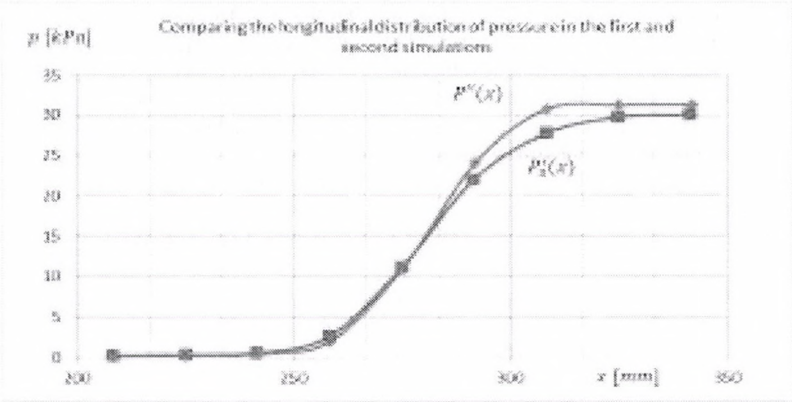


Figure 4. The longitudinal distribution of pressure simulations

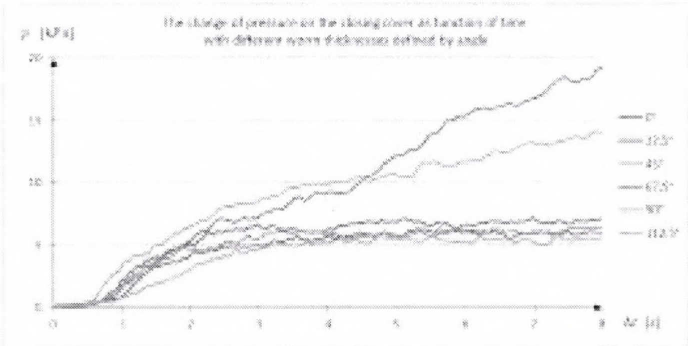


Figure 5. The change of pressure as function of time with different worm thicknesses defined by angle

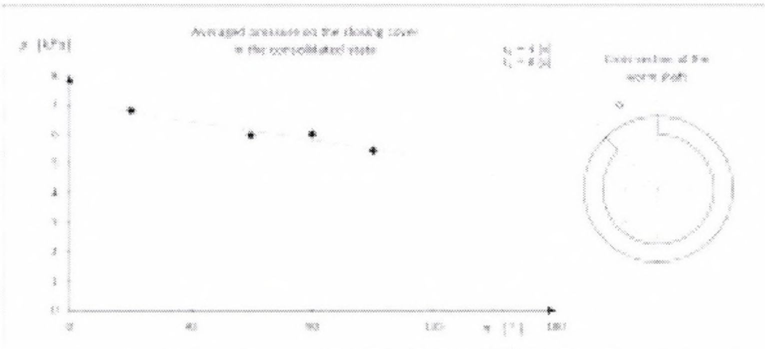


Figure 6. Averaged pressure on the closing cover in the consolidated state

At Figure 5. it can be clearly seen that two angle values; the 0° and the 45° have salient curves. At these angels the pressure does not consolidate in this time range about a value like the other graphs. Probably these false values were caused by the special relation of the geometrical dimensions including the diameter of the balls. At these setups the particles can stretch extremely instead of bouncing back because of their undeformable attribute. So it can result in very high pressure. The curve of 22,5° proves this idea because it is not located between the two salient curves but at the other ones. Examining the correct curves, the averaged pressure values show the expected relation (Figure 6).

The averaging was done in the consolidated state which started at t_0=4 [s] and ended at t_1=8 [s]. The scale of the simulated angles is tight. At first the size of the particles delimits the angle values using in the simulation because at higher degrees the small amount of material in the model could not effect significant pressure. Secondly the detailed analysis using more values would not lead to more precise graph. There are angles where the same amount of material would be caused by the generating method. It would lead to inaccurate values. Thirdly changing the size of the particles would highly increase the duration of the simulations.

Conclusions

In this paper, granular material behaviour is investigated by the numerical approach. The discrete element method (DEM) seems to be a promising approach for making an elaborated model to describe the thermal processes of the oil press. Former research has shown that virtual DEM simulations were developed in correspondence with the real tests (Tamás, Jóri 2011). It is important to simulate the behaviour of a synthetic material whose microproperties can be chosen to reproduce the relevant behaviors of a particular solid.

The simplified geometry of the pressing machine was built in the discrete element software to model the basic phenomenon under the pressing process. The results of the longitudinal distribution increasing quickly in the last round of the helical and the highest values were generated in this space.

As we experienced there are special geometrical setups which could lead to false calculations. Probably it happens when the size of the elements is relatively big and the stiffness values are relatively low so enables the material to stretch extremely. As a result of this when using similar setups to decrease the duration of the simulation it is suggested to make further analyses to be sure the setup does not give false values.

Basically the first aim at this stage of the research is to make sure about the suitability of the model for further simulations and developments. So the deep analysis of the special geometric relations is not needed. It is enough to ascertain the model is correct. The dimensions of the new model with worm thickness are equal the dimensions of $\alpha=90°$ model version. Based on this analysis the determined model looks suitable for further analysis and developments.

The simulations open the door to develop new models that are very similar to the real oil press machines. It can be concluded that the discrete element method can be used for simulating the thermal processes of the oil presses also. The model can be used in development procedures of pressing, reducing the number of real tests.

Acknowledgements

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THE EXAMINATION OF SURFACE SCRAGGINESS MAKES IT UP WITH 3 DIMENSIONAL IMAGING

A. LÁGYMÁNYOSI, I. SZABÓ, J. TÓTH
Faculty of Mechanical Engineering,
Szent István University
Páter K. u. 1., Gödöllő, H-2103, Hungary
Tel.:+36 28 522-000,
E-mail: lagymanyosi.attila@gek.szie.hu

Abstract

Visual appearance is a key factor for many industrial and agricultural products in terms of quality. The most important attributes are colours and shape. Digital image processing is a popular and important application to investigate visual appearance. Conventional 2D-imaging provides a good implementation of colour identification, but is not a perfect solution for surface monitoring. 3D laser imaging as a new technology provides some additional data on the investigated objects, beyond conventional imaging. Three dimensional representation looses colour information of the object, but provides a point to point surface mapping. This article presents results of a research which applied 3D image analysis in order to demonstrate and utilise advantages in terms of additional data over conventional images. It is concluded that the additional information gained can be used to describe object surface features in a more thorough manner.

Keywords

image processing, surface analysis

Introduction

In the field of agriculture post and pre harvest and in many other cases digital image processing is a popular and important application (Molto, 1996). For example the visual appearance is a key factor in quality assessment and sorting plants. Therefore applied procedure, are based on visual inspection. In this paper in scragginess analyses of applicable 3 dimensional imaging procedures are described.

Surface unevenness is not only a potential characteristic data in the case of homogenous materials, but also in bulk material sets. Elements on the surface of the material sets causes irregularities on the whole set according to its size. Assuming complete mixing we can characterise the size of elements in the whole set based on the knowledge of the surface element sizes. In the case of multiple element material sets fundamentally not the respective sizes of the elements themselves but the distribution of the elemental multitudes (size classes) will be a characterising data.

Thus, if we can give a good description of the elements of the set with a statistical methodology then we can assign this characteristics to the set and compare sets based on this information. A typical such material set can be firewood chopping utilised as a renewable energy source for heat production. The chopping size introduced in the combustion area has a definite influence on combustion quality (Bense, 2006). It is therefore straightforward that knowledge of firewood chopping provides additional information for configuration of combustion parameters.

The applied system and materials

The applied apparatus

Throughout the experiments a 3D laser scanner of the type Zscanner 700 was used. The main technical parameters were: sampling rate 18000 sample / sec., 2 built in cameras, improved resolution of 0,1 mm, maximal accuracy of XY positioning is 50 μm if the investigated volume is 100 mm x 100 mm. The applied computer was a PC with the following features: I7 quad processor, 6Gb memory, graphical subsystem with 1Gb memory. The connection between the scanner and computer was an IEE1394 interface.

The investigated materials

The examined material is wood chopping. The filtering method was as follows: 3 classes were applied, one under 4 mm, one between 4 and 8 mm, and one over 8 mm. The fractional selection resulted in three size classes, but the size filtering only applied to two out of the three physical dimensions; it was of course possible that in the 4 mm fraction a chopping of 4mm diameter but 40 mm length could penetrate. This resulted in a given probability distribution of size inside the given size groups, and the somewhat blurred distinction of the fractions.

Nevertheless it is understood that the sets formulated in the above manner carry distinctive size characteristics, and can only be assessed statistically.

The developed investigation method

During the experiment lighting was applied with no extra requirements in mind. In the preparation of the scanned recordings exclusively a filtered artificial lighting was used to ensure minimal bias over the scanner's own lighting apparatus (Szalay, 2011). Fractions of chopping was placed in boxes with open tops. Size of the boxes was selected to ensure the largest possible cover for chopping with multiple layers of cover. Multiple layers was necessary to provide an environment which is possibly the closest to the surface exhibited by real material sets. Surface was always equalised to ensure that its unevenness only relates to size irregularities of respective elements.

Figure. 1. One case of the investigated material

The investigations

During the analysis all size classes were 3D-scanned after applying 3 different mixings to each of them.

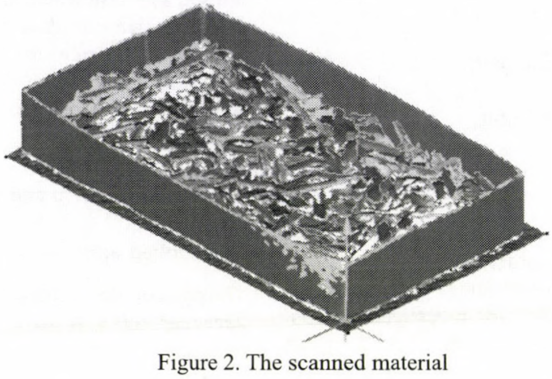

Figure 2. The scanned material

Scanned images represent the allocation of firewood choppings distribution on the examined material surface. The respective points of the image can be stored in a 3D matrix. Examining a 2D slice matrix of the 3D matrix allows us to get a cross-section of the scanned material set. If the cross section is selected perpendicularly to the surface of the set, we get a cross cut image of the original set.

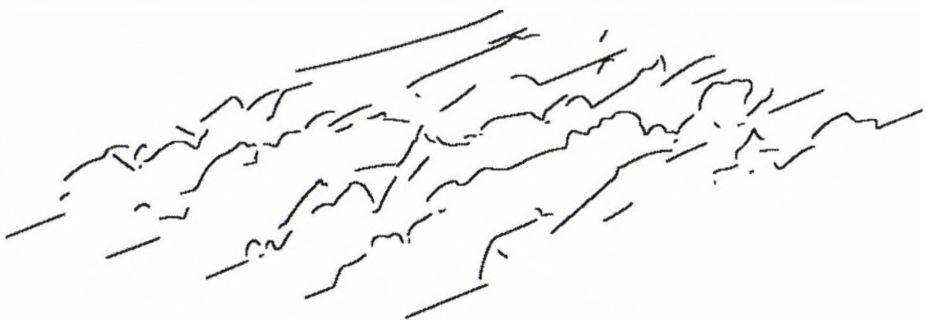

Figure 3. The selected sections form 3D matrix

For the purpose of our analysis always 5-5 slices were cut from the surface descriptor matrices. Considering the triple repetition of the three size classes this altogether resulted in 45 cross cut images and data sets.

Putting the data of the cross cut samples in a two dimensional vectorspace it can be stated that the cross cuts from the same fractions are very similar, while interfraction crosscuts show significant difference.

x and y axes scale are [mm]

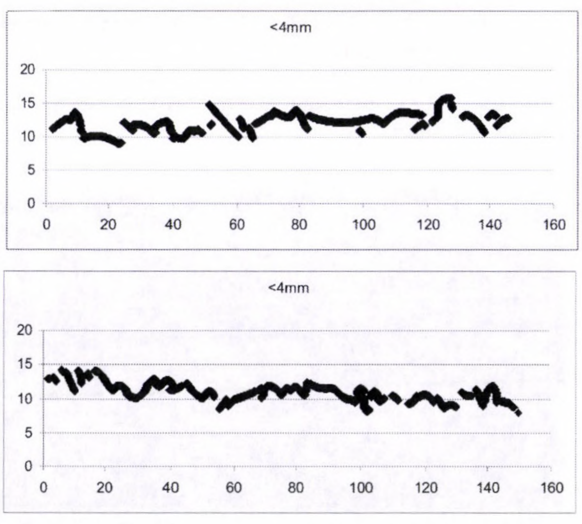

Figure 4. Comparison of the sections from same fractions (<4 mm)

x and y axes scale are [mm]

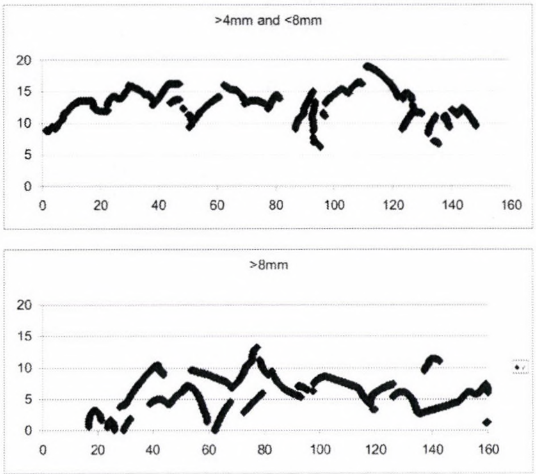

Figure 5. Comparison of the sections from different fractions (<4 mm and 4-8 mm)

Results and measured data

The above figures well demonstrate that depth encompassed by scanning differs radically. This is the consequence of the difference in depth of compression of the chopping, which is a function of the fill factor of the chopping. Space filling depends on the size of the elements in the set. Therefore it can be stated that the deeper insight we gain into the set the larger the size of the elements we can find on the top layer.

Enumerating the points composing the cross-section we get the frequency. The following distribution is shown by the set of points in the cross section of the three size classes after 5-times sampling.

The y axes are number of points and the x axes are [mm]

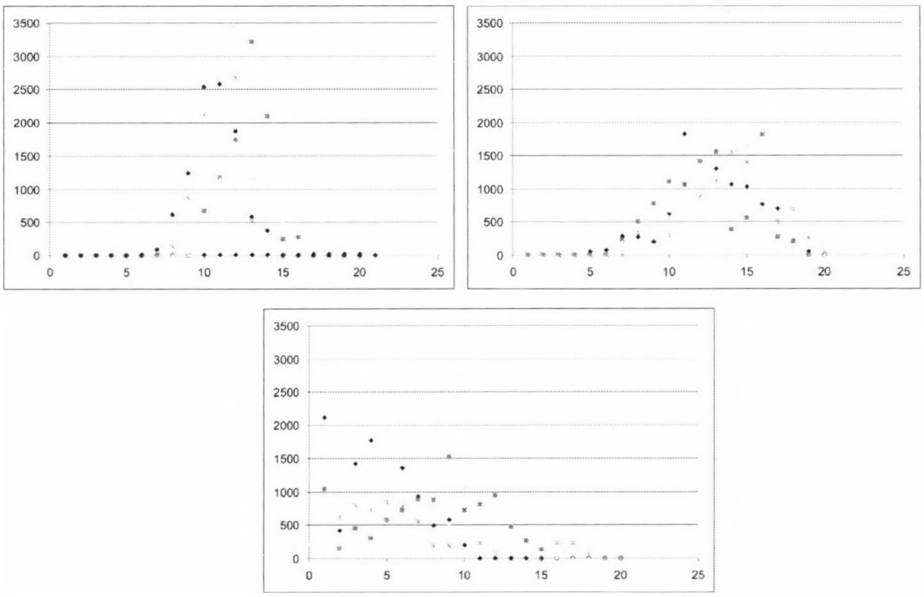

Figure 6. Development of frequencies

The images well depict that in the case of the smallest size class the frequency values surpass element numbers of 3000, and more than 90% of the points are positioned between 7 and 16 mm. The next size class already spreads out to the interval of 5-20mm, and the largest values fall under 2000 elements. The third image shows the frequency value of the largest size class, with an even more outspread range of values.

Examining the standard deviation of frequency we get the following values:

Case of <4 mm = 931

Case of >4 mm and <8 mm = 570

Case of >8 mm = 522

This shows that spread of image points is larger as the elements composing the set examined become smaller.

Conclusions

Summarising the results, we can state that the images of wood-chopping recorded in 3D can provide a valuable starting point to draw conclusions on the size of the elements in the examined material set. This relationship can be demonstrated in the under 8mm size class with strong reliability. The larger size classes could be assessed to be less coherent with the applied method and equipment. Applicability can be improved further with larger element image generation. The ongoing research is expected to provide applicability in a broader size spectrum by further refining and modifying the applied methodology. Additional objective is the crosscut image generation without 3D imaging as this would result in a real-time industrial applicability by making evaluation faster and simpler.

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INVESTIGATION OF POSITIONING OF FLUIDIC MUSCLES UNDER DIFFERENT TEMPERATURES

József SÁROSI[1], Gábor SZABÓ[2], Péter SZENDRŐ[3]
[1]Technical Institute, Faculty of Engineering,
University of Szeged,
Moszkvai krt. 9., Szeged, H-6725, Hungary
[2]Department of Process Engineering,
Faculty of Engineering, University of Szeged,
Moszkvai krt. 9., Szeged, H-6725, Hungary
[3]Institute of Mechanics and Machinery,
Szent István University,
Páter K. u. 1., Gödöllő, H-2103, Hungary

Abstract

Pneumatic Artificial Muscles (PAMs) have a wide range of use in industrial as well as medical fields. Their greatest disadvantage is said to be their nonlinear characteristics and due to this the difficulty of their positioning.

This paper presents our robust motion control of these muscle actuators under different temperatures using sliding-mode control.

Objective

Different solutions can be found for the control of Pneumatic Artificial Muscles during their use in [1], [2], [3], [4], [5] and [6]. The early control methods were based on classical linear controllers and then some modern control strategies have been developed (e. g. adaptive controller, fuzzy controller, neural network controller, sliding-mode controller and others).

The effect of temperature is scarcely mentioned at best in literature. This however is an important aspect since the muscles heat up considerably during use as well as cool down due to the temperature of their surroundings, for this reason we conducted our positioning experiments not only in room temperature but extreme temperatures as well.

Our goal was the design of robust control system that can guarantee accurate positioning up to 0.01 mm in room temperature as well as extreme high and low temperatures.

The layout of this paper is as follows. Section 2 (Methods and Materials) is devoted to display our positioning system and different LabVIEW programs. Section 3 (Result and discussion) presents several experimental results. Finally, section 4 (Conclusions and future work) gives the investigations we plan.

Fluidic Muscles DMSP-20-400N-RM-RM (with inner diameter of 20 mm and initial length of 400 mm) produced by Festo company were selected for our newest study. We have investigated type DMSP-20-200N-RM-RM (d_0 = 20 mm, l_0 = 200 mm) and type DMSP-10-250N-RM-RM (d0 = 1_0 mm, l_0 = 250 mm) in [7] and [8].

Methods and materials

A good description of our test-bed and experimental results for positioning can be found in [9].

The PAMs were installed horizontally and can be controlled by MPYE-5-M5-010-B type proportional valve made by Festo. Our robust position control method based on sliding-mode control. The linear displacement of the actuator was measured using a LINIMIK MSA 320 type linear incremental encoder with 0.01 mm resolution. To measure temperature inside and outside the muscle the test-bed was completed four thermocouples type K. Fig. 1 shows the block diagram of this positioning system with proportional valve.

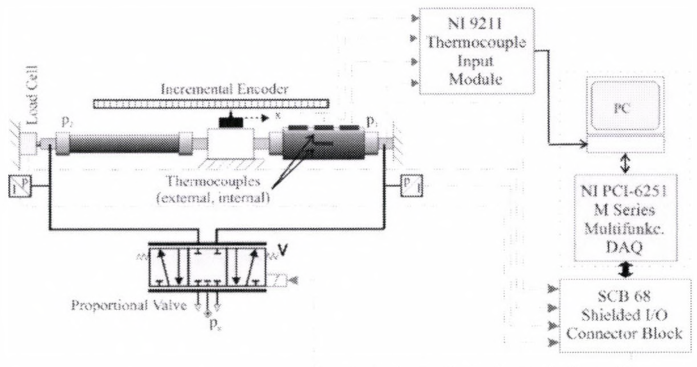

Figure 1. Block diagram of positioning system with proportional valve

For the data acquisition of temperature and positioning readings we used programs written in LabVIEW.

Front panel of LabVIEW program for positioning is shown in Fig. 2. Aside from the desired position the number of samples and the sampling time can also be set. The data can be saved into a text file.

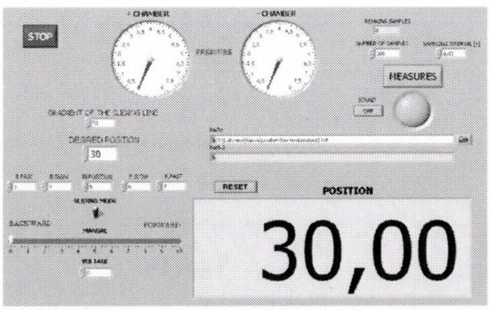

Figure 2. Front panel of LabVIEW program for positioning

The Figure 3 shows the front panel of the LabVIEW program created for temperature measurement. Here the number of samples and sampling time can also be set. During the periodic and automatic working of the muscles the contraction and rate of release can be adjusted with the frequency of the sine wave. The temperature inside and on the surface of the muscle can be read on the indicators on the screen also it is shown as a number. The measured results are saved in a text file for later processing.

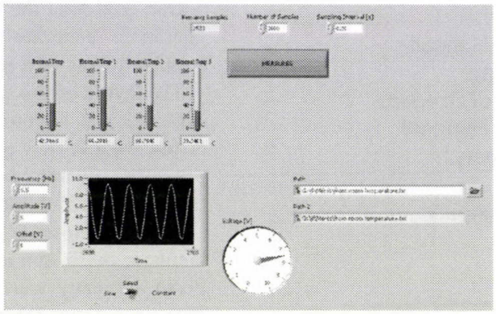

Figure 3. Front panel of LabVIEW program for measuring temperature

Result and discussion

Positioning was first done in room temperature on the pressure of 6 bars. The desired positioning was set to 40 mm, the number of samples was set to 300, while the sampling rate was set to 10 ms, thus the measurement took 3 s. Fig. 4 shows the positioning as a function of time. It took about 0.8 s for the position to reach the set value. To show the accuracy of positioning the area around the desired position has been magnified (Fig. 5). This Figure shows the accuracy of positioning is within 0.01 mm.

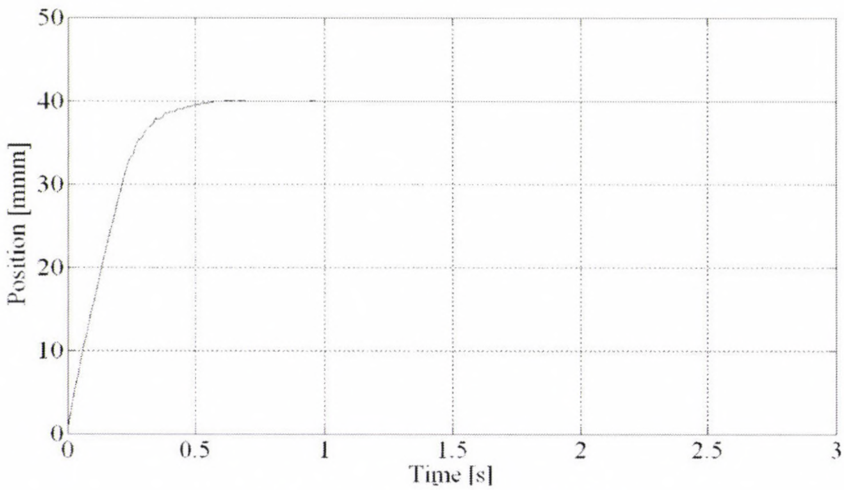

Figure 4. Positioning as a function of time

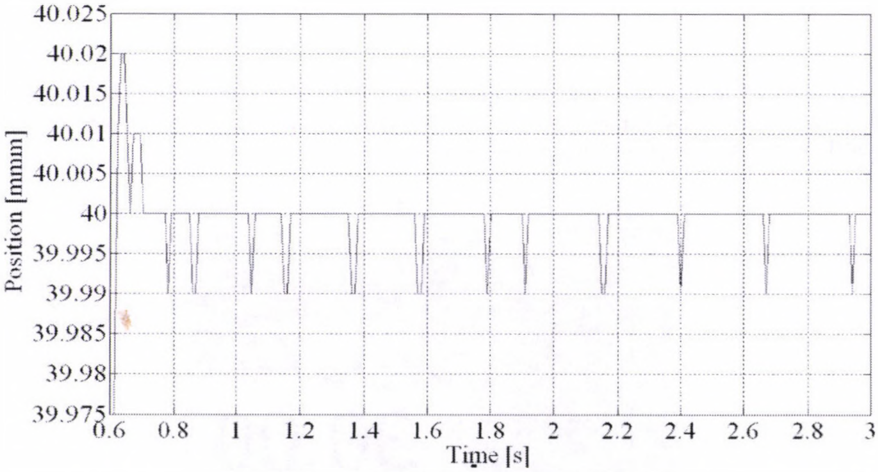

Figure 5. Positioning as a function of time (enlarged)

The periodic working of the muscles was achieved with a 0.5 Hz frequency sine wave. The measurement took 900 s during which the sampling time was 0.25 s, the acquired data is shown in Figure 6. While the external temperatures of the surface settle the internal temperature is changing because of the exchange of air.

After a constant temperature was reached positioning was measured on the pressure of 6 bars, too. The result of it is shown in Fig. 7. It shows the desired position was reached within 0.6 s. To show the accuracy of positioning the area around the desired position has been magnified (Fig. 8). The accuracy of positioning remained within 0.01 mm.

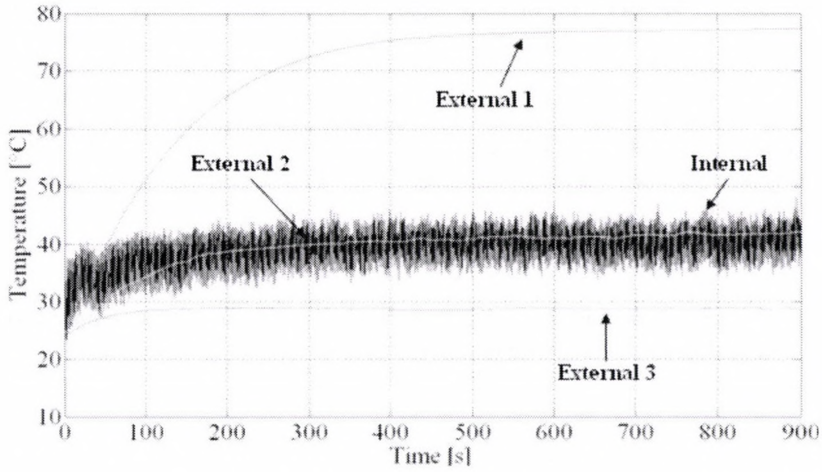

Figure 6. Temperature as a function of time

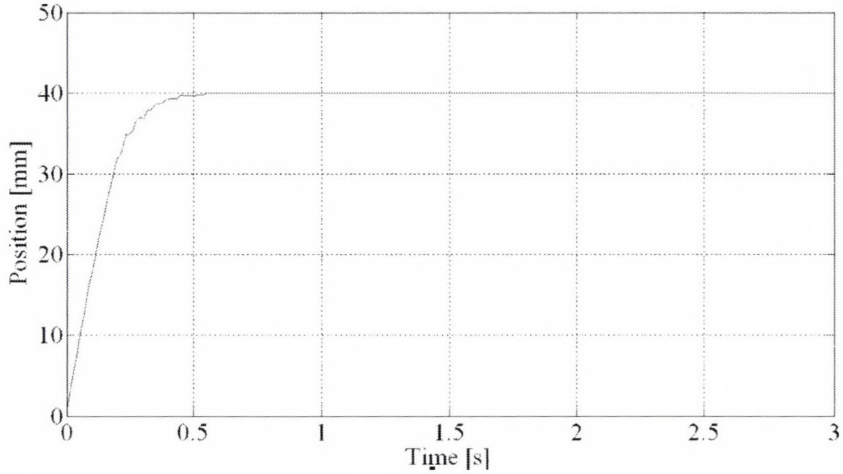

Figure 7. Position as a function of time after work cycle

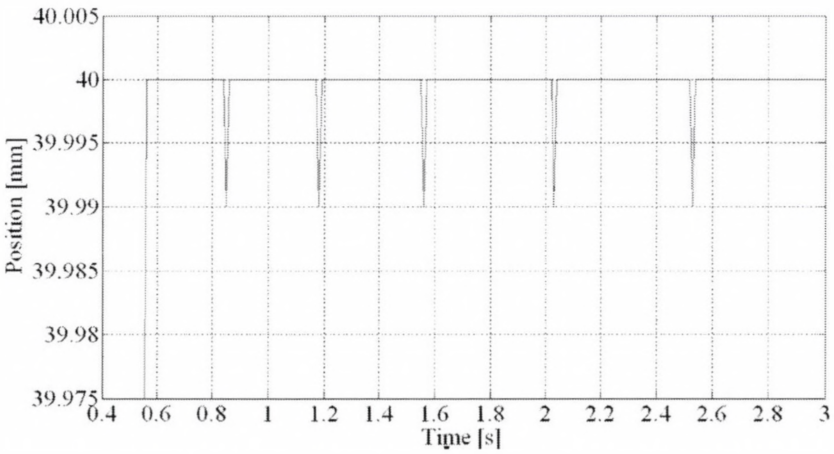

Figure 8. Position as a function of time after work cycle (enlarged)

Conclusions and future work

With the results of the experiments conducted with muscles of varying geometric parameters we can conclude that the accurate poisoning up to 0.01 mm is still possible on extreme temperatures and in the case of greater than room temperature positioning time is reduced. Our future will include experiments in temperatures lower than room temperature as well as the use of a 0.001 mm resolution encoder in the experiments with positioning.

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2D DEM SIMULATION OF THE SOIL- TOOL INTERACTION IN COHESIVE SOIL

Kornél TAMÁS, István J. JÓRI
Budapest University of Technology and Economics
Department of Machine and Product Design
H-1111 Budapest, Műegyetem rkp. 3.,
Tel.: (36)-1-463-2276, Fax.: (36)-1-463-3505,
e-mail: tamas.kornel@gt3.bme.hu

Abstract

The Numerical Model Systems are so modern nowadays. It means, that they can show under progress very similar physical phenomenas. To using a well built model is a useful and cost efficient method to develop the agricultural machines. In the agricultural point of view the contact or the interaction between the soil -tool and plant are very common. The optimization of the soil cutting is a kind of tool geometry design process. In these task we can validating the tool tillage method with qualitative and quantitative mode, because we can measure the work forces and can check the soil structure before and after the tillage method. The soil cluster quality or the porosity changing are so important and its dependences on the tillage speed and the tool geometry. To work cost efficiency is quite important in these days when the fuel and other equipments and man power prices are so expensive and the market competition is increasing.

Keywords

Soil, Cultivator, DEM, Modeling, 3D, Soil Bin, Forces,

Introduction

Computer simulations using Distinct Element Method (DEM) have been carried out to investigate the effect of cohesion on the flowability of polydisperse particulate systems (Tamás and Jóri 2007).

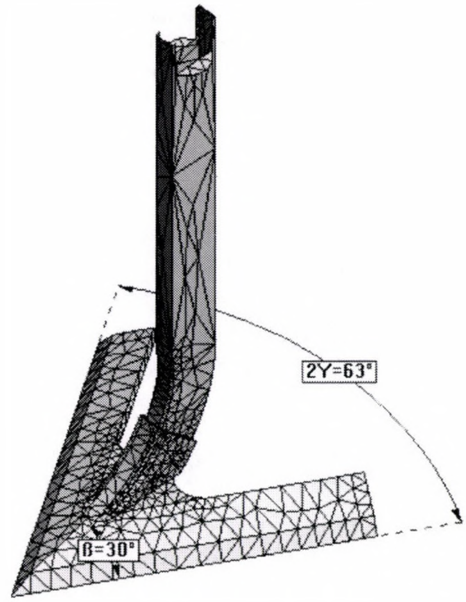

Figure 1. The Sweep-Tool geometry (2γ=63°, β=30°)

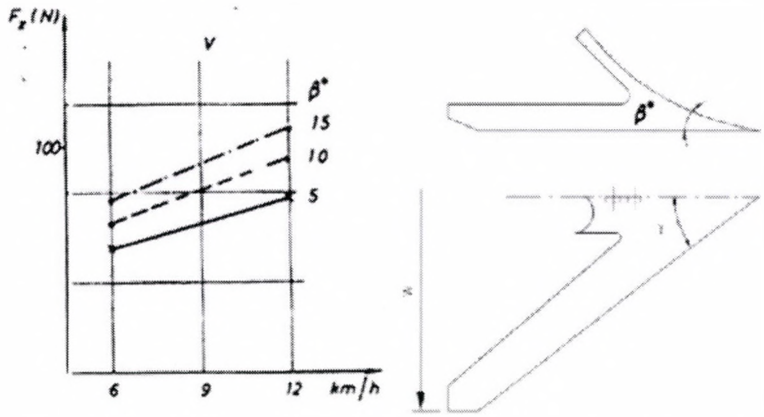

Figure 2. The draft force of the Tool vs. ß angle and the speed (SITKEI 1967)

The optimization of the soil cutting is a kind of tool geometry design process. In these task we can validating the tool tillage method with qualitative and quantitative mode, because we can measure the work forces and can check the soil structure before and after the soil- tool interaction. The soil cluster quality or the porosity changing are so important and it's dependences on the tillage speed and the tool geometry.

In this paper we introduce the most important process in the DEM that the synthetization of the real and artificial soil. There are many skepticists in face this field of science, that means they can not trust in the material models. We show the Sher Box Test, that sample (sand) got from the soil bin with the real physical properties. The other sample is on the computer and measured on Biaxial Test. The discrete balls, that bonded contacts representing the soil micro structure can be the most similar with the real soil. In the mechanical definition we used two values: the cohesion and the internal friction angle, that results of the Mohr- Coulomb criterion. In our works we used the PFC 2D DEM Code versatilities and efforts.

Materials and methods

DEM is a discontinuous numerical method based on molecular dynamics. It was developed and applied for analyzing rock mechanics by Cundall in 1971. The soil which is cut or separated by soil engaging components is much more discrete, therefore DEM is an ideal method to analyze large discontinuous deformations of soil. Cohesive soils are very common in agricultural operations and constructions (Asaf, Z., D. Rubinstein and I. Shmulevich 2007). The analysis of the dynamic mechanical behavior of cohesive soils subjected to external forces is very important in designing and optimizing the tillage tools. Cohesive soil contains water and the presence of water can produce cohesion between soil particles, which makes the mechanical structure of these soils much more complex (Cundall, Hart 1992). In order to simulate and analyze the mechanical behavior of cohesive soil accurately, it is necessary to establish a DEM mechanical model of cohesive soil by considering the effects of water on the mechanical behavior of cohesive soil. We could simulate this cohesion in the PFC2D Discrete Element Program, because it allows particles to be bonded together at contacts and with the virtual and real soil sample biaxial tests we can define the appropriate values.

DEM with the Parallel-Bond

PFC2D allows particles to be bonded together at contacts by employing the parallel-bond model. The parallel-bond model describes the constitutive behavior of a finite-sized piece of cohesive material deposited between two particles. The parallel bonds establish an elastic interaction between particles that act in parallel with the slip model described above. The existence of a parallel bond does not preclude the possibility of slip. Parallel bonds can transmit both forces and moments between particles, therefore, parallel bonds may contribute to the resultant force and moment acting on the two bonded particles.

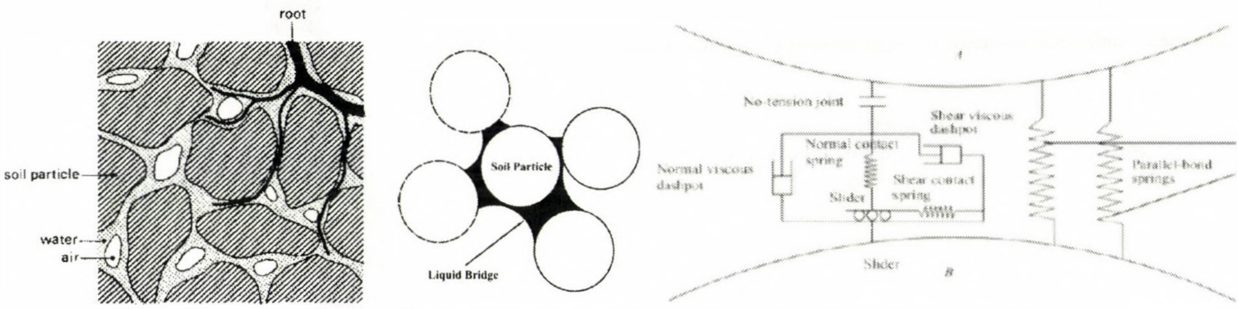

Figure 3. The microproperties of the soil, the liquid bridges, and the parallel-bond model (PFC2D Particle Flow Code in 2 Dimensions User's Guide 2002)

After the creation of a parallel bond, relative motion at the contact causes a force and a moment to develop with the bond material as a result of the parallel-bond stiffness. This force and moment act on the two bonded particles and can be related to maximum normal stress rmax and maximum shear stress smax acting within the bond material at the bond periphery. If either of these maximum stresses exceeds its corresponding normal strength and shear strength, the parallel bond breaks. If the parallel-bond model is used in the simulation. Although the configurations of the liquid bridges between cohesive soil particles change during the moving of soil particles, the effects of the deformations on the capillary and the dynamic viscous forces are ignored because of the above characteristic of the parallel bond. The capillary and the dynamic viscous forces are assumed to be influenced only by the parallel-bond forces. The parallel bonds produce the resultant force and the moment. (Bojtár, I., and K. Bagi 1989).

Description of the synthetic material

Most published work in the field of flowability and shear behaviour of powders is experimental. However, in experiments the measurements are usually made only from the boundaries of the assemblies as any effort to probe the internal state of the assembly might interfere with the behaviour of the particles. In contrast, the use of computer simulation allows the probing of the internal behaviour of particulate assemblies under mechanical loading. Therefore, the analysis of the flowability and shear behaviour of powders using computer simulation is attracting increasing attention recently.

In this biaxial test, a parallel bonded fine-resolution specimen was generated. The specimen has a height of 63.4 mm and a width of 31.7 mm and have uniform particle size distributions bounded by Rmin and Rmax, with Rmax = 1.66 Rmin (We can define the soil type with the particles distribution). We shouldn't define the value of R, because in the test we measure only a part of the full material (soil).

A strength envelope (peak strength versus confining pressure) was obtained by subjecting both rectangular specimens to a set of biaxial tests at confining pressures of 0, 1, 4, 10, 20, 30, 40 x105Pa.

During the biaxial test, the wall normal stiffnesses are set and the platen velocity is adjusted to reach a final value of 0.05 m/s in a sequence of 10 stages over a total of 400 cycles.

Table 1. Model parameters

Parameter in DEM	Value
Bulk density (kg/m^3)	1850
Particle shape	Ball
Normal spring coefficient (K_n) [N/m]	1,00E+07
Tangential spring constant (K_s) [N/m]	1,00E+07
Coulomb damping (μ_g)	0,3
Friction coefficient between particles (μ)	0,5
damp viscous normal [Ns/m]	0,7
damp viscous shear [Ns/m]	0,7
Particle radius distribution [mm]	23,44-39,07
Friction coefficient between particle and the sweep tool	0,6
Void ratio	0,4595
Parallel-Bond (heavy soil) (Result of the sinthezis)	
pb_rad	1
pb_kn (N/m)	2,00E+03
pb_ks (N/m)	2,00E+05
pb_nstren (Pa/m)	1,00E+06
pb_sstren (Pa/m)	1,00E+03
Parallel-Bond (loose soil)	
pb_rad	1,0
pb_kn (N/m)	2,00E+03
pb_ks (N/m)	2,00E+05
pb_nstren (Pa/m)	1,00E+05
pb_sstren (Pa/m)	1,00E+02
Time step of the calculation (Δt) (s)	4.0 ×10E5

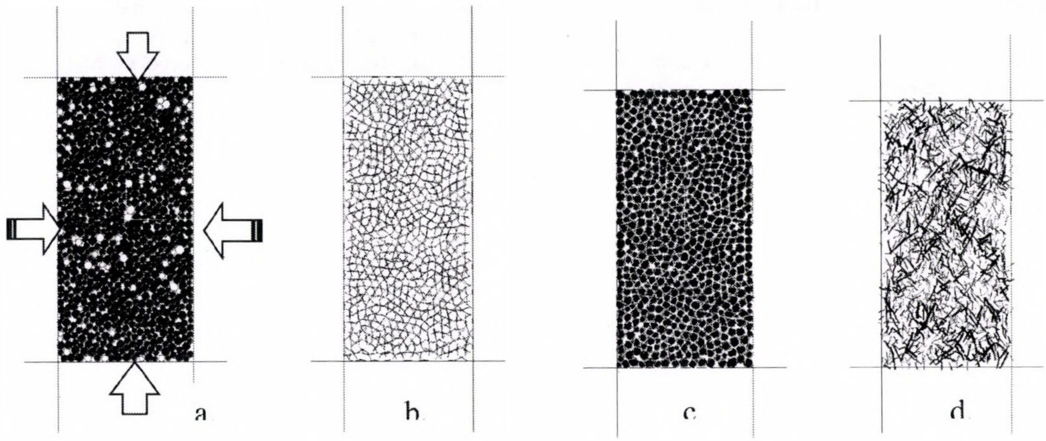

Figure 4. The specimen (a) vertical and confining stress, (b) contact structure, (c) parallel bonds between particles (white lines), (d) parallel bonds with normal and shear forces, when acting the vertical forces under the biaxial test.

Using the results of the biaxial test (the peak strength and confining stress) we defined the Mohr's circles. Touching the circles we drew the Coulomb line. The angle of the line and the x axis we defined the internal friction angle. The intersection of the Coulomb line and the y-axis we defined the cohesion. As we can see on the Figure 5. the cohesion is 51 kPa and the internal friction angle is 27°. This soil mechanics property following the real biaxial tests is a kind of loamy clay. We can validate these tests with the shear box test results and we can define the same material properties. With this process we can harmonize the real and the numerical methods. But in these test we used only the virtual aspect.

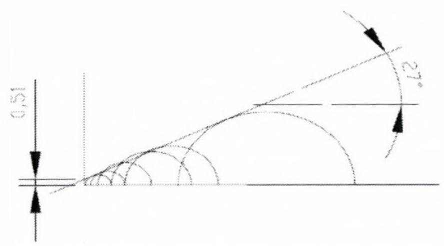

Figure 5. Mohr's circles, that define the cohesion and the internal friction angle. ($C=0,51x10^5Pa, \Phi=27°$)

Table 2. The results of the biaxial test

SPECIMEN		Results of Biaxial Tests
x: pack	y: Pc	sig_f
	($x10^5Pa$)	($x10^5Pa$)
1	1	7,59
1	4	20,56
1	10	34,07
1	20	61,97
1	30	90,82
1	40	118,95

We can see on the Table 2. the resulted peak strengh (sig_f) dependence of the confining pressure (Pc). With these results we can draw the Mohr's circles, thats tangential line define the cohesion and the internal friction angle. In our research these two soil parameters are enough to define the material.

Table 3. Soil mechanical values according to Schilling.

Soil Type	Cohesion (KPa)	Internal friction angle °	Friction modulus
Sand	0-10	37-34°	0,67-0,73
Sandy silt	10-25	35-32°	0,625-0,70
Silt	25-40	32-28°	0,53-0,625
Heavy silt	40,-60	28-25°	0,466-0,53
Clay	60-100	25-20°	0,37-0,466

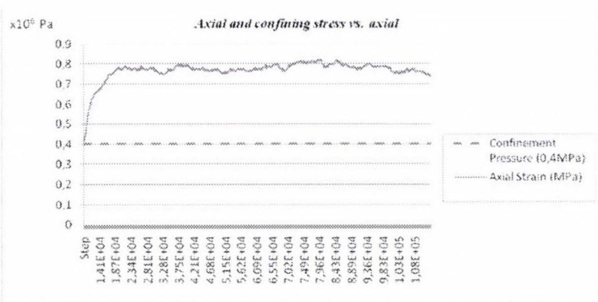

Figure 6. Axial and confining stress versus axial strain (Biaxial Test) (CP=0,4MPa)

Results and discussions

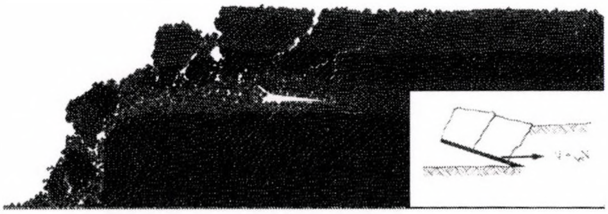

Figure 7. Side view of the loosening and clod generation by DEM and the theoretic aspect (SITKEI 1967)

The influence of the speed and the rake angle

The parallel-bond contact was used to describe the behavior of the cohesive soil (discontinuous) during soil-tool interface process. A series of models were analysed with various soil properties, speed and inclined angles using PFC2D Code. The results showed the significant effect of the tool incline angles and working speed on cutting forces in 20 cm depth.

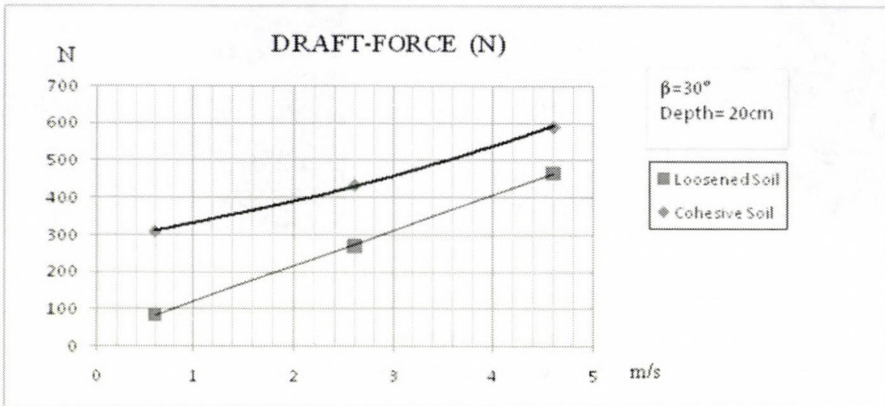

Figure 8. The influence of the speed (0,6-4,6 m/s) by DEM

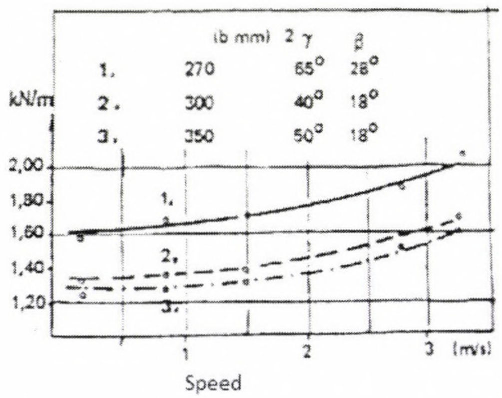

Figure 9. The Draft Force vs. velocity and ß angle (SITKEI 1967)

In this research between the two extremities (0,6-4,6 m/s and, 5°-30°) the results are parabolic. The parallel bonds produce cohesive forces between discrete particles, so parts of discrete particles are conglomerated and form particle aggregate clusters after the tillage process. The complete model is formed by bonding of elements in wide sizes. This structure of the model is similar to that of the actual cohesive soils.

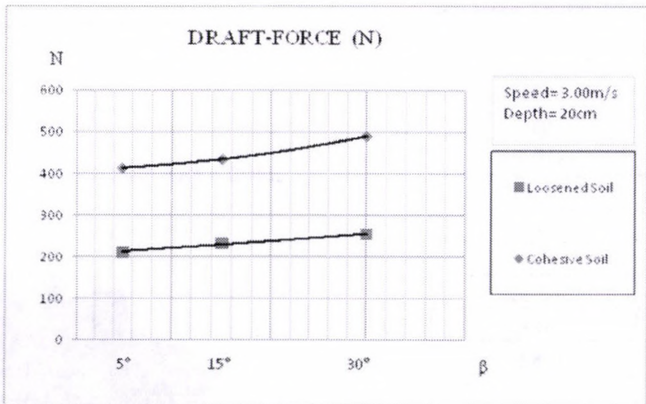

Figure 10. The influence of the incline resistant angle (5°-30°) by DEM

During the simulated tillage process by a cultivator sweep, soil evolves from the extrusion between soil clumps, the humping ahead of the tillage tool, and the climb along the surface of the sweep, to the rupture and separation of cohesive soil cluster.

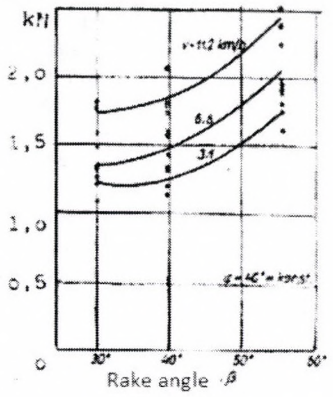

Figure 11. Draft Force - incline angle (ß) dependence (SITKEI 1976)

Conclusions

In this two dimensional discrete element analyses carried out to simulate soil-tool interaction and the comparison with the experimental results. The effects and draft-force of the tool geometry are very similar to the field tests. In the DEM numerical approach the parallel-bond contact was used to describe the behavior of the discontinuous, cohesive soil during soil-tool interface process. After the biaxial test method with which we validated the micro properties, a series of models were analyzed with various soil properties, speed and inclined angles using in the three dimensional models. The results showed the significant effect of the tool incline angles and working speed on cutting forces in 20 cm depth. Results calculated from the DEM model support the following conclusions:

- In case the set of the appreciable parameters in DEM synthetic material with parallel- bonds between the particles, we can synchronizing the virtual biaxial test (microproperties) and could be compared directly with the measured response of the physical material. The real soil macroproperties are the cohesion and the friction angle, that we got from the science articles (Kerényi 1996). With the parallel bonds we can model the presence of liquid bridges, which cause the cohesion in the artificial soil.
- Under the cutting process in 20 cm depth when the speed is increasing the draft force is increasing parabolic (Figure 8-9.).
- If the β angle is increasing the draft force is increasing parabolic as well (Figure 10-11.).

It can be concluded that the discrete element method can be used for simulating the soil cutting processes in non-homogeneous soils and for the investigation of soil loosening and sweep performance. The model can be used in development procedures of soil loosening tools, reducing the number of soil bin and field test.

Acknowledgements

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ENHANCED BIOETHANOL PRODUCTION FROM EXTRACTED SUGAR BEET CHIPS

Marietta ÁBEL, Zsuzsanna LÁSZLÓ, Gábor SZABÓ, Cecilia HODÚR
University of Szeged Faculty of Engineering, Department of Process Engineering
Moszkvai krt. 5-7, H-6725, Szeged, Hungary
E-mail: abel@mk.u-szeged.hu

Abstract

In this study generarlly/preliminary bioethanol production were analyzed from sugar beet *(Beta vulgaris)* chips to bioethanol. The sugar beet chip is a by-product of the sugar industry; it is created after pressing of the extracted beet slices. The chips are poor in sugar but rich in cellulosic components. Therefore the main aim of our project was to examine and intensify the enzymatic hydrolysis of cellulose to monosaccharides in order to obtain higher ethanol yield. Cellulase enzyme, from *Trichoderma reesei,* and cellobiase enzyme, from *Aspergillus niger* was applied for hydrolysis. During hydrolysis cellulose is degraded by the cellulases to sugars, which can be fermented by yeasts to ethanol. Sugar beet is the most promising biomass-derived energy feedstock crop and it has received considerable attention for the production of value-added products.

Keywords

bioethanol, sugar beet chips, by-product, enzyme hydrolysis

Introduction

The use of ethanol as an engine fuel has as long a history as the car itself. It began with the use of ethanol in the internal combustion engine invented by Nikolas Otto in 1897. Alcohols have been used as fuels since the inception of the automobile. The term "alcohol" often has been used to denote either ethanol or methanol as a fuel. With the oil crises of the 1970s, ethanol became established as an alternative fuel. Many countries started programs to study and develop fuels in an economic way from available raw materials. The interest then waned as the price of oil dropped, until 1979 when we had another oil crisis. Since the 1980s, ethanol has been considered as one possible alternative fuel in many countries [1].

The worldwide transport sector depends almost totally on fossil fuels. The vegetable oil and the vegetable alcohol are/even could be the environmentally friendly motor fuels for replacing crude oil. Ethanol (C_2H_5OH) (as ethyl alcohol or fuel ethanol or bioethanol) is fermented from sugars, starches or from cellulose biomass, so cellulosic materials can be used to produce bioethanol as well. Bioethanol represents an important, renewable liquid fuel for motor vehicles. The bioethanol can be used as petrol additive up to 20%, the optimal ratio of petrol: ethanol is 85:15 [2]. The bioethanol is appropriate for the mixed fuel in the gasoline engine also because of its high octane number furthermore, due to its low cetane number and high heat of vaporization it can impede the self-ignition in the diesel engine [3].

Production of bioethanol from biomass is a possible way to reduce consumption of crude oil with lower environmental load, and it is an environmentally friendly motor fuel for replacing crude oil. Bioethanol can be produced from several biomass feedstock using different conversion technologies, and it can be produced from raw materials containing fermentable sugars, especially sucrose containing feedstock, such as sugarcane or sugar beet. Beside these, ethanol can be produced from cellulose-containing materials, e.g. maize stalk, forest-products wastes, grasses or sorghum. In European moderate climate area the most convenient renewable raw materials for bioethanol production are grains and sugar beet [4].

Sugar beet is a biennial plant belonging to the family *Quenopodiaceae*. Its scientific name is *Beta vulgaris*. The roots are pivoting, almost totally buried, with a yellow-greenish rough peel. The root is the organ where most sugar is accumulated in the plant [5].

The beets arrive at the production plant without crown and loaded in silos by mechanical means through channels with circulating water. The beets are washed and passed through systems retaining diverse solid materials, such as stones, leaves and small roots. Once washed, the beets are transported to the choppers where they are shredded into very thin slices that called chips or cossettes, and passed to the diffuser to extract the sugar content into a water solution. The diffusers are large rotary drums where the chips are put in contact with a hot water stream flowing in the opposite direction. The sucrose is extracted from the vacuoles of the beet cells into the flowing water generating the raw juice or diffusion juice. The spent chips are called pulp and leave the diffuser with about a 95 % moisture content, but with low sucrose content. To recover part of the sucrose contained in the pulp, it is pressed in screw presses reducing the moisture to 75 % [6].

Extensive research has been completed on the conversion of lignocellulosic materials to ethanol production in the last two decades. This conversion includes two processes: hydrolysis of cellulose in the lignocellulosic materials to fermentable reducing sugars and fermentation of the sugars to ethanol. The hydrolysis is usually catalyzed by cellulase enzymes and the fermentation is carried out by yeast or bacteria. These enzymes are produced by several microorganisms, commonly by bacteria and fungi. These microorganisms can be aerobic or anaerobic, mesophilic or thermophilic. There are different factors that affect the enzymatic hydrolysis of cellulose, namely: substrate concentration, cellulase activity, reaction conditions (temperature, pH as well as other parameters), and a strong product inhibition [7]. Substrate concentration is one of the main factors that affect the yield and initial rate of enzymatic hydrolysis of cellulose. At low substrate levels, an increase of substrate concentration normally results in an increase of the yield and reaction rate of the hydrolysis. To improve the yield and rate of enzymatic hydrolysis, research has been focused on optimizing the hydrolysis process and enhancing the cellulase activity [8]. During hydrolysis cellulose is degraded by the cellulases to reducing sugars, which can be fermented by yeasts or bacteria to ethanol.

The factors that have been identified to affect the hydrolysis of cellulose include porosity, i.e., accessible surface area of the waste materials, cellulose fiber crystallinity and lignin and hemicellulose content. The presence of lignin and hemicellulose makes the access of cellulose enzymes to cellulose difficult, thus reducing the efficiency of the hydrolysis. Pretreatment must meet the following requirements: improve the formation of sugars or the ability to subsequently form sugars by enzyme hydrolysis; avoid the degradation or loss of carbohydrate; avoid the formation of byproducts inhibitory to subsequent hydrolysis and fermentation processes; and be cost effective [8].

One major problem with bioethanol production is the availability of raw materials for the production. The availability of feedstock for bioethanol can vary considerably from season to season and depends on geographic locations. Locally available agricultural biomass will be used for the bioethanol production. In Europe the main raw material of bioethanol is the beetroot, wheat, maize, in North-America it is the maize and wheat, and while in South-America it is the sugar cane. The different beet varieties are used for human food, animal feed and sugar production. Sugar beet is an important crop in Europe, North America, and Asia. France is the major producer of sugar beet followed by Germany and the United States [9].

Sugar beet contains from 12 to 15 % sucrose. Fuel ethanol production includes the generation of a large quantity of residues. Effluent treatment will always be an important topic of research [9].

In this work the utilization of organic waste from sugar beet processing was examined in ethanol production. Sugar beet chips after extraction and pressing are poor in sugar but rich in cellulosic components. Therefore the main aim of our project was to examine and intensify the enzymatic hydrolysis of cellulose to monosaccharides in order to obtain higher ethanol yield. The optimal conditions of fermentation the ethanol yield were investigated also.

Methods and materials

Sugar beet chips were used as the polysaccharide source for our experiences. They have gained after extaction and pressing. The particle size of sample was 0.5-2.0 cm after chopping. There was made different composition suspensions from sugar beet chips (min. 7.5 g/cm^3, max. 30 g/cm^3) for investigation.

For enzymatic hydrolysis cellulase (Cellulast 1.5L, Novozymes A/S, Denmark; 700 U/g) from Trichoderma reesei (Sigma) and cellobiase (Novozym 188, Novozymes A/S, Denmark; 250 U/g) from Aspergillus niger (Sigma) was applied dosed in a different concentration of 50; 100; 300 and 600 μLg_{TS}^{-1}.

The temperature and pH of enzymatic hydrolysis were controlled at 40±0.2°C and pH 4.0; 4.5; 5.0±0.1. The samples was incubated and mixed in a thermostat with magnetic stirrer for 7 days.

Reduction of the sugar concentration was estimated by 3.5-dinitrosalicylic acid (DNS) photometric method, with glucose as standard. This spectrophotometrically (S2000 UV/VIS) method means: using 3.5 dinitro-salicylic acid method after calibration with Invertas enzyme [10-12]. Mixture of cellulase and cellobiase enzymes were used to decompose the cellulose fraction of beet chips. In our experiments the ratio of enzymes to substrate, the pH of suspension, and the temperature were varied to find the optimal condition for hydrolysis.

Results and discussion

The time-depending cellulose hydrolysis to monomer sugar was investigated without pre-treatment from sugar beet chips in the first series of experiments. We focused on the determination of the maximum value of cellulose hydrolysis. The sugar content was measured at the received ferment-juice and it was given per unit dry material weight basis (g/g $_{TS}$).

The Figure 1 demonstrates the effect of the pH on the enzyme hydrolysis. The results have showed that the optimum pH of enzymatic hydrolysis of cellulose is pH 4.5. This value is the same as it is publicated in the international Journals as the pH optimum of cellulose enzymes.

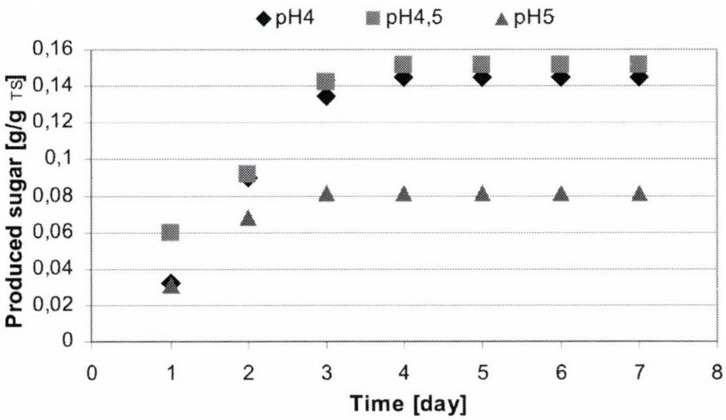

Figure 1. Produced sugar from sugar beet chips during enzymatic hydrolysis (7.5 g/cm^3 substrate concentration; 300 $\mu LgTS^{-1}$ enzymes concentration)

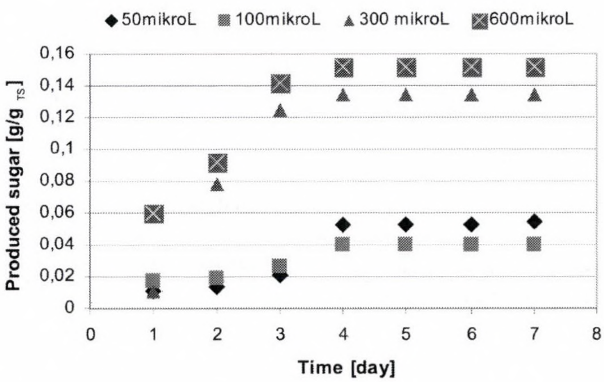

Figure 2. Produced sugar from sugar beet chips during enzymatic hydrolysis (7.5 g/cm^3 substrate concentration, pH 4.5)

In the Figure 2, we can follow the effect of the enzyme amount on the sugar yield. The results have showed that the highest sugar production have been measured at the suspension 300 and 600 $\mu LgTS^{-1}$ and there isn't significant difference between these two values. There isn't relevant sugar production at the smaller enzyme concentrations

The Figure 3, shows the optimal substrate concentration is 7.5 g/cm³ at a given enzyme quantity (300 $\mu LgTS^{-1}$); at the more concentrated suspensions the sugar yield was smaller. The sugar content of the suspensions was increased until the 4th day of fermentation and after that the sugar content of the samples was constant. It shows us, that the real useful period of the enzymatic degradation is only 4 days, after this period is no longer appropriate to continue it due to there will not be changes in the amount of converted sugar yield.

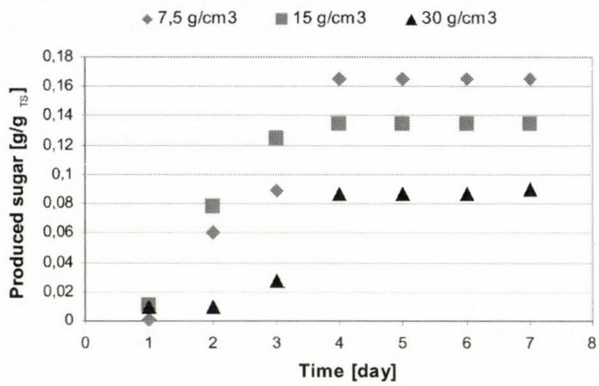

Figure 3.: Produced sugar from sugar beet chips during enzymatic hydrolysis (300 $\mu LgTS^{-1}$ enzymes concentration, pH 4.5)

Conclusions

In this experiments the ratio of enzymes to substrate, the pH of suspension, and the temperature were varied to find the optimal condition for hydrolysis. The amount of fermented sugar was determined from sugar beet chips. The chips were not pre-treated. Our preliminary results showed that the sugar beet chips have a great potential to biofuel production. The bioethanol yield can be large-scale increased by the optimized condition of cellulose hydrolysis prior to the fermentation.

Acknowledgement

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THE PHOTOVOLTAIC MODULES PERFORMANCE BASED ON EXERGY ASSESSMENT

Dani RUSIRAWAN[1], István FARKAS[2]
[1]Institut Teknologi Nasional (ITENAS), Bandung, West Java – Indonesia
[2]Szent István University, Gödöllő – Hungary

Introduction

Presently, the direct conversion of solar energy into electricity is being accepted as an important form of power generation. This electricity generated by a process known as the photovoltaic effect using photovoltaic (PV) system (cells/modules/panels or array), which are made from semiconductor materials. It is well known that most of the radiation (solar energy) absorbed by a PV system is not converted into electricity (electrical energy) but contributes also to increase the temperature of the module (thermal energy), thus reducing the electrical efficiency.

In thermodynamic point of view, photovoltaic (PV) system performance can be evaluated in terms both energy and exergy. Unlike energy, exergy is not subject to a conversion law (except for ideal or reversible processes).

Exergy is defined as the maximum amount of work (or electricity) that can be done by a system or a flow of matter or energy as it comes to equilibrium with a reference environment. Exergy is consumed or destroyed, due to irreversibility in any real processes. The exergy consumption during a process is proportional to the entropy created due to irreversibility associated with the process. Exergy analysis is a methodology that uses the conservation of energy principle (embodied in the "First Law of Thermodynamics") together with non-conservation of entropy principle (embodied in the" Second Law of Thermodynamics") for the analysis, design and improvement of energy and other systems (Rosen et al., 2009). A different conceptual about energy and exergy analysis is shown in Figure 1 (Shukuya et al., 2002). .

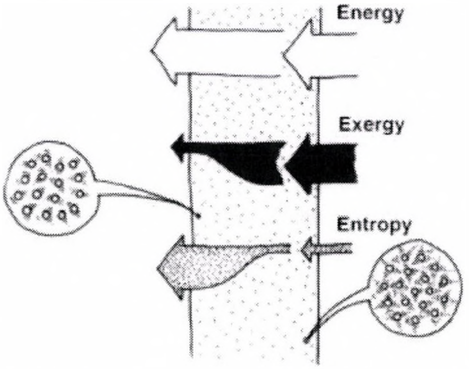


Figure 1. Energy, exergy, and entropy flow in and flow out of a system.

In this research, an exergy evaluation of PV module, as a basic component of PV array system, will be applied and elaborated, refers to a 10 kWp grid-connected PV array system at Szent István University, Gödöllő - Hungary, which uses two different of PV technology i.e. polycrystalline PV technology (ASE-100) and amorphous silicon PV technology (DS-40) (Farkas et al., 2008). Amorphous silicon is a non–crystalline form of silicon i.e. its silicon atoms are disorder in structure. As a results, comparison of two exergy evaluation methods of PV, i.e. "solar energy parameters" and "photonic energy" will be presented in this paper.

As a long term target of this research, the other possibility to optimize and increase the overall performance of grid-connected PV array system at Szent István University, can be studied, observed and proposed.

Methods of Evaluation

For a steady state flow system, energy and exergy balances through a system can be expressed as follow (Dincer et al., 2005):

$$\sum_i en_i \dot{m}_i - \sum_e en_e \dot{m}_e + \sum \dot{Q} - \dot{W} = 0 \quad 1$$

$$\sum_i ex_i \dot{m}_i - \sum_e ex_e \dot{m}_e + \sum \dot{E}x^Q - \dot{E}x^W - I_r = 0 \quad 2$$

$$I_r = T_a S_{gen} \quad 3$$

where $\dot{m}$ is mass flow rate across the boundary system [kg/s]; en and ex are specific energy [J/kg] and specific exergy [J/kg], respectively; $\dot{Q}$ is the heat transfer across the boundary system [W]; $\dot{E}x^Q$ is the exergy transfer associated with $\dot{Q}$ [W]; $\dot{W}$ is the work (including shaft work, electricity, etc.) transferred out of the system [W]; $\dot{E}x^W$ is the exergy transfer associated with $\dot{W}$ [W]; I_r is the system exergy consumption due to irreversibility during a process [W]; T_a is ambient temperature [K]; and S_{gen} is entropy generated by the system [W/K].

In exergy analysis, the characteristics of a reference environment need to be specified, and in this study the temperature is used as reference.

To evaluate the exergy efficiency of PV system (η_{ex}), the exergy of the total solar radiation is needed, and in general η_{ex} could be represented as:

$$\eta_{ex} = \frac{\dot{E}x_{out}}{\dot{E}x_{in}} \quad 4$$

where $\dot{E}x_{in}$ equal with exergy total solar radiation.

Exergetic PV assessment using solar energy parameters method

A PV array is non linear device and can be presented by its I-V-P (current-voltage-power) characteristic curve. The general equivalent circuit of a solar cell in a single diode model is presented in Figure 2, and consists of a photocurrent source, a diode, a parallel resistor expressing a leakage current and a series resistor describing internal resistance to the current flow (Wenham, 2007).

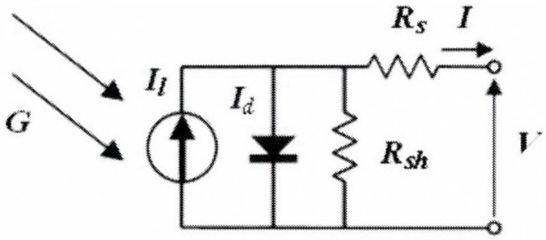


Figure 2. General model of solar cell circuit in a single diode model

The current-voltage characteristic equation for a PV system is given as:

$$I = I_l - I_o\left[\exp\left(\frac{V + IR_s}{\left(\frac{nkTc}{q}\right)}\right) - 1\right] - \frac{V + IR_s}{R_{sh}} \quad 5$$

where I is the current produced by the solar cell [A], I_l is a light-generated current or photocurrent [A], I_o is the dark saturation current (the diode leakage current density in the absence of light) [A], V is the output voltage/applied voltage [V], q is an electron charge [1.602 x 10-19 C], k is the Boltzmann's constant [1.381 x 10-23 J/K], T_c is the cell working temperature [K], n is an ideality factor (a number between 1 and 2 that typically increases as the current decreases), R_{sh} is shunt resistance of the cell [Ω] and R_s is a series resistance of the cell [Ω].

Based on equation (4), the exergy efficiency of a PV system in this method can be expressed as:

$$\eta_{ex} = \frac{\dot{E}x_{elect} + \dot{E}x_{thermal} + \dot{E}x_{dest.}}{\dot{E}x_{solar}} \quad 6$$

$$\eta_{ex} = \frac{\dot{E}x_{elect} + I_r}{\dot{E}x_{solar}} = \frac{\dot{E}x_{elect} + \sum \dot{E}x_{dest.}}{\dot{E}x_{solar}} \quad 7$$

$$\sum \dot{E}x_{dest.} = \dot{E}x_{dest.thermal} + \dot{E}x_{dest.elect} \quad 8$$

I_r contains both internal and external losses. Internal losses are electrical destruction, $\dot{E}x_{dest.elect}$, and external losses are heat losses, $\dot{E}x_{dest.therm}$, which is numerically equal to $\dot{E}x_{thermal}$ (Joshi et al., 2009).

$$\dot{E}x_{elect} = V_{mp} \times I_{mp} \quad 9$$

where V_{mp} is voltage at maximum power point and I_{mp} is current at maximum power point.

$$\dot{E}x_{thermal} = \left(1 - \left(\frac{T_a}{T_c}\right)\right) \times \dot{Q} \quad 10$$

$$T_c = T_a + \frac{G}{G_{ref}}\left(NOCT - T_{a,ref}\right) \quad 11$$

Based on equations (6), (9) and (10), $\dot{E}x_{out}$ from the PV can be expressed as:

$$\dot{E}x_{out} = V_{mp} \times I_{mp} - \left(1 - \frac{T_a}{T_c}\right) \times \dot{Q} \quad 12$$

meanwhile,

$$\dot{E}x_{in} = \dot{E}x_{solar} = \left(1 - \frac{T_a}{T_s}\right) \times G \times A \quad 13$$

where $T_{a,ref}$ is the reference of ambient temperature [K]; $NOCT$ is Nominal Operating Cell Temperature [K]; G and G_{ref} are the actual and reference solar radiation [W/m^2], respectively.

Exergetic PV assessment using photonic energy method

Solar energy can be termed as photonic energy from the sun and this energy travels in the form of photons. The energy of a photon, $En_{ph}(\lambda)$[J], can be calculated as:

$$En_{ph}(\lambda) = \frac{hc}{\lambda} \quad 14$$

where h and c are physical constants; h is Planck's constant [≈ 6.626 x 10^{-34} J.s]; c is speed of light in vacuum [2.998 x 10^8 m/s]; and λ is wavelength of spectrum the light [nm].

In order to evaluation of photonic energy parameters, the sets equations as follow can be implemented (Joshi et al., 2009):

$$N_{ph} = G\frac{4.4 \times 10^{21}}{1367} \quad 15$$

$$\dot{E}n_{ph}(\lambda) = En_{ph}(\lambda) \times N_{ph} \times A \quad 16$$

$$\dot{E}n_{chemical} = \dot{E}n_{ph}(\lambda) \times \left(1 - \frac{T_c}{T_s}\right) \quad 17$$

where N_{ph} is the numbers of photon falling per second per unit area on the Earth [1/m^2.s]; $\dot{E}n_{ph}(\lambda)$ is the photonic energy falling on the PV system [W]; $\dot{E}n_{chemical}$ is available photonic energy or Chemical potential [W] and T_s is the sun temperature [5777 K] (Joshi et al., 2009).

In this method, $\dot{E}n_{chemical} = \dot{E}x_{in}$ and $\dot{E}x_{out}$ equal with power generated by the PV modules, and can be calculated as the product of their output current (I) and the voltage across their terminals (V) or as shown in equation (9).

Table 1 Monthly variation of climate data for Gödöllő, Hungary.

Month	G_{hor} [kWh/m2.m]	G_{arr} [kWh/m2.m]	v [m/s]	T_a [°C]	*Sun-hours** (h)	$G_{arr} = G$ [W/m2]
January	29.79	44.57	2.65	-0.94	9	159.75
February	46.35	62.82	2.70	1.70	10	224.34
March	86.25	104.16	2.82	6.20	12	279.99
April	127.23	140.31	2.91	11.54	14	334.07
May	162.17	163.76	2.67	16.48	15	352.16
June	172.06	167.49	2.76	19.30	16	348.93
July	182.90	182.05	2.75	21.42	15	391.51
August	153.71	164.99	2.38	20.82	14	380.16
September	109.33	130.47	2.29	16.54	12	362.42
October	70.55	98.39	2.12	11.37	10	317.39
November	35.31	52.03	2.49	5.30	9	192.71
December	23.06	33.38	2.64	1.14	8	134.60

* Based on sun - path diagram.

Results and discussion

For analysis, the yearly (monthly variation) of climate data for Gödöllő - Hungary (specific site location: 47.4° N for lattitude and 19.3° E for longitude) are taken from PV*SOL 3.0 software packages, which acquires data from MeteoSyn, Meteonorm, PVGIS, NASA SSE, SWERA (Klise et al., 2009). The following data such as solar radiation (both in horizontal, G_{hor} and tilt array position, G_{arr}), ambient temperature and wind velocity (v) are shown in Table 1. Meanwhile the electrical parameters under reference conditions (STC), such as I_{SC} (short circuit current); V_{OC} (open circuit voltage); I_{mp} (current at maximum power point); V_{mp} (voltage at maximum power point), are provided by manufacturer sheets.

The calculated results of the modules performance in exergy efficiency is shown in Figure 3.

Figure 3 (a)-(b) shows the exergy efficiency for both methods, refers to preceding sets equation. The values of I and V is taken from *I-V-P* characteristics which obtained from previous research (Rusirawan et al., 2011).

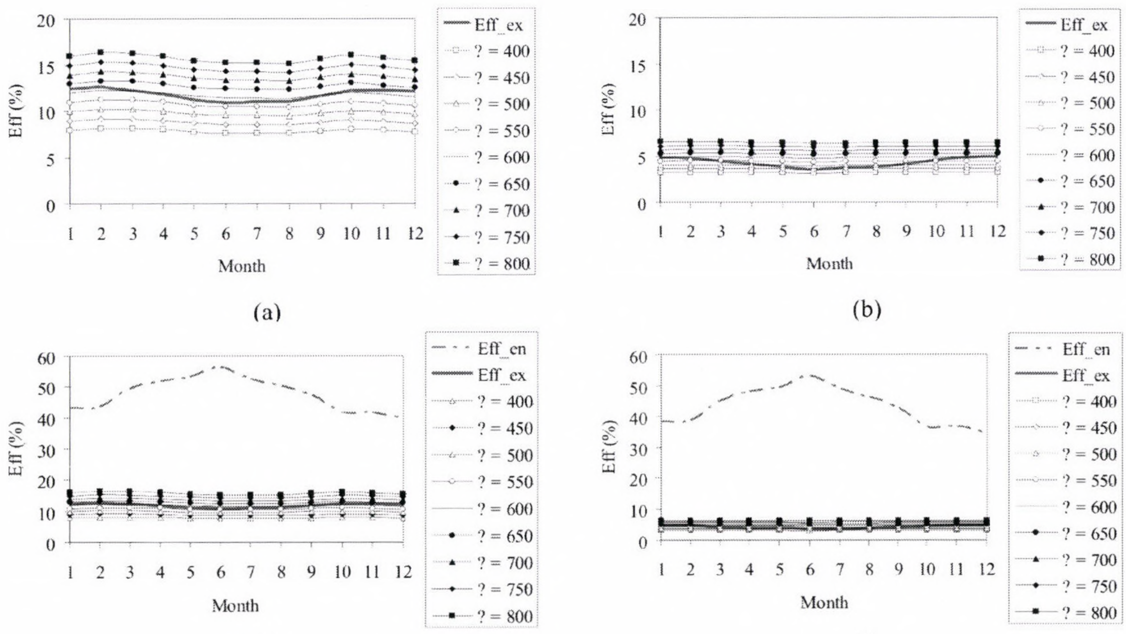
For the photonic method purpose, calculated are performed by varying wavelength of the visible spectrum, for a given range of 400 to 800 nm. Comparison between exergy efficiency based on photonic, exergy efficiency based on solar energy parameter and energy efficiency is shown in Figure 3 (c)-(d).

Based in Figure 3(a)-(b), it can be seen that for the same case, exergy efficiency based on "solar energy parameter" is spread between exergy efficiency values based on "photonic energy" in the varying wavelength of the visible spectrum. Both of methods results an average of exergy efficiencies 11-12 % for ASE-100 and 4-5 % for DS-40. On the other hand, the actual PV efficiencies (electrical efficiency) average based on operational results are 13 % and 4 % respectively for ASE-100 module and DS-40 module.

Figure 3(c)-(d), shown that energy efficiency of PV higher than exergy efficiency, because in the energy efficiency terminology, the thermal energy and electrical energy are taken into account as an output of energy of the PV system. Meanwhile, in the exergy efficiency terminology, the thermal energy is viewed as losses and is not taken into account as an output.

Conclusion

In this study, exergy efficiency characteristics of two type of PV modules, i.e. polycrystalline silicon (ASE-100) and amorphous silicon (DS-40), as a main part of 10 kWp grid-connected PV array systems at the Szent István University, have been performed, based on "solar energy parameter" method and "photonic energy" method. It is observed that both methods of PV exergy assessment gives the realistic values than the PV energy assessment (if compares to an actual electrical efficiency). It also has been found that in the photonic energy method the wavelength of visible spectrum plays an important role on the exergy efficiency characteristics. As expected, the efficiency characteristics of ASE-100 module (which included crystalline materials type) are higher than DS-40 module (which included thin film materials type). Further parametric studies are still needed, in order to obtain a deep correlation between climatic and operating parameter, and finally other possibility to optimize and increase the PV module performance can be found.



(c) Polycrystalline (ASE-100)

(d) Amorphous silicon (DS-40)

Figure 3 PV exergy efficiency at different wavelength (λ, nm) and its comparisons with exergy efficiency based on solar energy parameter (Eff_ex) and energy efficiency (Eff_en).

Acknowledgments

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SOLAR ASSISTED GROUND SOURCE HEAT PUMP SYSTEM

L. TÓTH[1], S. ŠLIHTE[1], B. ÁDÁM[2], K. PETRÓCZKI[1], P. KORZENSZKY[1], Z. GERGELY[1]
[1]Institute of Process Engineering, Szent István University
Páter K. u. 1., Gödöllő, H-2103, Hungary
Tel.:+36 28 522-043
E-mail: Toth.Laszlo@gek.szie.hu,
Petroczki.Karoly@gek.szie.hu,
Korzenszky.Peter@gek.szie.hu,
Gergely.Zoltan@gek.szie.hu
[2]Hydro Geodrilling Kft.
Zsigárd u. 21. Budapest, H-1141, Hungary
Tel.:+36 1 221 1458, E-mail: info@hgd.hu

Abstract

The objective of the project was to find the most suitable solution for heating and cooling a conference room in an office building at Gödöllő, Hungary. Ground source heat pump system assisted by four solar photovoltaic cells for electric energy generation was installed in 2009. For a collector system two 100 m deep U-type-tubes were placed in separate boreholes. The system works in heating and cooling mode. The heat pump is not used for cooling. The excess heat is delivered to the soil by a heat exchanger situated in a depth of 15 m.

Keywords

ground source heating, heat pump, solar energy, heating, cooling

Introduction

The price of fossil fuel and the need for an independent and pollution free energy source motivates businesses and households looking for alternative energy sources in Hungary especially for heating and cooling [3]. Heat pumps are suitable for the weather in Hungary as it can provide heating in winter and cooling in summer and soil conditions in this geographical area are suitable for collecting heat from the relatively high temperature ground[6].. The disadvantage of heat pumps is that they require external power and as a solution it is possible to combine it with a solar system for electricity generation. A solar assisted ground source heat pump system is installed in one of the office buildings at Gödöllő. The purpose of this project was to find a cheaper, cleaner and more independent heat energy source.

Design and installation

A solar assisted ground source heat pump system is installed for heating and cooling a 100 m^2 conference room of an office building at Gödöllő in 2009. The heat pump requires electricity and to provide cheaper and more environmental friendly energy solar collectors are used for power generation. The system consists of a heat source - ground collector system, water-to-water heat pump which raises the temperature of the collected heat and transfers it in form of the water to a buffer tank and further to a heat distribution system – water is transferred from the buffer to fan-coil units[1].. The collector system consists of two 100 m deep boreholes. A location of boreholes and a floor plan of conference room are shown in Figure 1.

There are two different types of ground source heat pump systems – a direct expansion system where a refrigerant is circulated through the heat pump and the collector system; and an indirect system where a mix of water with antifreeze circulates through the collector system and the refrigerant circulates only in the heat pump. In this case it is an indirect system[4].. The distribution heat system of the conference room consists of four series connected fan-coil units, the heat exchangers in which water is circulated and heated or cooled air is transferred to the room by a fan[6]..

The system is assisted by four solar photovoltaic cells for electricity generation to run the circulation pump. System is shown in Figure 2.

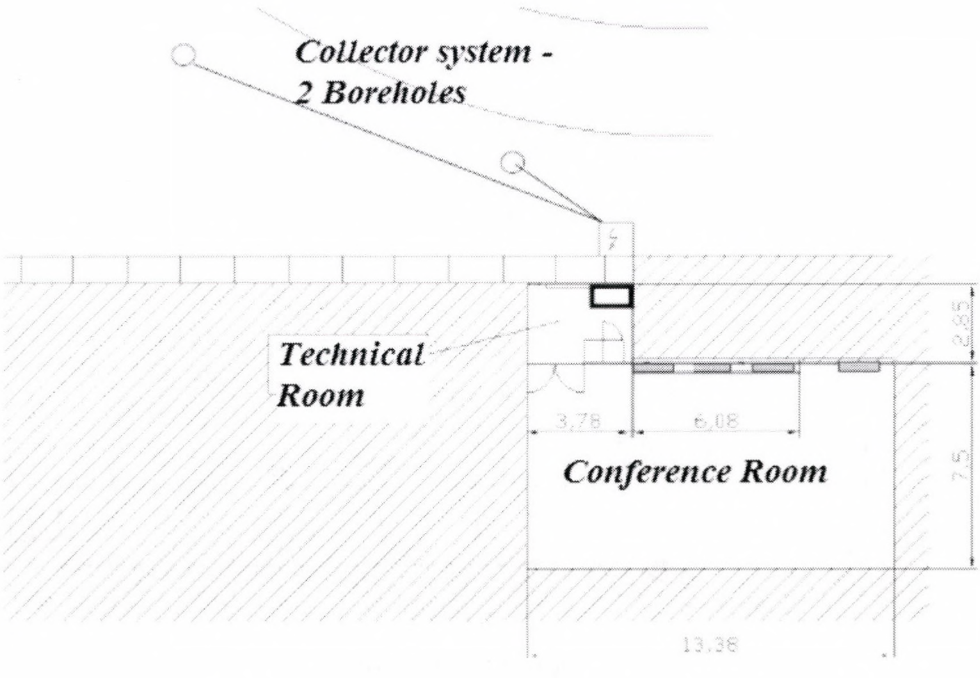

Figure 1. Floor Plan of a Conference room and borehole locations

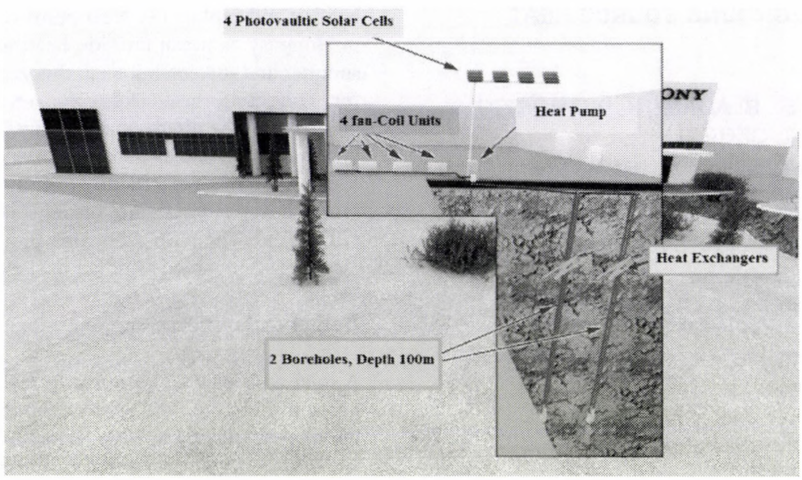

Figure 2. Solar assisted heat pump system

The components of the heat pump system

The system consists of two parts – primary and secondary side which are separated by the heat pump[7]. The primary side consists of a vertical ground collector system with the heat exchanger and the secondary part consists of a heat distribution system with four fan-coils. A compressor of the heat pump works periodically by turning on and off. To maintain a correct and constant flow a buffer tank is used. In summer in cooling mode the heat exchanger is used without using heat pump. Figure 3 and Figure 4 shows a schematic and components of the installed heat pump system.

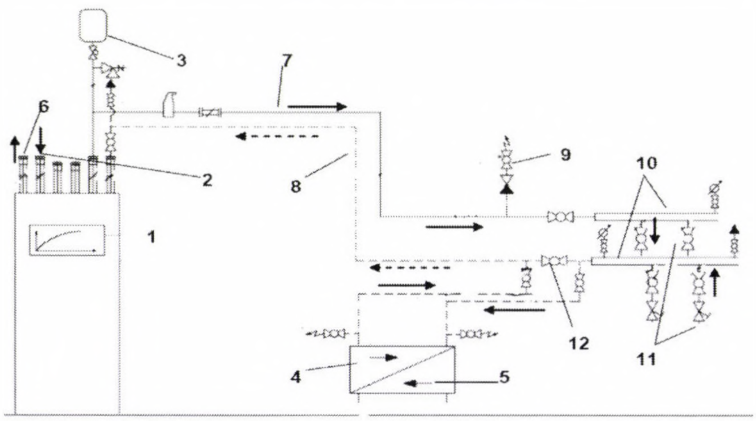

Figure 3. Primary side
1. Heat pump 2. The secondary side (return pipe) 3. Compensator container 4. The primary side of the refrigeration heat exchanger 5. The secondary side of the refrigeration heat exchanger 6. The secondary side (outgoing pipe) 7. The branch of the primer side (outgoing pipe) 8. The secondary side (return pipe) 9. Recharging tap 10. Boreholes return pipes 11. The boreholes outgoing pipes 12. Relay tap in case of refrigeration in summer

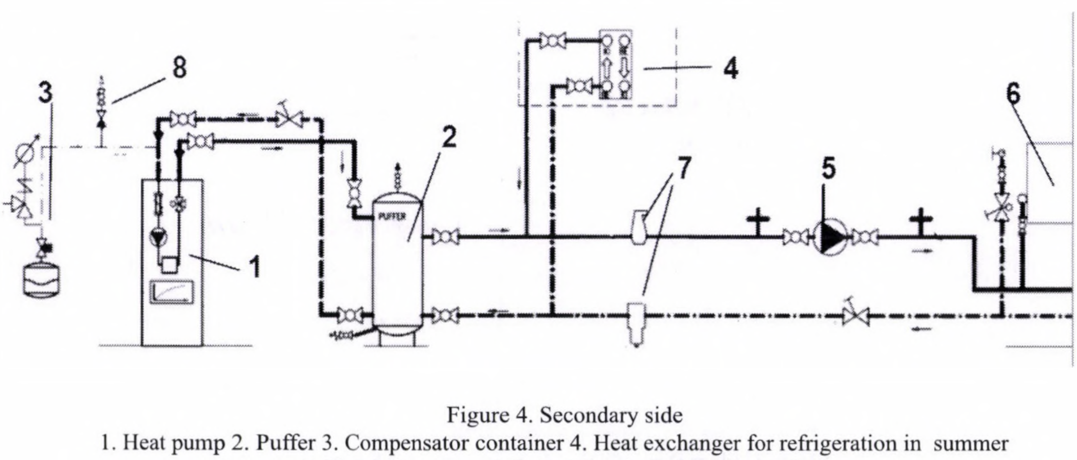

Figure 4. Secondary side
1. Heat pump 2. Puffer 3. Compensator container 4. Heat exchanger for refrigeration in summer 5. Circulation pump 6. Fan-coil units 7. Cleaning units

In heating mode heat is collected from the soil by a special liquid – mix of water and glycol running through U-type tubes situated in boreholes. In heat pump the heat is transferred to a refrigerant by heat exchanger and the temperature of it is increased by a compressor and the heat is transferred to the secondary loop by the heat exchanger and is delivered to a buffer tank where the heated water is stored. It equalizes the temperature of the water because the compressor works periodically. The water flow is circulated by a pump and transferred to four fan-coils. In cooling mode the process is reversed but a ground heat exchanger is used for giving the heat to the soil directly. The heat exchanger is in the 100 m deep boreholes. By using cooling heat exchanger the power requirement is lower.

Results

To analyse the performance of the system monitoring was carried out. Measurements were made for a period of 20 days starting from 30th October 2010 to 18th November 2010. Temperatures in 16 different points were measured. Most significant results of minimal, maximal and average temperatures of 24 hour measurement in 6th November are shown in Table 1.

Table 1. Measured temperatures

	Max T °C	Min T °C	Average T °C
Temperature of the soil (16m deep)	13,4	11,7	12,6
From the heat pump (out)	37,5	24,9	27,7
Back to the heat pump (in)	30,1	24,9	27,1
Air temperature in the room	25,0	23,4	24,3

Temperature parameters are closed to design ones. The difference between the heat pump minimal and maximal temperature is because the compressing process of the heat pump doesn't happen constantly. The temperature sampling time was 10 minutes. Figure 5. shows 24 hour (144 × 10 min) temperature diagram of outgoing and returning water of the buffer.

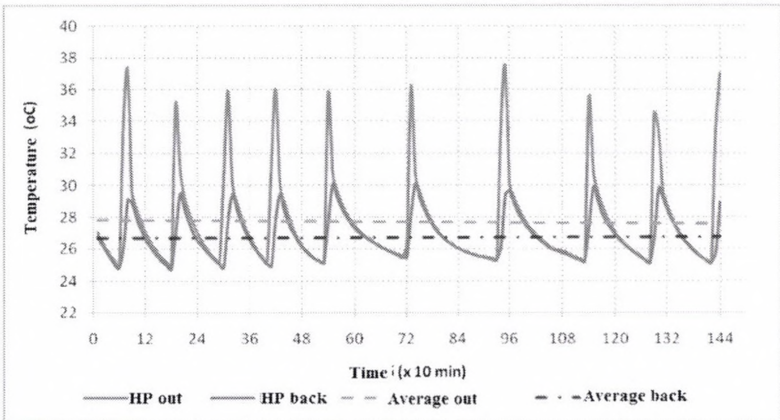

Figure 5. Outgoing and returning water temperatures of the Buffer

24 hours period of temperatures of borehole exchangers and the soil in 16 m depth are shown in Figure 6. The green line shows the soil temperature in 16 m depth which is between 11,8 and 13,4°C.

To analyse the performance of the hall system it is significant to analyse the consumption of the electricity. The system provides electrical energy for compressor, fan-coil units and the circulation pump. Performance of the system in a cold winter day when average outdoor temperature is -3 °C is shown in Fig. 7.

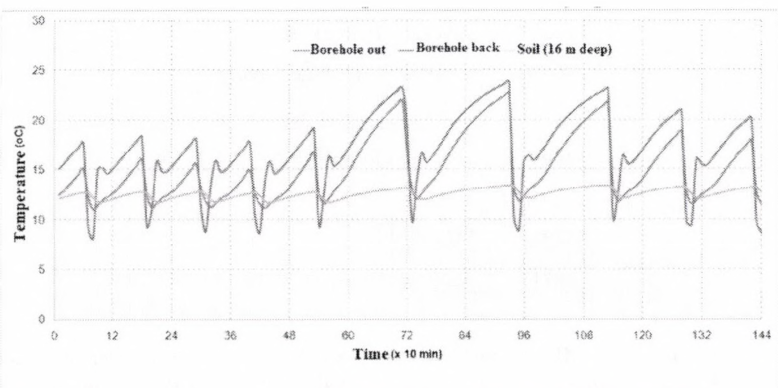

Figure 6. Temperature of U-tube-type borehole exchanger and the soil [2]

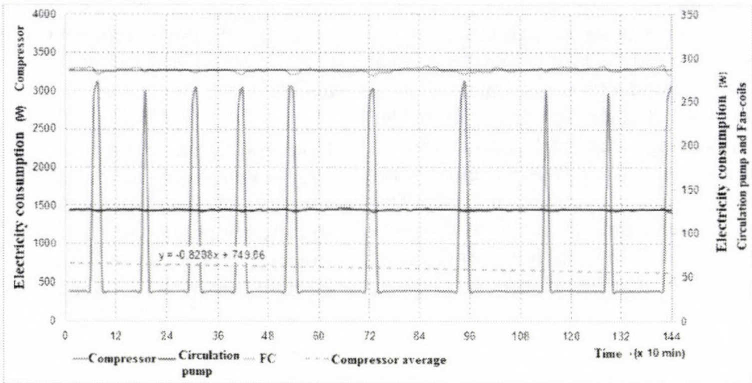

Figure 7. Electric consumption of the system

During a 24 hour period the compressor of the heat pump works with interval 17 – 25 min. The electric power consumption of the compressor unit during compressor turn-off only about 380 W, in turn-on state the electric consumption increases up to 3100 W. Electric consumption of fan-coils varies from 279,7 W to 292,2 W and the circulation pump's consumption is between126,5 and 129,9 W.

A variation of the supplied water temperature to fan-coils and the supplied air temperature to the room is shown in Figure 8. The supplied water temperature varies from 24,5 °C to 31,5 °C. And the supplied air temperature varies from 21,0 °C to 23,8 °C.

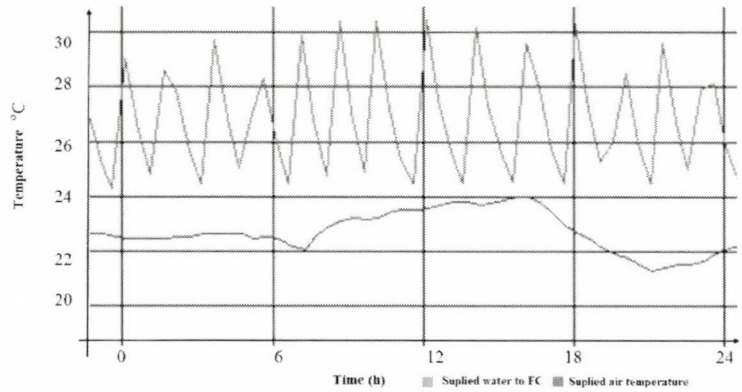

Figure 8. Fan-coil performance

Measured data proves that the project system meets the requirements. The operation was satisfactory and there was no trouble during a long period. Measured temperatures are close to designed temperatures and a comfort temperature +22 °C (± 2°C) was provided in the conference room even in the coldest months of the year.

Energy consumption of the running system – heat pump, circulation pump and fan-coils is shown in Table 2. It is compared with energy consumption of a natural gas boiler heating system combined with a separate climate control which would be required to heat and cool the same room. Savings of energy and carbon emissions of one year are shown in the table.

Table 2. Energy consumption of the heat pump system compared to the energy consumption of a traditional system

	kWh/year	MJ/year		kWh/ year	MJ/ year
Natural gas burner	11550	51975	Heat pump	2880	10368
Split clime	1650	5940	Circulation pump	480	1728
			Fan-Coils	162	583
Together	**13200**	**57915**	**Together**	**3522**	**12679**

Saving	**45236**	MJ/year
CO_2 Saving	**3871**	kg/year

One year energy consumption was 12679,2 MJ (Heat pump 10368 MJ, circulation pump 1728 MJ, fan-coil units 583,2). By using a traditional heating system with boiler and climate control this number could be 4,6 times bigger and saves about 45236 kg carbon emission and € 135 708 with it during one year. Energy consumed by a circulation pump is provided by solar panels on the roof.

Parameters and the performance of solar panel such as size, collected energy of one m² and a factor of a performance, working hours of a year and produced energy in one year are shown in Table 3.

Table 3. Performance of solar panels

m^2	kW/m^2	η	h/year	kWh/year
1,8	1000	0,16	2100	604,8

As shown in table solar panels provide 604 kWh/year but the circulation pump requires only 480 kWh/year. Cost of the heat pump system was € 13 868 (1 drilling of 100 m deep borehole in Hungary costs € 2190).

Conclusions

By installing a ground source heat pump system the energy consumption and CO_2 emissions are reduced. This solution for heating and cooling provides comfort for users as temperatures are easy to regulate and the system does not require maintenance. The system works error free and provides heating and cooling just by changing a position of a switch. The consumed energy is reduced by 4,6 times which makes up to € 135 708 savings in one year (according to the electricity and natural gas tariff in 2011) making the system environmental friendly and cost effective for the business. The results of measured data shows that system works without any disorders and appropriate to designed parameters.

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ECONOMIC AND LOGISTICAL BACKGROUND OF SOLID BIOMASS PRODUCTION FROM AGRICULTURE IN HUNGARY AND SERBIA

László MAGÓ[1], Goran TOPISIROVIĆ[2],
Snežana OLJAČA[3], Mićo V. OLJAČA[2]
[1]Szent István University,
Faculty of Mechanical Engineering
Páter K. u. 1., Gödöllő, H-2103, Hungary
Tel.:+36 28 522-000/1453,
E-mail: Mago.Laszlo@gek.szie.hu
[2]Faculty of Agriculture,
Institute of Agricultural Engineering
Nemanjina 6, Belgrade, 11080, Serbia
[3]Faculty of Agriculture, Institute of Crop Science,
Nemanjina 6, Belgrade, 11080, Serbia

Abstract

The research aimed to measure the quantity of agricultural biomass suitable for energy purposes at regional level (mostly in Serbia and Hungary). Furthermore, our common research also aimed to determine the potential of biomass for energy purposes with regards to the grown plants. We also aimed to name the possibilities and ways of utilisation of the solid biomasses of various origins.

Experiments of this kind have already commenced in Hungary and Serbia, in the Gödöllő-based Hungarian Institute of Agricultural Engineering, also in the Faculty of Mechanical Engineering of Szent István University, Gödöllő and in the Beograd - Zemun-based Institute of Agricultural Engineering of Faculty of Agriculture University of Belgrade.

The potentials of different types of solid biomass from agriculture are presented in the paper. The survey has included the comparative presentation of solid biomass potentials in Hungary and Serbia.

Keywords

solid biomass, agricultural biomass potential, renewable energy, energy utilisation, economy and logistic

Introduction

Renewable energy sources are strongly emphasized among the other items for renewable energy production and environmental protection. Besides, very important are improvements in rural development, employment, energy supply diversification, lower fossil fuels consumption, reliability of energy supply, engagement of domestic industry, etc.

According to the EU Directive 2003/30/EC, the biomass is defined as following: 'biomass' means the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste.

In the Action plan for biomass 2010 - 2012, that was designed by the Ministry of Environment and Spatial Planning and the Ministry of Energy and Mining of the Serbian Government, this definition is more precise: biomass is the biodegradable fraction of products, waste and residues from agriculture (including vegetal and animal substances), forestry and wood industry, as well as the biodegradable fractions of industrial and municipal waste, which use in energy production is allowed, according to the relevant regulation from the field of environmental protection.

Basically, biomass is plant or animal matter (hence organic resources) that can be used to produce energy through different processes. The energy of plant matter is recaptured by the plants in the photosynthesis, transforming the sunlight into chemical energy and providing the base for the environmental chain. During the photosynthesis, plants combine carbon dioxide from the air and water from the ground to generate carbohydrates, which form the building blocks of biomass. In this way, the solar energy is stored in the chemical bonds of the structural components of biomass. This energy can be extracted using different methods. On the other hand, the main source of energy from animal sources mainly comes from cattle manure.

The general importance of the renewable energy sources in the EU economy can be illustrated by the following table, that presents the planned increase of renewable energy sources in the EU from 1995 to 2010.

Table 1. Renewable energy sources in the EU in 1995 and the predicted capacities in 2010

Type of energy	Renewable energy source potentials in 1995	Predicted potentials in 2010	Increment index
1. Wind	2,5 GW	40 GW	16
2. Water	92 GW	105 GW	1,1
Large power plants	82,5 GW	91 GW	0,01
Small power plants	9,5 GW	14 GW	1,5
3. Photovoltaic cells	0,03 GW	3 GW	100
4. Biomass	44,8 M toe	135 M toe	3
5. Geothermal			
Electricity	0,5 GW	1 GW	2
Heat	1,3 GWt	5 GWt	3,8
6. Solar collectors	$6{,}5 * 10^6$ m^2	$100 * 10^6$ m^2	15,3
7. Passive solar energy		35 Mtoe	-
8. Other		1 GW	-

Hungarian preview

According to surveys there is a significant biomass potential in Hungary. The total bulk of biomass in the country is up to 350-360 million tons out of which 105-110 million tons (about 30 %) reproduce themselves annually. The energy content of the biomass developing annually is up to 1185 PJ which is 5 % more than the total annual energy consumption of the country (1120 PJ). The fact that quantity of coal generated annually by plants is four times as much as the quantity of fossil coal exploited for energetic purposes in a year – as much as 30.4 million tons.

Table 2. Potential and utilization possibilities of energetic biomass from the agriculture

No.	Biomass	Quantity 1000 t/year		Energy content PJ/year	
		Min.	Max.	Min.	Max.
I. Biomass for combustion					
1.	Straw	1.000	1.200	11,7	14,0
2.	Stalk	2.000	2.500	24,0	30,0
3.	Energy grass	500	600	6,0	7,0
4.	Vine- and orchard shoot	300	350	4,3	5,0
5.	Energy plants on arable land	1.800	2.500	27,3	38,0
II. Production of biofuels					
1.	Corn maize	1.200	2.000	14,4	24,0
2.	Wheat/rye	600	1.800	7,2	21,6
3.	Rape	220	460	3,3	7,0
4.	Sunflower	50	200	0,8	3,2
III. Biogas production					
1.	Liquid manure, organic waste	6.000	10.000	5,4	9,0
2.	Silomaize, sorghum	1.600	3.200	5,4	10,8
Total:				109,8	169,6
In % of the total Hungarian energy consumption of 1120 PJ				9,7 %	15,0 %

In the primary biomass produced by the agriculture first of all the by-products arising in better amount can be reckoned with for energetic purposes. Under common or regular conditions 2,6-2,9 million tons of **cereal straw** is processed annually of which 1,6-1,7 million tons are utilized for animal breeding and for industrial purposes. The major part of the remaining 1,0-1,2 million tons of cereal straw could be used for energy production and annually 11,7-14 PJ energy could be produced of it. At present straw is practically not utilized for energetic purposes in Hungary due to the lack of appropriate stokes.

Maize stalk production in Hungary is 8-10 million tons of which 2-2,5 million tons could be utilized for energetic purposes which could yield 20-24 PJ energy p.a. Among the by-products of crop growing sunflower stalk and rape straw also arise in big quantities which could be utilized for burning and could supply 5-6 PJ thermal energy annually should the appropriate technologies for harvesting and burning be available.

The quantity of **vineyard and orchard pruning residues** (branch tendrils and fruit tree loppings) arising annually is 300-350 thousand tons which could supply 4,3-5 PJ energy. There have only been attempts for their burning till now. The harvesting in bales and burning in small stokes of branch tendrils is a viable solution on the vine growing farms. For the chopping, collecting and burning of pruning residues no technology has been developed so far.

Among the plants which can be produced on big areas for energetic purposes first of all the energy-grass and the energetic tree plantations can come into consideration in Hungary.

The energy-grass as a short rotation herbaceous grasses is able to provide a dry bulk of 10t/ha which can be baled for several years the energy content of which is 110-120 GJ/ha. The energy-grass can easily be pelletized. 6-7 tons of pellets can be produced of the grass yield of one hectare the burning features of which are more auspicious in lower capacity stokes than that of the chopped material in thermal power stations.

Should the final form of firing technology of energy-grass be developed cropping could be started in a short time maybe on 50-60 thousand hectares which would supply a 500-600 thousand ton bulk of biomass annually, of which 6-7 PJ energy can be produced. Another prospective source of bio-energy is the energetic tree plantation classified in the agricultural plantation management cultivation sector by which dendromass can be produced relatively fast and in big quantity for energetic purposes.

According to experiences hitherto it is expedient to plant the **short rotation wooden crops** varieties (poplar, willow) with a number of plants 12000-15000/ha which will be ready for felling in 3-5 years. The re-shooting tree stock can be harvested in another 3-5 years by felling totally 5-7 times assuming a plantation lifespan of 15-25 years. On the basis of long term-experiments made with different tree varieties yields of 11-20 t/ha/year can be achieved, of which 185-330 GJ/ha energy can be produced.

A rapid territorial expansion of the energetic plantations is expected in the near future which can achieve, or even exceed 100 thousand hectares of which 25-30 PJ energy can be gained.

For energy production under arable land conditions *triticale in the form of whole plant* cut into windrow and baled can also be taken into account the yield of which may reach 8-10 t/ha with 40 % grain bulk in it. Its energy content is 15-16 GJ/t so 120-160 GJ/ha energy can be produced. It has a favorable feature from the point of view of firing technology, that in baled form it burns more slowly and with a more even heat regress than wheat straw.

These biomasses originating from plants which can be produced on the field and utilized by direct burning are gaining a growing emphasis in our national energy policy in the coming years.

Table 3. The real and feasible capacity for energetic utilization of solid biomass in Hungary

Biomass	Utilization	Actual capacity			Expected growth till 2020		
		Unit (pieces)	Capacity (MW)	Biomass demand (2000 t)	Unit (pieces)	Capacity (MW)	Biomass demand (1000 t)
1. Wood chips (forest or planted wood)	Electricity	5	140	1000	8	420	2800
	Central heating	5	24	25	25	120	150
	Central heating + electric energy production	2	12	32	20	120	180
2. Straw, Energy grass	Straw power plant, electric energy production and heat utilization	-	-	-	2-3	40-60	450
Sum total		12	176	1057	55-56	700-720	~ 3600

Serbian preview

The agricultural biomass wastes are coming from cereals, mostly wheat, barley and corn, and from industrial crops mostly sunflower, soya, and rapeseed. In addition, there are many livestock farms in agricultural regions, where liquid and solid manure are considered as biomass waste. Fruit growing is also present in the agricultural areas, but the main area of fruit growing is the hilly region on the south, where main types of fruit are plums, apples, cherries, peaches, and grapes.

Actual annual biomass production in Serbia is app. 12.5 million t (2.7 million of TOE). From this sum, 1.7 million TOE is agricultural biomass, and 1.02 million TOE comes from the forestry.

Table 4. Possibilities for energy production from biomass in Serbia

Biomass source	Potential (toe)
Wood biomass	1.527.678*
Wood for combustion	1.150.000
Wood residues	163.760
Wood processing residues	179.563
Outside forests wood	34.355
Agricultural biomass	1.670.240
Crop production residues	1.023.000
Fruit and grape production and processing residues	605.000
Liquid manure (for biogas production)	42.240

* Recent research on wood biomass, according to the FAO methodology

For easier classification, biomass that originate from agriculture can be divided in three main categories: from crop production, fruit production and livestock breeding.

Biomass from crop production

In Serbia, there are many small individual landowners who deal with production of cereals or industrial plants, like sunflower or soya. A great deal of crop farming production, almost 75% is achieved in small or medium size private ownership, while only about 25% of crop farming production belongs to agricultural companies of relatively larger size.

The modern way of livestock breeding does not consider extensive use of bio mass residues for animal bedding. At large agricultural farms it is more favorable and cost effective to collect biomass residues in bales, and use them without any further preparation in small or medium sized boilers.

About half of bio mass residues at large agricultural farms can be used for energy purposes, while only about 20% bio mass residues generated on relatively small private farms can be used for energy purposes.

Table 5. Yield of main species in crop farming and energy potential of their residues

Plant	Yield (10^3t)	Total residues (10^3t)	Residues for energy use (10^3t)	Energy potential (toe)*
Wheat	2.905,0	2.905,0	1.365,0	Average heating value 14MJ/kg
Barley	365,0	295,0	180,0	
Rye	14,1	15,5	4,4	
Corn	4.827,0	5.310,0	1.140,0	
Sunflower	280,0	705,0	240,0	
Soya	160,0	320,0	130,0	
Rape seed	2,6	7,8	1,6	
Total		9.560,0	3.060,0	1023000

*1 toe – ton of oil equivalent = 41,860 MJ

Greater amount of bio mass residues generated on small agricultural farms can be used for energy if these owners would have appropriate ovens and boilers for burning biomass residues, or if they find an interest to collect residues and sell them.

Biomass from fruit production and viticulture

One of main activities in fruit growing and viniculture is pruning of small branches, and these cut small branches can be available for energy purposes. Total number of registered fruit trees is about 94*106. Half of this number are plum trees, about 20% are apple trees and almost 15% are cherry trees, both sour and sweet cherry.

The total bio mass residues from fruit growing amounts about 475.000 t, with average heating value of 14 MJ/kg the energy potential of biomass residues from fruit trees pruning is about 159.000 toe. The energy potential of vine pruning residues is about 155.000 toe.

Table 6. Energy potential of biomass residues deriving from fruit cultivation and processing

Species	Number of trees [10^3ha]	Type of biomass residues	Biomas residues [t]	Annual energy equivalent [toe]
Plum	50.630	pruning, stones	393.500	132.600
Apple	17.570	pruning, peel	36.200	10.900
Cherries	12.280	pruning, stones	55.000	16.500
Pear	7.080	pruning, peel	14.000	4.300
Peach	4.450	pruning, stones	35.100	11.700
Apricot	1.900	pruning, stones	15.500	4.100
Walnuts	2.100	pruning, shell	55.000	14.100
Grape	77.390	pruning, peel, seeds	515.000	166.300
				Total: 360.500

Stones of plums, cherries, peaches, and apricots together with peels and seeds of apples, pears, and grapes are wastes derived from processing of fruit. The quantity of these wastes amounts to about 200,000 t. With a relatively modest heating value of 9 GJ/t, the energy potential of fruit processing wastes is about 46,000 toe. This value is relatively small comparing to the energy potential of other fruit residues derived from growing. But an important advantage of these wastes is that they are already collected in every company dealing with fruit processing.

The overall energy potential of bio mass residues from fruit growing, viniculture and fruit processing is about 605,000 toe.

Biomass from livestock breeding

Liquid manure deriving from cattle and pig breeding together with poultry litter are potential energy sources as well. Because of high water content (up to 90%) these slurries are usually treated by anaerobic digestion. These wastes are recommended for anaerobic digestion, not only for an energy reason, but also for get ting more suitable and environmentally friendly fertilizers.

Livestock breeding in Serbia comprises mainly cattle, pigs, poultry and sheep.

Table 7. Livestock in medium and great farms and energy potential of their manure (Dänzer, 2006; FNR, 2006)

Livestock	Location of farms	Number of heads	Manure [m^3/day]	Biogas [m^3/day]	Annual energy equivalent [toe]
Cattle	Flat regions	149.300			
	Hilly regions	111.000			
	Total	260.300	5.270	105.000	20.140
Pigs	Flat regions	1.369.500			
	Hilly regions	285.600			
	Total	1.655.100	4.560	91.200	17.500
Poultry		2.350.000	480	24.000	4.600
				Total	42.240

The major part of livestock is located in small farms, with only a few heads in each. An organized manure collection from these small farms is not likely to be easily technically feasible, and the financial feasibility is uncertain as well. Therefore, in the analysis of energy potential, only manure in medium and great farms is considered as a prospective source of fuel, since manure from these farms does not need to be transported, and can be efficiently treated in an aerobic digestion.

Competition between food and energy production

FAO and OECD estimate that food consumption will increase 10% annually, while energy consumption will increase 3% by 2030. Increased need of food will be covered with bio-technical progress before all on suitable location for agricultural production. Some analysts note that oil prices will not stay on present price of US$87.63 a barrel - the highest level since late 2008. Considering that oil price has exceptional influence on bioenergy production, production of bioethanol in Brasil is rentable without subsides if the oil price is between US$30 and US$40 per barrel. In such areas more agricultural land will be used for energy production and higher food prices will be reasonable consequence.

EU commission evaluates profitability of biofuel production in Europe when oil prices are between US$60 and US$90 a barrel which means double than breakeven point in Brasil. According research (Quirin and Reinhart, 2005) food production in Europe will be still in the foreground ahead energy production. According to the authors' (Henniges and Zeddies, 2005), own calculations for EU countries, domestically produced biofuels would not be viable without a subsidy of some kind unless oil prices were consistently higher than US$80 a barrel. Given that such prices are not imminent, the biofuel industry in Europe, as in the United States, is heavily dependent on continuing political support. The European Union has supported biofuel production primarily to promote sustainable farming, protect the countryside, create additional value added and employment in rural areas, reduce the cost of farm support policies, and diversify its energy supplies. Reducing emissions of greenhouse gases is only a secondary goal because the net energy efficiency of the biofuel crops grown in Europe is low. Thus the biofuel industry has much higher carbon abatement costs than do some other fields of energy use.

Partly as a result of negative publicity regarding biofuels, the European Union watered down its 2020 biofuels conversion goals while Germany began to remove tax credits that aided its domestic biodiesel industry. The biofuel tax increases, aimed at ultimately creating tax parity between biofuels and conventional fuels, rendered the domestic German biodiesel industry unable to compete with subsidized biodiesel from South American and the US. 27% of German capacity shut down altogether, while 36% ran at less than 50% of capacity. Meanwhile, the European Union flirted with doing away with a 10 percent biofuels target and 2008-2020 conversion schedule. The EU ultimately agreed to confirm the targets as a renewable energy conversion, but 30% of the target would be met by electric cars or trains, with the remainder to come from biofuels. The EU also said it would develop regulations by 2010 to limit the impact of indirect land-use change, while biofuels developed from non-food sources will receive preferred treatment under the agreement. The agreement will need to be ratified by the European Parliament and all 27 EU members.

Real meaning of bioenergy and reality of other sources

Actual results of bioenergy use are not much encouraging except direct burning of biomass. Bioenergy contribution is marginal in total energy balance. If we use half of all arable land for bioenergy production, it will cover only 5% of energy needs. Although some researches are in progress, there is no new kind of bioenergy on market such as BtL (Biomass-to-liquid) (FNR, 2006). There are prospect that mankind will have secure and cheap sources of energy such as nuclear fission and fusion (atomic power plant for the future) (Oljača S., 2006), (Potočnik, 2006).

Conclusions

The energy crisis on the world draws the attention to the energy sources which can be produced by the agriculture. The lasting energy deficiency can be replaced with the big mass of biomass gained mostly from the agriculture and forestry. The agriculture would be capable to cover 10 % of the country's energy needs from renewable energy sources on a middle term.

A new power generating section of the agriculture takes shape across Europe in the immediate future expectedly, that may contribute in a considerable measure to the reduction of the energy deficiency collaborating tightly with the energy producer's and the service provider's sections of the countries, while he secures new revenue source.

- Bioenergy contribution is marginal in total energy balance except direct burning of biomass.
- Economy of bioenergy production depends of subsidies in EU and without them only biomass combustion is cost effectively.
- Producer's dilemma what is better to produce: food or energy depends of income and household capacities.
- Ecological acceptability of bioenergy is not always positive.
- Ethnical questions (burning of grains) sometimes are significant but economy is in first plan.
- Plant use for energy in EU will not significantly decrease food production but it will increase food prices.

Comments

This paper is the parts of results of the project „Determination of Solid Biomass Potential from Agriculture in Hungary and Serbia" of the Hungarian Institute of Agricultural Engineering, Gödöllő, Faculty of Mechanical Engineering of Szent István University, Gödöllő and the Institute of Agricultural Engineering, Belgrade.

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HEAT RECOVERY FROM THERMAL WATERS USED FOR HEATING BY HEAT PUMP BEFORE BACK-INJECTION

B. ÁDÁM[1] and L. TÓTH[2]
[1]HGD KFT, Veresegyház, Executive manager
[2]SZIE Faculty of Mechanical Engineering

Abstract

The heat energy recovered from the fluid produced by deep thermal wells is used very economically for heating buildings – covering the heat demand – and supplying utility hot water. After cooling the in-taken fluid must be injected back into the reservoir water layer. The temperature of back-injection is usually equal to that of the return line and the water still contains quite significant energy amount. Before injecting-back this heat energy can be recovered by the heat-pump technology, and fed back into the basic heating system. In this way the very expensive investment of new production and injection wells is avoidable. Authors prove this on the theoretical base and with a practical case in the present article.

Introduction

The thermal water itself for purposes of balneology as well as the inherent heat energy of the thermal water is utilized at a considerable degree today as well. With the increase in prices of conventional energy carriers, its account in the heat-energy market gets higher and higher. The government aims an increased role to the utilization of geothermal energy already in the medium-term planning (*Nemzeti Megújuló Energia Hasznosítási Cselekvési Terv* – National Action Plan on Utilization of Renewable Energy) as well [1]. By the *NCST*, in accordance with the sustainable power-resource management, an especial attention must be paid to the conservation of the natural treasure inhered in the geothermal fluid in the course of building new capacities up which usually requires the back-injection or the further utilization with the suitable purpose.

There is a considerable energy potential in increasing the role of geothermal energy in the heat-supply systems which is already a usual heating way in certain fields in Hungary (e.g. in horticultures) today as well. In the case of utilization of geothermal energy, besides the direct cost of the installation of well and the back-injection, the expenditure of the building of the heat-supply and distribution system is significant due to which the financing conditions often mean a limit factor.

In the present paper, such a method of the heat utilization is discussed which increases the efficiency of the recovery of geothermal energy, helps the sustainability in the view-point of environment protection, and yields a considerable reduction in costs as well.

The energetic professionals, theoretically and in practice, have dealt with the increasing of the efficiency of thermal-water use for a long time. Büki G. has presented a detailed analysis on this topic in the issue of January 2011 of Energiagazdálkodás [2]. Authors, accepting and following the theoretical bases of his work, discuss also the practice of the utilization in the present paper.

Supply for heating demands and peak heat cosumption

Base of investigation

In the example, the (incidentally well operated) utilization of thermal-water heat of an actual country town [1] has been taken as the base and the conditions of the improvement are investigated. (The data base used here does not cover exactly the present situation because the development is continuous in the town. Approaching the real data, authors preferably present a further modernization option.)

Basic data:
Producing well
- Bottom depth of thermal well: 1 462 m
- Maximum temperature of off-take thermal water: 64 to 68 °C
- Carbonate hardness of off-take thermal water: 303 CaO (30,3 °dH)
- Maximum volumetric flow rate of production: 130 m^3/h
- Volume of energetic thermal water: 280 000 m^3/yr
- Volume of thermal water for balneology: 80 000 $m^3/év$

Back-injection well
- Bottom depth of thermal well: 1 600 m
- Gravel-packing of thermal well: 1 309 to 1 333 m, 1 353 to 1 365 m, 1 392 to 1402 m
- The handling diagram of thermal water before injection back is shown in Fig. 1
- Temperature of back-injection: 48 °C

In order to protect the thermal-water resource, it is allowed to inject only perfectly pure fluid (thermal water) back into the reservoir water layer. This requires a suitable storage and filter system (Fig. 1).

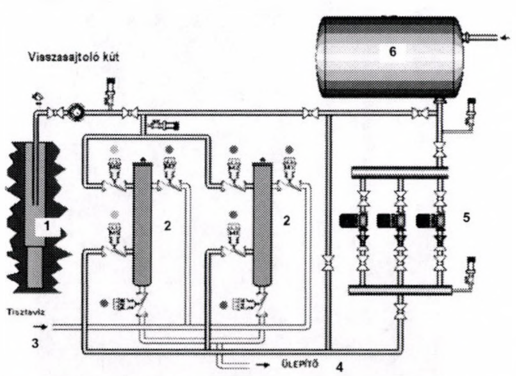


Figure 1. Handling of thermal water before back-injection
1 – back-injection well, 2 – filters, 3 – rinsing filters with clean water, 4 – settling of mineral component and other polluting materials filtered out, 5 – pumps, 6 – storage tank

[1] Veresegyház

Table 1. Data of energy consumption in 2006-2007

Number of consumers in the town	Heating power demand kW	Utility hot water peak demand kW	Utilized geothermal energy GJ	Equivalent natural gas m^3/yr
11	1580	445	14200	406000

Starting from the above basic data, the calculations were carried out; Table is shown with the purpose of control.

Goal: *Cooling the fluid with high temperature of back-injection; utilization of the heat quantity gained in this way and improvement of the system with this; and, instead of new improvement by well drilling, creating a system that better assists the sustainability*

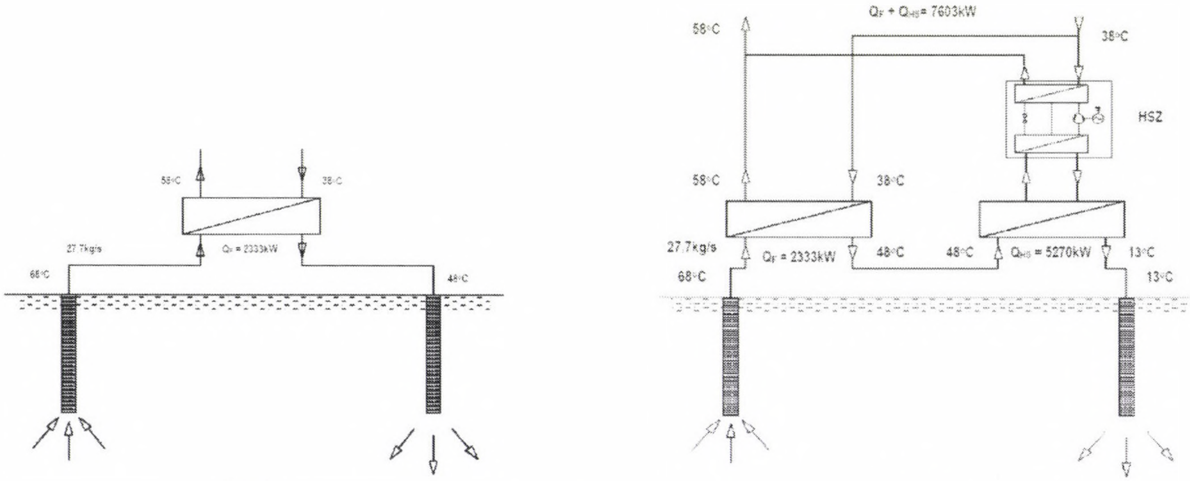
Thermal-water heating and heat pumping before injecting back

Heat pumping for peak power

Fig. 2A shows the heating purpose utilization in the town taken as an example in the basic case. Eventually, by a simplex heat exchange (Fig. 3), the off-taken heat is used for purpose of heating and utility hot water.

If one would like to utilize the remnant heat content before the back-injection, the heat pumping technology should be applied (Fig. 2B). According to the capacity of the operating well, the mass flow rate of the output thermal water is $\dot{m}$ = 27.7 kg/s (1000 m³/h) and its temperature is T_{TK1} = 68 °C (Fig. 4). In peak periods, the temperatures of heating water are T_{FE}/T_{VF} = 58/38°C; for the sake of simplicity, its mass flow rate is taken equal with the former value.

In the basic case, the output thermal water is cooled down to T_{VSO} = 48 °C ($\dot{m}$ = thermal water, $\dot{m}_{fv}$ = mass flow rate of heating water).



Part A **Part B**

Figure 2. The original (A) and the „improved" version (B) (fulfilling the increased demands)

In case "A", the heating peak power is provided by this thermal water:

$$Q_{ACS} = Q_F = \dot{m}c(T_{TK1} - T_{VSO}) = 27{,}7 \cdot 4{,}2(68 - 48) = 2333 \text{ kW}$$

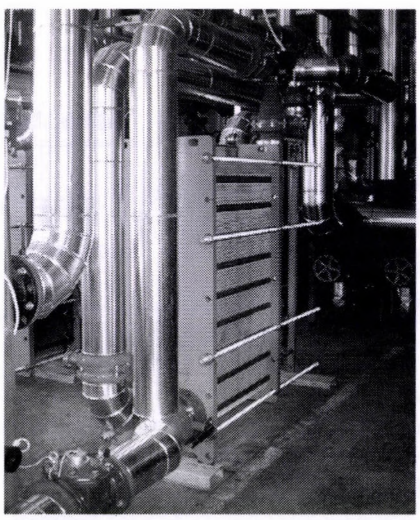


Figure 3. Plate heat exchangers before the heating circuit

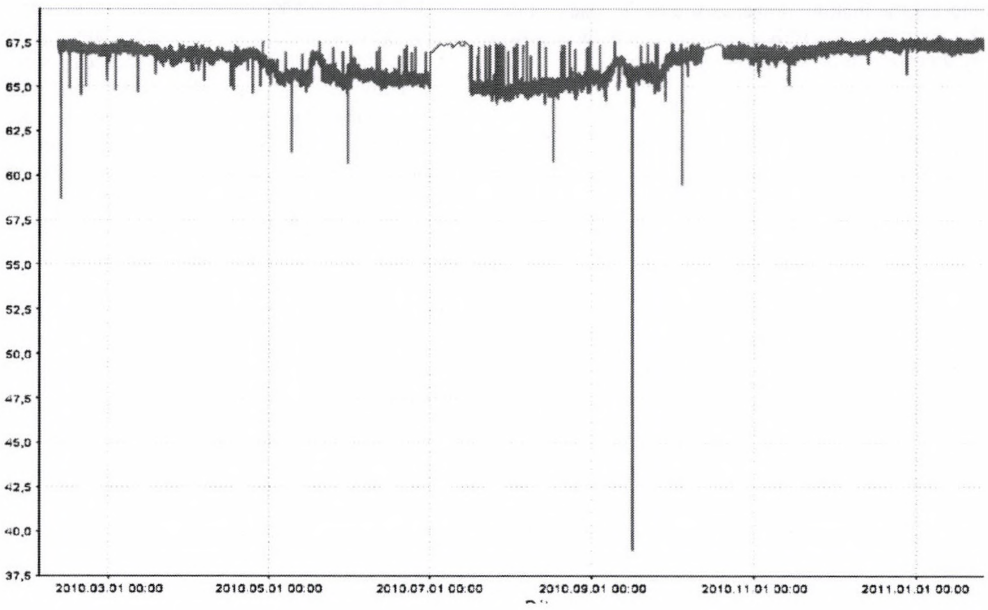


Figure 4. Temperature of thermal water

In the system with heat pump (B), the effluent thermal water of 48 °C temperature from the direct utilization is cooled down to about T_{vsi} = 13 °C temperature and the heating water can be heated up from the return temperature of 38 °C to the outgoing temperature of 55-58 °C. (The heating-water temperatures are equal to those of the heating water produced directly by thermal water.) With these temperatures, the coefficient of performance (COP) of the heat pump is relatively well estimable:

$$\varepsilon_f = (COP =) \frac{T_{FE}}{T_{FE} - T_{VS1}} \nu = \frac{331}{331 - 286} 0,6 = 4,4$$

v = 0.6 is the loss factor

With this, the heating power of the heat pump is –

$$Q_{HSZ} = \dot{m}c(T_{VSO} - T_{VS1}) \frac{\varepsilon_f}{\varepsilon_f - 1} =$$

$$= 27,7 \cdot 4,2(48 - 13) \frac{4,4}{4,4 - 1} = 5270 \ kW$$

Consequently, this value is 2.25 times greater than the achieved heat power in the basic case (A; direct heat utilization). The two cases together perform –

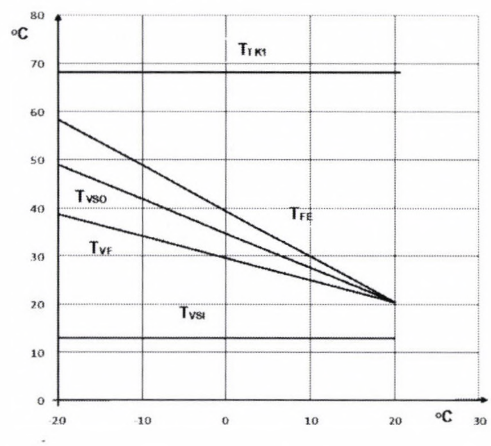
$$Q_{EGY} = Q_F + Q_{HS} = 2333 + 5270 = 7603 \, \text{kW}$$

The heat-power value with the peak heat power increased to 2.4-fold of that of the basic case.

In sum, the heat pumping results in a significant increase in heat content and better utilization of the thermal water as well as a lower temperature of the fluid to be injected back. The coefficient of performance can be considered as an advantageous value.

Heat pumping of thermal water at partial load

The value of the coefficient of performance is greater during the year than that in the peak heat-power season. Fig. 5A demonstrates the required degree of heat pumping as a function of external temperature while Fig. 5B – as a function of user demands during the year. (For the better perspicuity, the utility-hot-water supply is neglected.)



Part **A**

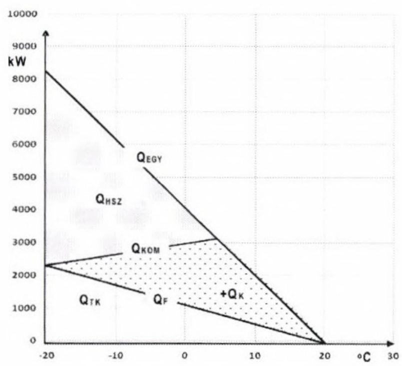


Figure 5. Temperature values of the thermal water and the heating (A), and the heat performances (B) as functions of the environment temperature
(with the original and the heat-pump solution)

Line $\dot{Q}_F$ indicates the heating power in the basic case and line $\dot{Q}_{EGY} = 4{,}4\dot{Q}_F$ – in the case of heat pumping. The heat power performed by thermal water with mass flow ṁ is –

$$\dot{Q}_{KOM} = \dot{m}\, c(T_{TK1} - T_{VSO})$$

The running of the heat pump ceases when the thermal water alone is capable of covering the actual heat demand loading the net:
and expressing it with temperatures –

$$\dot{Q}_{KOM} = \dot{Q}_{EGY} \text{ that is}$$

$$\dot{m}\, c(T_{TK1} - T_{VSO}) = 3{,}4\, \dot{m}\, c(T_{FE} - T_{FV})$$

The searched value is at about 4 °C environment temperature.

$$T_{FE} - T_{VF} = \frac{T_{TK1} - T_{VSO}}{3{,}4}$$

The heat demands covered by thermal water is indicated by the range Q_{TK} in the basic case, and the range $+Q_K$ in the case of heat pumping while the part Q_{HSZ} shows the heat demand covered by heat pumps. According to Fig. 6, the demand for heat production by heat pump (Q_{HSZ}) will be of shorter period while the direct heat use of thermal water increases in the extended heat demand in a year. (This means also that, instead of heat pumps due to the lower use efficiency, natural-gas boilers could be applied for the peak load as well; this would result in a bivalent system.)

With the same equipment, the value of coefficient of performance increases with the decrease in heat production. Fig. 7 shows the temperature (T_{FE}) of hot water produced by heat pump and the consequently expected changing in the coefficient of performance.

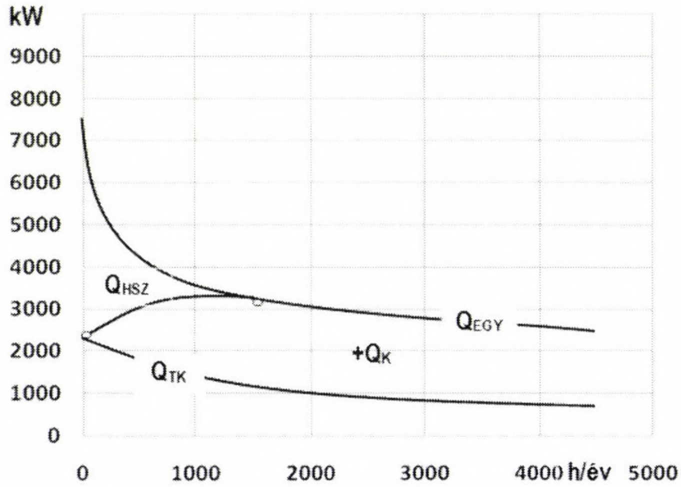


Figure 6. The load-duration diagram of the heating year with and without heat pumping

$$\varepsilon_f = COP = \frac{T_{EGY}}{T_{EGY} - T_{VS1}} \nu$$

It appears from the figure that the annual average coefficient of performance (seasonal performance factor $\bar{\varepsilon}_f = SPF$ – already not a performance ratio but really the gained-to-input energy ratio in kWh/kWh) considerably betters the peak-season coefficient of performance.

$$\bar{\varepsilon}_f = \frac{Q_{HSZ}}{E} > \varepsilon_{fcs} = \frac{Q_{HSZcs}}{P_{cs}}$$

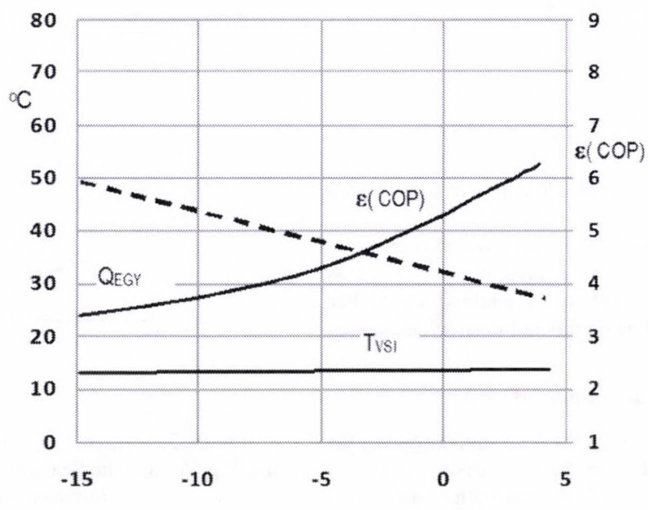


Figure 7. Changing in coefficient of performance of the peak-load heat pump

Energetic characterization of heat pumping

For the correct evaluation, the efficiency of the consumed electric energy has to be compared with that of the modern gas heating.

The electric energy input of the heat pump is E_V and the energy content of the used natural gas is E_G.

The efficiency of the input electric energy is $\eta_E = E_V/E_G$.

The efficiency of the natural-gas is η_K.

The annual average performance coefficient must exceed the ratio of the two efficiencies (Büki, 2010) [7]:

$$\bar{\varepsilon}_f > \frac{\eta_K}{\eta_E}$$

For the account of the consumed electric energy [7], the recovered geothermal heat can be considered as renewable energy if the average performance coefficient is –

$$\bar{\varepsilon}_f > \frac{1{,}15}{\eta_E}$$

This means that the heat production with heat pump has to be compared only with the condensation boiler of the best efficiency.

The efficiency of the heat production by heat pumping obviously increases with increase of the performance coefficient of the heat pump and electric-energy generation [7]. In the case of the further cooling of the thermal water, approximately an average coefficient of performance (COP) of 4 to 4.7 is gained which is 60 to 80 % of the achievable value (see Fig. 7).

Economical advantages

What does it mean in an actual case for the user in operating costs or in initiating a new improvement (according to the concrete example of the chosen settlement)?

In the heating season, the heat performance as an average is 3200 kW (Fig. 6) or 11 520 MJ/h. With the natural gas of a heating value of 34 MJ/m³, this means a gas consumption of 434 m³/h (with 100 % boiler efficiency). With the price of 136 Ft/m³ of natural gas and in the case of 4500 h/year use, the heating cost is 207.2 million Ft per year.

With heat-pump heating, the electric-energy consumption is 3200/4,4COP = 727 kWh. If the energy price is 31.50 Ft/kWh, the energy cost per year is 103 million Ft in the season of 4500 h/yr.

The difference of the two values is the saveable sum by heat pumping – 104.2 MFt/yr. The investment cost of the heat-pump system itself (with e.g. 5270 kW, about 520 million Ft as a total) recovers in 5.8-6.5 years in comparison with the gas heating

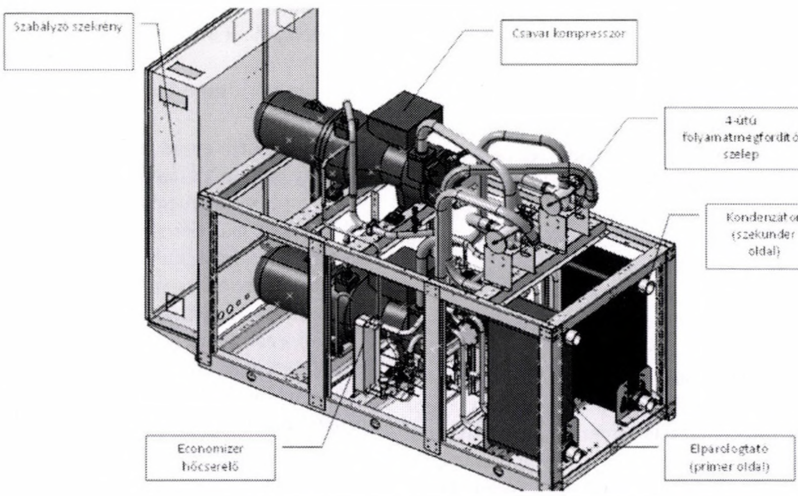


Figure 8. Construction of a modern heat-pump unit

A *further investment* advantage is that the planting of 2 new well units fit to the maximum performance (i.e. 4 well-drillings together with the back-injection) gets needless; the invested cost would be 2 to 2.5-fold of the installation of heat pumps.

According to NCST, a discount electric-energy tariff is applied in the case of utilization of geothermal energy by heat pump that improves its economical advantage. At the same time an extra regulation can be expected that "The estimated annual SPF value must be minimum 4.2 with the heat pumps built on the base of ground heat probes, ground collectors and ground water wile 4.0 with other heat pumps – certified by the adequacy declarations of the manufacturer and the project manager". It must be taken the total amount of the electric energy consumed during the heating season into consideration for calculating the values of SPF – the electric energy used for cooling must not be taken into account.

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THE OPPORTUNITY OF CONNECTING SMALL SCALE WOOD GAS GENERATOR PLANT TO GREENHOUSES

V. MADÁR[1] and P. TÓVÁRI[2]
[1]Termo-Energo-System Ltd
Tamási Áron u. 3., Vásárosnamény, H-4800, Hungary
Tel.: +36 45 570 192; E-mail: madar.viktor@gek.szie.hu
[2]Hungarian Institute of Agricultural Engineering
Tessedik Sámuel u. 4., Gödöllő, H-2100, Hungary
Tel.: +36 28 511-611; E-mail: tovari@fvmmi.hu

Abstract

The biggest difficulties of the Hungarian horticultures are caused by the high energy prices and the fluctuating and decreasing vegetable prices. In order to solve this we outlined a concept which will be implemented at the Termo Energo System Ltd.'s research site. The most important subsystem of the concept is the small scale wood gas generating power plant with 45kW electric and 90kW thermal output. The power plant's waste heat is utilized in the heating system of the greenhouse while its exhaust (CO_2) is used to fertilize the land.

Keywords

Gasification, pyrolysis, greenhouse heating,

Introduction

The importance of an efficient utilization of biomass as a renewable energy in terms of global warming and resource shortage are well known and documented. Biomass gasification is a promising CHP technology, due to its high electrical efficiency compared to other CHP systems in the lower and middle range of power. This power class has high potential with respect to heat demand, and hence, biomass gasification is predestined for decentralized energy systems.

In case of the modern greenhouse cultivation technology we already met the utilization of heat generated by natural gas fueled cogeneration unit to heat greenhouse. With this technology the cost of heating can be decreased. CO_2 fertilizing has major importance considering the Hungarian circumstances, since the amount of heat leaving the installation due to ventilation in case of early plant growing can be decreased, since the amount of CO_2 needed by the plant's photosynthesis is not provided by the cold ambient air. Generally the CO_2 does not originate from a natural gas fueled furnace's exhaust, but from expensive fluidized CO_2 stored in tanks. The reason behind this is the danger of pollutants possibly present in the exhaust gas (hydrocarbons due to incomplete combustion, and other pollutants originating from the sulphur content of natural gas).

Method

A three-way R+P work was pre-made before planning the connection of the small scale gasifier plant to the greenhouse.

- The development of low-temperature heating system for greenhouses, utilizing the waste cooling water of combined cycle power plant
- The effects of CO_2 fertilizing on the tomatoes' average yield and composition
- Development and analysis of gasifier creating low tar content wood gas

The following steps induced the connection:

- The increasing gas prices make the operation of horticultures impossible (high energy prices)
- The decreasing vegetable prices and uncertain merchandizing (e.g.: german vegetable scandal in 2011) renders the earnings uncertain
- The beneficial effect of CO_2 fertilizing on the vegetables' composition and the opportunity of price reduction of CO_2 fertilizing utilizing the wood gas generator's exhaust
- The electricity generated indicates a constant income for the horticulture, increasing the stability and sustainable development of it.

Low temperature heating system for greenhouses

The combined cycle power plant, powered by natural gas, recently built in Vásárosnamény induced the development of the low temperature greenhouse heating system. During the process of research and development a modular concrete panel was researched, which is able to utilize the cooling water at 30-35°C to heat greenhouses without complementary heating. With aid from tender financing we built two greenhouses with an area of 780 m² each. One of these installations acted as a reference greenhouse with conventional hot water heating system with steel pipes, while in the other greenhouse the developed concrete panels' thermal parameters were analyzed. These systems were heated with natural gas fueled furnaces.

Parameters of the experimental greenhouses:

- Greenhouse area: 780 m²
- Greenhouse outer surface: 1417 m²
- The ratio of the greenhouse area and outer surface: 1 : 1.816

Figure 1. Greenhouses and service buildings

We measured a U-value of 4.1 W/m²K for the greenhouses. Due to this measurement the daily, monthly and annual energy requirements of the installations can be precisely calculated. Near the two greenhouses with an area of 780m² each four 10 m x 30 m solo greenhouses were built. We intend to connect their heating system to the planned scale gasifier plant. In the following tables we can find the calculated energy requirements based on measured U-values, illumination and the average temperature values of the last 40 years.

Table 1.: The energy requirement of the heating system of a 780 m² large greenhouse during heating season.

	Daily energy [MJ]	Monthly energy [MJ]
October	1330	41245
November	3923	117685
December	6866	212835
January	8091	250826
February	5043	141213
March	3081	95503
April	1286	38565
Annual energy [MJ]		897873

Table 2.: The energy requirement of the heating system of a 300 m² large greenhouse during heating season.

	Daily energy [MJ]	Monthly energy [MJ]
October	590	18296
November	1822	54646
December	3112	96479
January	3679	114052
February	2367	66287
March	1437	44535
April	570	17107
Annual energy [MJ]		411402

Figure 2. The Hydroponic growing in the experimental concrete panel heated 780 m² greenhouse.

Development and analysis of gasifier creating low tar content wood gas

The gasification technology, which was first utilized on industrial level in the 19th century, only spread in the 20th century due to the fuel shortage occurring after the world war. The interest in biomass appeared, mainly in developing countries where waste (e.g.: by-products of agriculture, forestry and wood industry, like: straw, chips, waste-wood, trimmings) was utilized to save energy for a short time during the energy crisis of the 80's. In this way import of expensive petroleum products could be avoided.

During the last years fix bed gasification technologies developed rapidly. Due to this technological advancement the tar content of the wood gas created decreased, which increased the technology's accessibility and the simplicity of the gas cleaning system, therefore increased the technology's economic efficiency.

We started to develop our own gasifier after studying these modern staged systems. The most important aspect of the research was to create a gasifier which is able to generate synthesis gas with low tar content.

The reactor design is moving bed, co-current, downdraft and throatless. The fuel feed is on the top and in the middle of reactor, with the help of a double sluice feeding device. The feeder is flushed with fresh air. The reactor has double walls, so the hot producer gas preheats the fresh air, which is very important to reach the low tar content of the generator gas. The zone of reduction is sheathing is isolated with fire-bricks. The grate is rotating to promote constant ash removal from the reduction zone. The measurements done during the operation of the gasifier gave positive results. The tar content under 50 mg/Nm^3 and the cold gas efficiency reaching almost 80% makes possible to operate a gas engine continuously with the gas generated.

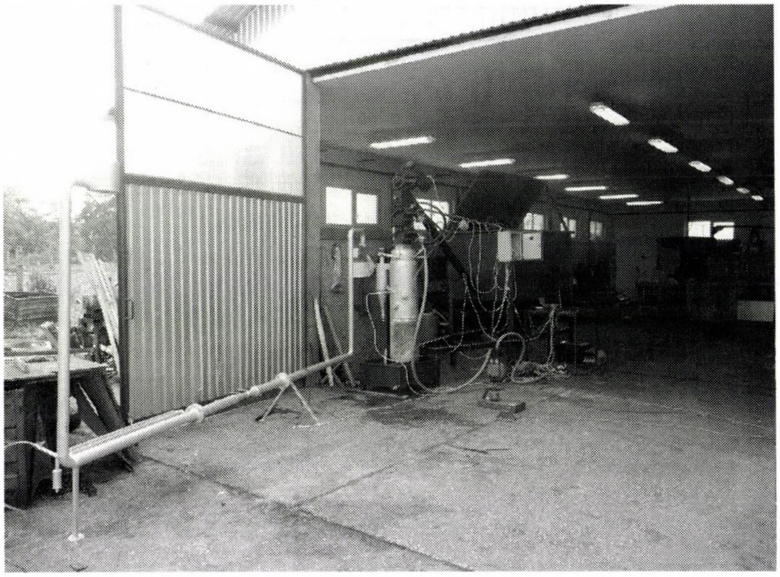

Figure 3. The gasifier prepared for measurements with the woodchips container and the measurement system.

The effects of CO_2 fertilizing on tomato average yields and composition

During tomato growing we analyzed the effect of increased CO_2 in the greenhouse on growing and quality. The growing took place in two greenhouses at once. One of these greenhouses was treated with CO_2, while the other was used as reference. The CO_2 concentration in the greenhouses was around 800-900ppm, which means around 50-70 kg/ha CO_2 gas consumption hourly.

Based on the harvested amount the treated greenhouse has a larger yield. The amounts harvested from both sources indicated distribution. More significant differences appeared during the early and the final periods to the advantage of the treated greenhouse.

Results

The greenhouses' annual energy requirement is 3441 GJ (calculated with 212-day-long heating season). The energy output for this period of the small scale power plant is 1648 GJ (7.776 GJ daily), which less then half of the amount of energy needed. This ratio is worsened by the increasing demand during the cold months (e.g.: in January the daily energy requirement of the heating system is 30.89 GJ). For this reason the greenhouse should be involved in growing gradually to improve the occupancy of the power plant, which has a major effect on its economic efficiency. The maximum thermal requirement of the two 780 m^2 greenhouses is 390 kW, therefore to supply the blockhouses a 300kW biomass furnace should be installed. A 30 m3 puffer tank should be installed together with the power plant, which is able to store 4.4 GJ heat, which allows the small scale power plant to supply the complete heat demand of the whole installation. With this design the utilization of the heat generated by the power plant is close to 100% during heating season, which means an operation time of 4500 hours.

The gasifier power plant generates 42kg of CO_2 hourly. The total surface of the heated greenhouses is 2760 m^2, which means a CO_2 consumption of 19.32 kg/h while maintaining the concentration of CO_2 used during the experiments, around 800 ppm. For this reason higher CO_2 concentration might be reasonable if it has a positive effect on the plants and not harmful on the employees.

Conclusions

The fuels of the small scale wood gas generating power plant are chips of energy plants or wood. In contrast to conventional biomass power plants, not only a closed CO_2 cycle develops, but it is consumed. Since the fertilized plants absorb ambient (exhaust) CO_2 and since these plants will not be burned, but composted the CO_2 accumulated in them will not return to environment. The amount of CO_2 absorbed a year is almost 150 tons in case of a power plant with 45kW electric output.

If the small scale gasifier plant replaces gas heating and tanked CO_2 fertilizer, then in case of a 2500 m^2 heated culture the price of fuel used during 7000 hours of operation can be saved. The investment is recovered after 4 years from the price of the electricity generated during 7000 hours of operation annually and after this it continuously generates a well calculable income.

Acknowledgements

Making use of this opportunity, I would like to thank the support provided for this agricultural energetic research by the National Office for Research and Technology (NKHT) and the Agency for Research Fund Management and Research Exploitation (KPI).

NANO-BUBBLES' EFFECTS ON THE PHYSICOCHEMICAL PROPERTIES OF WATER – THE BASIS OF PECULIAR PROPERTIES OF WATER CONTAINING NANO-BUBBLES –

S. LIU, M. ENARI, Y. KAWAGOE, Y. MAKINO
and S. OSHITA*
Graduate School of Agricultural & Life Sciences,
The University of Tokyo
Yayoi 1-1-1, Bunkyo-ku, Tokyo 113-8657, Japan
Tel.: +81 (0)3-5841-5362,
*E-mail: aoshita@mail.ecc.u-tokyo.ac.jp

Abstract

Proton NMR relaxation times, T_1 and T_2 of the water containing nano-bubbles (NBs) were measured to compare with the control water. The water containing NBs displayed statistically longer T_2 values than those of the control water. The increase in T_2 by the generation of NBs meant that the mobility of the water molecules increased and consequently a longer period was required to reach equilibrium of the spin-spin relaxation process. These observations indicated that the NBs in water could influence the physicochemical properties of water and that it could be used to verify the stability of nano-bubbles in the water.

Keywords

proton relaxation time T_1, T_2, water mobility, stability of nano-bubbles

Introduction

While micro- and nano-bubble (MNB) technology has widely been applied in various fields, people are showing more and more interest and attention to the fundamental research of the MNB mechanism. As much as to say that researchers are not only satisfied with their research on the application of the MNB but they also want to do the further research on the reasons why the MNB have such effects on their applications. Compared to the normal bubbles, MNB have mainly the following characteristics: smaller bubble sizes which cause the lower buoyancies; either negative or positive zeta potentials; larger specific areas; higher internal pressures which cause the increase of dissolution of gas in the liquid; free-radicals generation with the collapse of micro-bubbles under the water; the ability of reducing friction.

Due to the characteristics above, MNB technologies have been applied in many research fields such as medical, medicine, environmental engineering, horticulture and agricultural, food science and technology, fluidic physics and mineral processes.

Recently, more attention has been focused on application of MNB technology in biological processes. It has been reported that the water containing MNB can accelerate the growth of plants and shellfish and it can also be used in aerobic cultivation of yeast. The air micro-bubble supply in the cultivation of oysters *(Heterocapsa circularisquama)* results in a better quality product in terms of size and in taste (Onari, 2001). Kurata et al. (2007) who applied oxygen micro-bubbles in osteoblastic cell culture, proved higher alkaline phosphatase activity, which was related to the higher osteoblastic cell activity. Park and Kurata (2009) found that the fresh weights of the microbubble-treated lettuce were 2.1 times heavier than those of the macrobubble-treated lettuce under the similar dissolved oxygen concentration. Ushikubo et al. (2008) showed when the barley coleoptile cells floated in water after the generation of oxygen micro- and nano-bubbles, cytoplasmic streaming rates inside the cells were accelerated. In addition, Nakao et al. (2008) proved the enhancement of micro-bubble water on seed germination. At present, the explanation has not theoretically been given for these new scientific findings. At this point, the applied studies on MNB precede its fundamentals and some fundamental aspects of the water containing MNB still remain unclear. Thus, the basic research on physicochemical properties of the water containing MNB becomes very important.

Up to now, many researchers have put forward their opinions on physicochemical properties of the water containing MNB through experiments or models. According to Ohgaki et al. (2010), the water molecules may form shells of hard hydrogen-bonded icelike structures around the MNB that may reduce the diffusivity of gases through the interfacial film. Craig (2010) showed that the increase in the radius of curvature associated with the nanoscopic contact angle resulted in a much reduced internal pressure and contributed to the stability of MNB. Jin et al. (2007) found that the coverage of small amphiphilic organic molecules at the gas/water interface greatly reduced the pressure inside MNB. Hampton (2010) also says that a reduction on surface tension of vapor-liquid interface reduced the Laplace pressure and increased MNB stability. But none of the achievements above can explain the mechanism of the acceleration of metabolism.

Nuclear Magnetic Resonance (NMR) relaxation can detect weak molecular interactions such as hydrogen bonding, molecular mobility and steric effect (Balci, 2005). As a result, it is widely used to study the mobility and diffusion of water molecules in agriculture and food field. In view of this, we expect that NMR technology will be helpful to the research on the characteristics of the NBs in water. In this study, spin-lattice and spin-spin relaxation times (T_1 and T_2) were measured both in control water and the water containing NBs aiming to obtain the effect of NBs on physicochemical properties of water.

Material and methords

Ultrapure water

Ultrapure water was obtained using a water purification system (Direct-Q, Nihon Millipore Ltd., Japan), which was equipped with a reverse osmosis cartridge and modules of ion-exchange and activated carbon. According to the result from Nanoparticle tracking analysis technology (Z-NTA, Quantum Design Japan, Inc.), the ultrapure water didn't contain any particles and bubbles. The ultrapure water naturally contained about 6mg/l dissolved oxygen.

Control water

The desired control water has low DO concentration and is free of bubbles. In order to remove the DO in the ultrapure water, bubbling method was used. Dissolved gasses in the ultra-pure water of 2l were purged by introducing nitrogen gas directly through a tube with 4 mm diameter inside. The dissolved oxygen concentration (DO) of this control water was below 0.15mgl^{-1} and few bubbles were observed through a laser scattering image system (Zeecom, Microtech Co. Ltd., Japan).

Water containing NBs

Control water was placed into an Erlenmeyer flask. The gas (N2, purity 99.99995 %) was introduced into the water through a Micro-bubble Generator (OM4-GP-040, Aura Tec Co. Ltd., Japan) for 1 hour at the constant temperature of 20°C, to obtain the "water containing NBs". The difference of DO concentration between the control water and the water containing NBs was less than 0.05mgl^{-1}.

Sample for NMR measurement

For the NMR measurement, the volume of water samples is normally 0.4ml. In order to eliminate the paramagnetic effect of dissolved oxygen, two methods were used in the research. For one method, the NMR tubes were filled with water and then were sealed. In the case of 0.4ml water placed in the tubes, the air was replaced by nitrogen. All the tubes were stored in an incubator at 20°C.

NMR measurement

Proton Spin-lattice relaxation time (T_1) and spin-spin relaxation time (T_2) were measured by a pulsed spectrometer (JNM-MU25A, JEOL, Japan) at 25MHz frequency and at the constant temperature (20°C, 24°C and 30°C). The pulse sequences used for T_1 and T_2 were saturation recovery and Carr-Purcell-Meiboom-Gill (CPMG), respectively. Five replications of each sample were collected in pressure-tight tubes with the diameter of 8.5mm inside, and then sealed.

Bubble size and distribution

The NBs' size distribution measurements were performed using Nanoparticle tracking analysis technology. Based on a laser-illuminated optical microscope, NBs were seen as light-scattering centers moving under Brownian motion. After the NBs generation, water was stored in 15 BOD bottles in incubator at 20°C. Then the bubble size distribution was measured with different storage time.

DO concentration

The dissolved oxygen (DO) concentration was measured both in control and the water containing NBs at 20°C, using a DO meter (SG6, Mettler Toledo GmbH, Switzerland).

Statistical analysis

The statistical tests were performed with the EXCEL software 2003. Paired sample t-test was used to compare the difference between the control water and the water containing NBs with a significance level (p-value) set from 0.0005 to 0.25.

Results and disscussions

Water sample of 0.4ml in pressure-tight tubes

The water containing NBs displayed statistically longer T_2 values than those of the control water as shown in Fig. 1. The sample temperature was 20°C. The pH values for the control water and the water containing NBs were 6.31 and 7.06, respectively. T_2 values of both control and the water containing NBs shortened 2 days later, and their difference in T_2 values observed on the day of generation became unclear with time as shown in Fig. 1. Under a normal condition, the significance level higher than 0.05 is of little meaning. In order to compare the difference between the control water and the water containing NBs with different storage time, test levels of p values higher than 0.05 (0.1 and 0.25) were also involved. The reason for both the shortening and the decrease of the difference in T_2 was estimated as the oxygen in the head space of NMR tube dissolved into water and elevated DO in the sample water caused T_2 shorter. At the same time, the bubble number density would become smaller with time. Therefore, the effect of NB on T_2 was partly masked by the paramagnetic effect of oxygen at the observation after 2 days and more. The mean T_1 value on the day of generation of both the water containing NBs and the control water was 2.48s. T_2 is more sensitive comparing with the T_1, and meanwhile there will be a few contaminants of foreign materials in the control water. It may be the reason why the difference between the control water and the water containing NBs could only be seen from T_2 values.

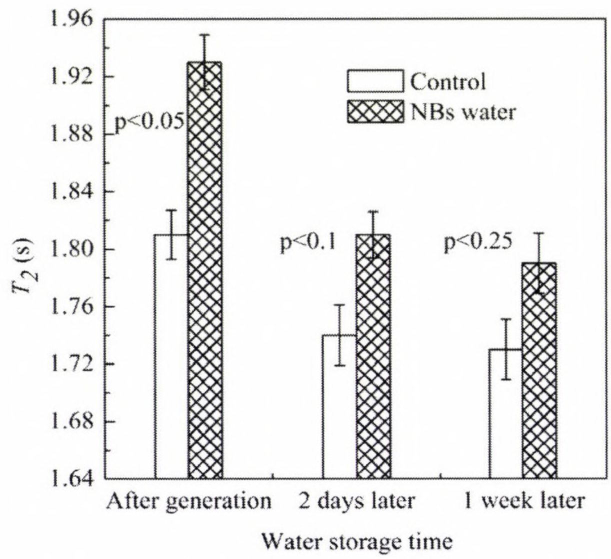

Figure 1. Change of T_2 values of control water and the water containing NBs with water storage time

The decrease of bubble number density with storage time was supported by the results shown in Fig. 2b in which both the total bubble number and the main bubbles size decreased with storage time. The main bubble size observed was divided in two sizes,

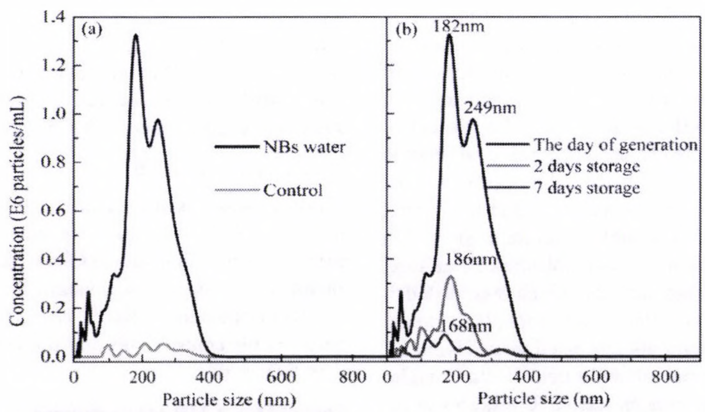

Figure 2. Bubble size distributions with time of control water and the water containing NBs. a shows the comparison of bubble size distribution of control water and the water containing NBs. b shows the change of bubble size distributions in the water containing NBs with different storage time

182nm and 249 nm on the day of generation, two days later 186nm, and seven days later 168nm. The shrinking tendency of the bubble sizes was shown clearly.

The total bubble number density of the water containing NBs was 1.97 $\times 10^8$ particles per milliliter on the day of generation. For the control water, the total bubble number density was about 0.09 $\times 10^8$ particles per milliliter, which was less than 1/20 of the water containing NBs (Fig. 2a). The measurement was done at room temperature, and the temperatures for the water containing NBs and the control water were 29.8°C and 28.7°C, respectively.

Water samples filled in pressure-tight tubes

The presence of oxygen, a paramagnetic molecule, would make the relaxation time shorter. Aiming to eliminate the paramagnetic effect of oxygen in the head space, both the control water and the water containing NBs were filled in the pressure-tight tubes to ensure that there was no gas in them. Fig. 3. showed results done at three different temperatures, 20°C, 24°C and 30°C. The mean T_2 values of the water containing NBs were all longer than those of control water. Moreover, the increase of sample temperature would enhance the difference in T_2 between the water containing NBs and the control water.

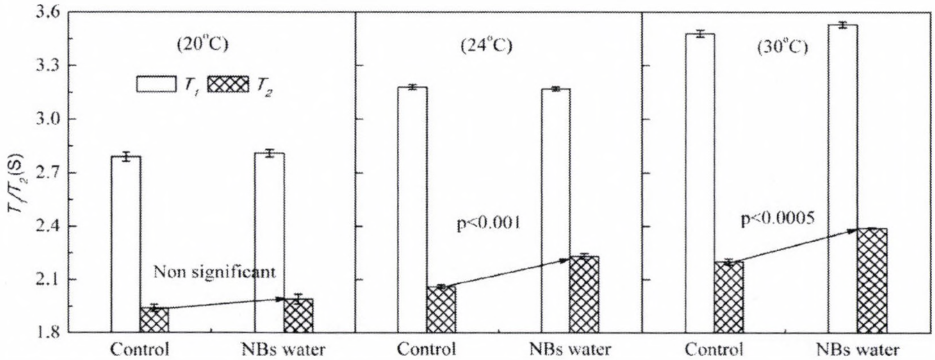

Figure 3. T_1 and T_2 values of control water and the water containing NBs under different temperatures (DO concentrations of both control water and the water containing NBs were lower than 0.15mg/l, their difference below 0.05mg/l)

In order to approve further effect of high temperature, both the T_1 and T_2 values were measured using the same set of samples under two different temperatures (24°C and 30°C). Sample set was the same as that used in Fig.3. at 24°C, and the measurement was done two days later. Fig. 4. shows more significant difference between the water containing NBs and the control water under the higher temperature.

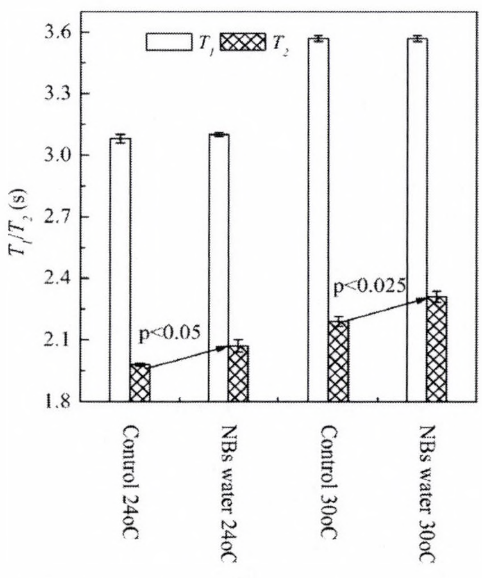

Figure 4. T_1 and T_2 values of control water and the water containing NBs under different temperatures after two days generation

Besides, the Zeta potential values of the water containing NBs were also measured. Two repeated experimental results showed that the Zeta potential of the water containing NBs was negative with the mean value of -32.26mV at pH 7.28 and -38.84mV at pH 7.55.

From the experiments above, the difference of T_1 values between the control water and the water containing NBs still couldn't be detected.

Water sample of 0.4ml in the NMR tube under nitrogen atmosphere

Replacing the air in the tube by nitrogen was another method to prevent the head space oxygen to dissolve into the water. Fig. 5. shows results under different measurement temperatures (20°C and 30°C). For the same results as above, the mean T_2 values of the water containing NBs were all longer than those of the control water and the increase of sample temperature would enhance the difference in T_2 between the water containing NBs and the control water. There is also no significant difference of T_1 values between the two kinds of water.

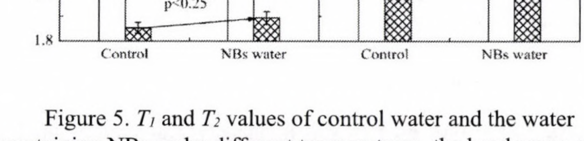

Figure 5. T_1 and T_2 values of control water and the water containing NBs under different temperatures, the head space of which was replaced by nitrogen

Discussion about the influence of NBs on the physicochemical properties of water

According to Ohgaki et al. (2010), the water molecules may form shells of hard hydrogen-bonded icelike structures around the MNB, and the higher surface tension (twice the normal value) arising from the presence of the hard interface helps to maintain a kinetic balance against the high internal pressure. On the contrary, Himuro (2007) found that shrinking of MNB greatly decreased the number of hydrogen bonded water molecules causing smaller surface tension. MNB contributed to weakening the hydrogen bonded network. We can't say which opinion is right, but the results from multiple parallel experiments showed that introducing NBs did increase the T_2 value of water.

One of our explanations is that the mobility of the water molecules increased and consequently a longer period was required to reach equilibrium of the spin-spin relaxation process. Takahashi (2005), who measured zeta potential in different solutions and distilled water with NBs, reported that bubbles were negatively charged, and OH- and H+ ions should play an important role in electrical charge. Negative-charged bubbles could adsorb hydrogen ions on their surface which made Coulomb repulsion forces compensate surface tension forces (Chaplin, 2007).The presence of ions, therefore, could modify the hydrogen bonding network in water. The hydrogen bond around the bubble surface may enhance the viscosity of water which was near the interface of bubbles and cause to decrease the mobility of a limited part of water molecules. But for the rest of the larger quantity of water, the NBs contributed to weakening the hydrogen bond network of the water (Fig. 6.). The bubbles' forming, shrinking and disappearing would affect the total hydrogen bond network and the structure of water as well. The disturbance of hydrogen-bond would accelerate the mobility of water molecules. The higher temperature might have destructing effect on hydrogen-bonds. And at the same time it might enhance the moving rates of both water molecules and NBs, which increased the chances of their collision.

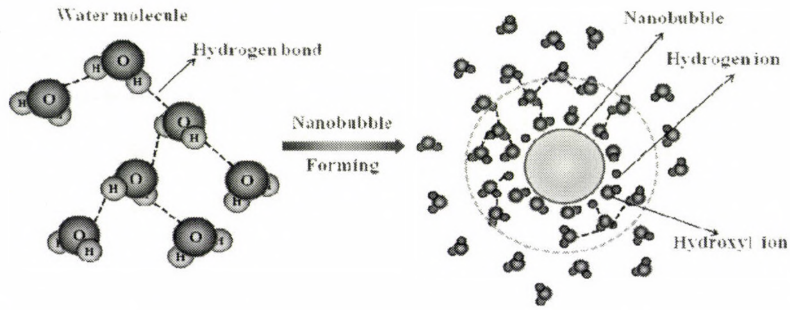

Figure 6. Nanobubles effect on the hydrogen bond network and the structure of water. In the red circle were the water molecules near the interface of bubbles which formed hydrogen-bonded shell. Outside the red circle were the free water molecules whose hydrogen bond network was weakened by NBs.

The other explanation was that the magnetic field radiation might affect the gas-liquid interface leading to the destabilization of bubbles mostly by disturbing the ionic balance between the shell formed with water molecules of adsorbed negative ions and counterions. (Vallee et al., 2005).

No single theory can explain NBs' effect on physicochemical properties of water, and is more than likely due to a number of mechanisms, depending on the conditions of the system.

Water activity was the important factor that could accelerate the growth of bacteria and enzymatic reaction. The fundamental data showed here could contribute to explain the mechanism of the effect on the physiologic activity.

Conclusions

The water containing NBs displayed statistically longer T_2 values than the control water indicating that the mobility of the water molecules increased and consequently a longer period was required to reach equilibrium of the spin-spin relaxation process. Moreover, increasing the sample temperature would enhance the difference between them. From these findings, it was considered that the NBs in water could influence the physicochemical properties of water and that it could be used to verify the stability of NBs in the water.

Acknowledgements

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DISCUSSION OF THE INFLUENTIAL FACTORS OF COMBUSTION SPEED OF WOOD-CHIPS CONGERIES

L. BENSE, P. SZENDRŐ, A. LÁGYMÁNYOSI
Faculty of Mechanical Engineering,
Szent István University
Páter K. u. 1., Gödöllő, H-2103, Hungary
Tel.:+36 28 522-080,
E-mail: bense.laszloy@gek.szie.hu

Abstract

This article presents a method, which, irrespective of the blast conditions of the furnaces, can investigate the combustion process of the ligneous chips congeries. With the help of homogeneous and artificial mix structures, the authors tentatively demonstrate, that the combustion speed of wood-chips is not depend on only the surface area of sample (size of pieces), but the order of the parts of pile too. Consequently: the combustion process will be optimum in the case of a purpose structure with suitable size distribution only. This research project is supported by the Hungarian Scientific Research Fund (OTKA-K-68103).

Keywords

wood-chips, combustion process, optimization

Introduction

With the full knowledge of the chemical composition of the fuels, their combustion heat can be calculated easily by Dulong's formula. This method takes into consideration that a certain part of the fuel material is originally already oxidized in organic compounds. After deducting the evaporation heat of the original water content of the material, the calorific value can be determined. If the chemical composition of the material is unknown, the combustion value (otherwise gross calorific value) of the material can be experimentally measured by a calorimetric-bomb test as well. However, in this case, the fuel (or heating) value is only estimated; the moisture content of the sample can be determined by the drying-box test but the exact calculation requires the value of the hydrogen content of material, too. Both the combustion heat and the heating value mean the maximum withdrawn energy from the unit of fuel during its perfect burning; accordingly, it supposes the use of ideal furnaces (boilers) with no loss. The so-called condensation boilers utilizing the total combustion-heat recover the heat content of the vapour in the off-gas. Their theoretical efficiency referred to the fuel heating value may achieve the value 108.8 %. Nowadays these types are widely used in gas-fired systems but they have not spread in the multi-fuel furnace technology yet because of the high sulphur content of the solid fuels, more exactly the formed aggressive acidic condensates from the off-gas.

When burning wood or other grown biomass plants, the complete oxidation cannot take place alone – it requires especial technical and firing requirements to be fulfilled. The necessary volume of air (oxygen) must be provided in more stages – in the form of primary, secondary and (maybe) tertiary air supply at the different points of the combustion space. Since the hot wood-gas hardly intermixes with the cold air, practically an air excess of 70% ($\lambda = 1.7$) is required to provide the stoichiometric combustion-gas to combustion-air ratio. The design of the combustion chamber of the boiler and the quantitative control of the induction of combustion air basically influences the utilization efficiency of the solid fuel matter. The dual goal of the control is –

1. the power control for matching the heat performance of the boiler with the power demand of user and
2. the control of the combustion process for decreasing the harmful-matter content of the flue gas

Since the control takes place by throttling the combustion air flow, the rated efficiency of 72 to 86 % given by the boiler manufacturer can be referred only to the planned heat power and even this ideal value is lower than the 92-% efficiency of the traditional gas boilers – not to mention the achievable value of the condensation technique.

The firing control must provide such a combustion quality in all boiler-load states which ensures a low polluting-matter emission. Beside the combustion-air control, the application of the feed-back of flue-gas as well as the mechanical fuel feeding helps to perform this goal. However, the required solid fuel must be homogeneous as to its material, particle-size composition, moisture content and heating value.

Practically, the ground or chopped fuels are considered as homogeneous matters. Amongst the wood-chips firing large devices, the control of the fluid boilers is the simplest. The boilers with underfeed or overfeed firing are more sensitive to the particle-size distribution of the chips mass due to the spreader stoker.

Materials and methods

The international trends of researches on biomass firing can be briefly summarized as follows:

- The fundamental researches are focused on the chemical description of the combustion process, the measurement and comparison of the calorific values of biomass fuels and their mixtures.
- The applied researches concentrate on determining the size range of fuel chips to be burned in the different boiler (furnace) types.

In the first case, the experiments are carried out with samples of some grams so the after-grinding of the bulk – in this way changing the combustion properties – is unavoidable. These types of measurement have an integrating effect; accordingly, they do not provide information about the course of the process and the effect of the original structure.

In the second case, the biomass congeries is optimized according to the demands of the boiler (furnace) type. Taking the combustion properties into consideration is only one of the points of view in the optimization. With a chain-grate boiler type, for example, the grate pitch limits the minimum size of the fuel chips.

Consequently, it can be established that both the calorimetric tests and the firing experiments carried out in in-plant conditions are insufficient for qualifying fuel chips. The condition of the reproducibility is the use of an independent laboratory measuring system from the blast patterns of the actual boilers.

This is why the effect of the structure of the fuel congeries was analysed by the method of derivatography. Originally, this technique was elaborated for measuring the volatile and ash content of fuels. The test device is a program-controlled burning furnace with standard parameters, connected with a digital scale. With the help of the test process, the mass decrease of a fuel substance with unknown composition can be continuously measured and recorded as a function of the programmed temperature zones and time. Even a 300-g sample can be put in the furnace so the after-grinding or chopping is not necessary. In accordance with the standard CEN/TS 14775:2004 elaborated for lignocelluloses, the sample desiccates in the first period of 105°C and then, between 250 and 550°C, the dry distillation of the biomass takes place. In the course of this, volatile matters (hydrogen, nitrogen, sulphur, oxygen, carbon monoxide, methane and other light hydrocarbons – together composing wood-gas) as chemical reaction products leave the sample and a certain amount of charcoal (similar to the coke) remains and its dominant part is chemically pure coal. Finally the charcoal burns between 550 and 850°C and only some percents of ash remains from the sample. Accordingly, the processes of drying-degasification-burning are carried out in three temperature stages, and drawing apart in the time. With this method, an accidental explosion caused by an intensive gasification can be prevented but it cannot be considered a single-variable process because the combustion takes place mainly during the heating-up. Consequently, the standard test is suitable only in part to answer the questions of the authors. For eliminating the transient processes, it is reasonable to place the sample in the burning space of the preheated furnace.

In order to protect the measuring instrument of the accredited laboratory, a new (and cheaper) device had to be constructed. Such an annular furnace was purchased where the heating coils were built in the sidewall of the device so the top cover could be bored through and, by a drop-in device mounted on the cover, the sample could be inserted into the preheated furnace. With the process of derivatography because of the small amount of sample, instead of the weight of the complete furnace, the weight of the incinerator pot has to be directly measured. It was solved by a precision scale mounted under the furnace, equipped with transmission elements made of heat-resistant ceramics. The method of measurement was as follows: The prepared, photographed and documented sample was dropped in the preheated furnace. The scale was tared and the measurement was carried out up to the mass constancy (ash content). Without emptying the incinerator pot, after dropping the following sample in, the scale was tared again. So the furnace did not cool down and, utilizing its thermal inertia, a large amount of data could be collected in a short time. Against the recommendation of the standard, the temperature of the furnace was chosen to 450 °C. Several preliminary experiments were carried out before selecting the temperature value during which it was established that the full combustion of the sample took place at this temperature and, at the same time, the explosion of the vapour from the remnant moisture content of the air-dry sample and wood-gas developed by a quick degasification should not be expected.

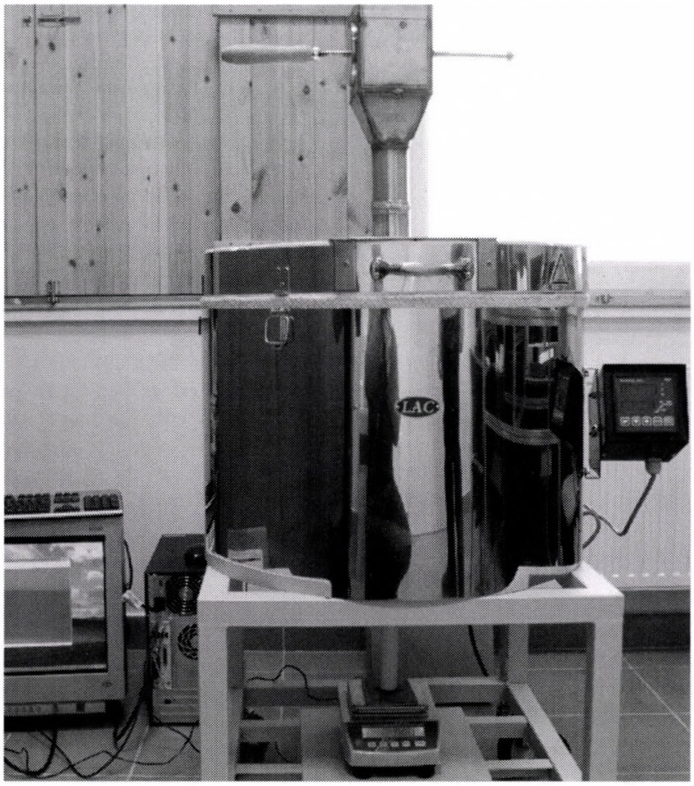


Figure 1. The modified derivatograph

The practice consider the fuel chips as homogeneous mass but, according to the experiences in this research, the congeries gained by grinding or chopping, as to their size distribution, are not quite homogeneous at all; nor the experiments are reproducible or the test results – comparable. During the laboratory tests artificial structures were mainly used because of the above described circumstances. In this article, those experiments selected from the others are presented which carried out on showing the effect of the comminution degree of the congeries, the composition of the mixture bulks upon the combustion characteristics. For these, two sample sets with different artificial structures were prepared. Their common property was that the inhomogeneity in material quality of the congeries components was precluded. The wood dowels available in do-it-yourself stores were found as the most uniform fuel material. These are made of birch duramen with an acceptable size tolerance from the view point of the tests. The congeries structure used in the investigations was made by re-cutting and mixing together the dowels. The samples containing also bigger pieces were manufactured from softwood roof battens. As the samples were cut from the same batten, the combustion properties can be considered as approximately equal here as well.

Results

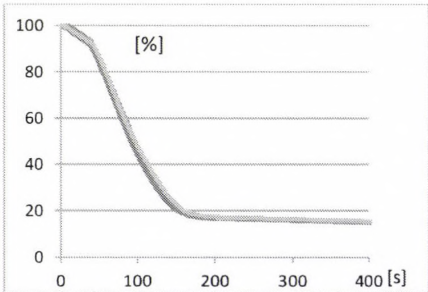
Authors searched for the reply to two basic questions with the help of the above presented experiments of derivatography:

1. Is there an optimal congeries composition existing in terms of firing? With the help of the artificial structures, authors

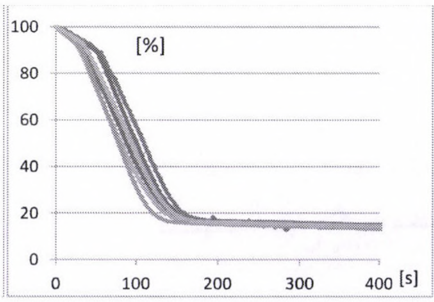
searched for such signs indicating the dominance of composition which basically determine the combustion parameters of the congeries.

2. The combustion takes place in the form of surface-reaction so the fuel material must be ground (chopped or cut) to the possible finest particles. However, the compaction of the extremely over-ground fuel particles can cause also an air shortage in the firing equipment. Consequently, the second question can be stated in the following way: Is there an optimum existing below which it is already not expedient to decrease the size of fuel particles?

For examining the ideal congeries composition, sample masses composed of wood dowels re-cut at different degrees were selected. It was established that the theoretically predicted relationship between the comminution degree and the dynamics of combustion is valid. However, with the mixture structures, the spatial order of the particles basically influences the combustion speed. Mixing 20 to 25 % fuel particles with the size deviating even by a magnitude order in the bulk will not change the combustion characteristics of the congeries yet; the experiment takes place in the expected way according to the dominant size fraction. After mixing 50 % small fraction in the bulk, the course of the combustion process cannot be predicted.



20 % small fraction



50 % small fraction

Figure 2. Derivatograms of wood dowels

During the repetition of the experiments, the results can be found anywhere between the combustion curves of the two fractions. This means that the speed of the mass decrease taking place in the course of the combustion also depends on the free surface area formed due to the stochastically ordered particles of the congeries – and not only on the total surface area of the bulk. This is denominated as channelling effect in the professional editions of English language. Along the ordered flowing paths formed in the congeries, the propagation speed of the flame front increases. The unpredictable behaviour of the fuel mixture is caused by the ventilating cavity system which is clogged when the congeries collapses but then newly formed randomly along another pathway. In a homogeneous congeries, the lengths of the clogging and the developing channels are not significantly different so the data of the repeated experiments show slight deviations. For demonstrating this observation, further experiments were carried in which the fuel particles were arranged in a wire net in such a way that the congeries could keep this order during the full combustion. With the congeries prepared in this way, the reproducibility of the combustion experiment significantly improved.

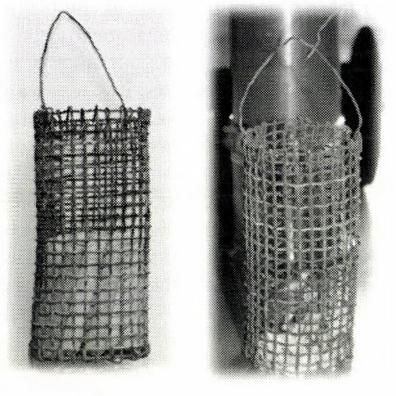
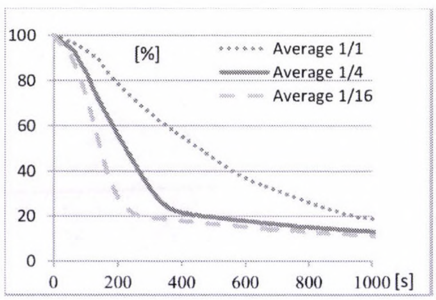
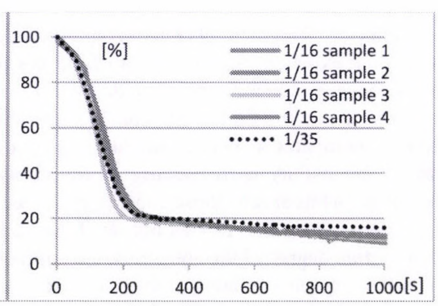


Figure 3. Wood towels sample, and ash in the cage

When determining the optimum of comminution degree, besides the homogeneity of the fuel material, just the mentioned channelling effect was employed in reducing the impact of the random arrangement of congeries. The fuel samples were prepared by lengthwise splitting wood prisms of 40 g mass. So practically the channelling was increased up to the degree at which the increase of the free surface area already caused no change in the dynamics of mass decreasing. During the investigation the main question was whether such an optimum exists or no rather than determining the optimum particle size by measurement. By the experience of authors, the optimum exists – already no significant difference was found between the derivatograms of the sample prism split into 16 pieces and the sample split into 35 pieces.





(Specific surface of samples 1/1 = 3,4 cm2/g, 1/4 = 6,1 cm2/g, 1/16 = 11,5 cm2/g)

Figure 4. Derivatograms of splitting wood prisms

The degasification and the burning process, due to the deviating time demands, might indicate different characters but the functions of mass decrease (m) vs. time (t) – even with the single-step process taking place by applying the sample-drop-in device – can be approached by the arc-tangent function introduced earlier by authors (Bense et al., 2009):

$$m(t) = a + b\frac{arctg(\frac{t-c}{d} + \frac{\pi}{2})}{\pi}$$

The regression functions and the quality factors of curve-fitting have not been shown in the figures since the numerical indication of the parameters does not provide essential extra information for better understanding of the processes.

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A SIMPLE METHOD FOR INFLUENCING AMPLITUDE AND ACCELERATION OF SHAKEN FRUIT TREES

Z. LÁNG[1], L. CSORBA[2]
[1]Corvinus University of Budapest,
Faculty of Horticultural Sciences, Technical Department,
Budapest, 1118, Villanyi út 31, Hungary
[2]Szent István University,
Department of Mechanics, Gödöllő, Hungary
e-mail of corresponding author:
zoltan.lang@uni-corvinus.hu

Abstract

To achieve similar amplitudes and accelerations for larger orchard trees than for smaller ones with unchanged shaker machine setup, a slider crank type shaker with an extra unbalanced mass was suggested. This mass was able to slide free in direction of shaking with defined stroke. The kinematic model of the new shaker arrangement was set up and orchard tests were carried out with an experimental rig to prove the effect of the extra mass. As a result of the model calculation the extra mass resulted in higher amplitudes for larger tree masses and didn't change them below a certain mass value. In orchard tests a smaller and a larger tree was involved. Both were shaken with the experimental rig in 4 different setups. As a result of the tests the best setup seemed to be when the stroke was set to 15 mm. In this case the rig had no effect on the smaller tree and increased the acceleration and amplitude of the larger one by about 50 ms^{-2}.

Keywords

fruit tree shaker, harvesting, shaker frequency and amplitude

Introductions

In the shaker harvesting practice the amplitude of fruit bearing branches and the frequency of shaking play the most important role in fruit detachment, as Fridley and Adrian, 1966 have reported. According them, the detachment in % is:

$$L = 100 \cdot \left(1 - e^{-cS^a \omega^b}\right)$$

where S is the stroke of the branch (mm)
ω is the angular frequency of shaking (1/s)
a, b and c are empiric constants, related to the fruit variety

To avoid tree damages both stroke and angular frequency has its upper limit in the practice.

Replacing the fruit tree by a three-element model and vibrating it virtually sinusoidal, its amplitude can be calculated as follows (Fig. 1):

$$X_M = \frac{mr\omega^2}{\sqrt{\left(k - M_t\omega^2\right)^2 + (c\omega)^2}} \qquad 1$$

Where
- X_M is the trunk amplitude of the model tree trunk in m;
- m is the unbalanced mass of the shaker in kg;
- M is the mass of the tree and of those shaker parts, which are joint to the trunk in kg;
- M_t is the total mass (m+M) of the limb-shaker system in kg;
- c is the viscous damping coefficient of the limb in Nsm^{-1};
- k is the spring stiffness in Nm^{-1};
- r is the eccentricity of the unbalanced mass in m;
- ω is the shaking frequency in rad s^{-1};

For the amplitude of the unbalanced mass m the following equation stands:

$$X_m = \sqrt{X_M^2 + r^2 - 2X_M r\cos\phi} \qquad 2$$

were:

$$\phi = arctg\frac{kc\omega}{1 - M_t k_1 \omega^2} \qquad 3$$

Acceleration of the shaken tree can be calculated easily as follows:

$$a = X_M \omega^2 \qquad 4$$

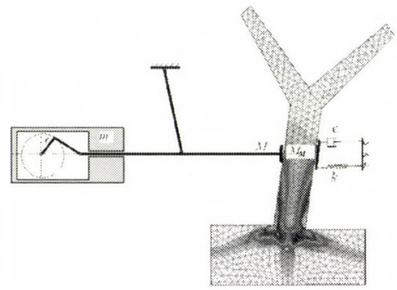

Figure 1. The three-element fruit tree model with the inertia shaker

In the case of unchanged shaker machine setup, for larger trees the shaker input to the trunk results in smaller amplitude than for younger trees with smaller trunk diameter. Possibilities to reduce losses due to reduced amplitude at larger trees are limited. To achieve an appropriate stroke for larger trees as well, the unbalanced mass of the inertia shaker must be increased.

The effect of unbalanced mass m on trunk amplitude can be studied on Figure 2. (Láng, 2008). I. e. increasing the unbalanced mass from 130 to 160 kg, the amplitude of the trunk will increase in the whole examined frequency spectrum of 0-16 Hz. Due to the increased mass, the power demand of the shaker increases as well.

The unbalanced mass can be changed on some shaker machines however only in out of work position, which takes valuable time in the harvesting process.

The aim of the investigation described below was to find a simple solution for a partly automatic adjustment of unbalanced mass to the trunk stroke.

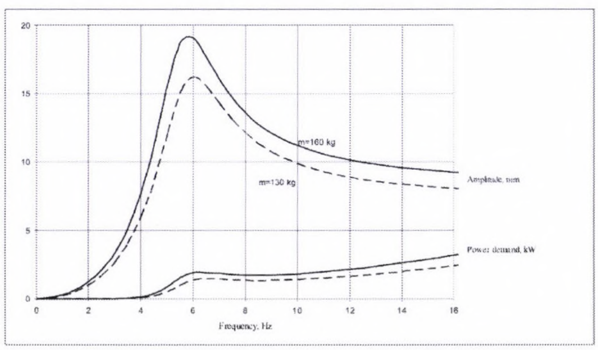

Figure 2. The effect of the change of the shaker's unbalanced mass

Material and methods

The kinematic model

Figure 3 shows the effect of changing trunk mass on the amplitudes of both trunk and unbalanced shaker mass. For the calculation of the curves Eqns. 1 and 2 were used with real fruit tree and shaker machine parameters. With those data the trunk amplitude of the simple fruit tree model decreases continuously with increased reduced trunk mass, meanwhile the amplitude of unbalanced mass increases. For larger trees the decreased amplitude won't be enough for a high frit detachment %.

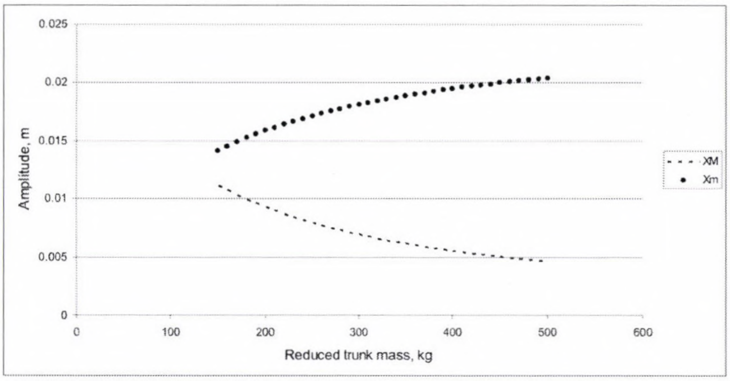

Figure 3. Trunk and unbalanced shaker mass amplitude in function of reduced trunk mass

From Fig. 2 follows that the increased unbalanced mass leads to increased trunk amplitude. This gave the idea to add a second unbalanced mass m_{extr} to the one on the machine (m). As a technical solution m_{extr} is able to move free only along the path $2l_0$ (Fig. 4), so it has no effect on shaking below the unbalanced mass amplitude l_0. Above that it joins to the mass m and increases the trunk amplitude.

On the Fig. 4:

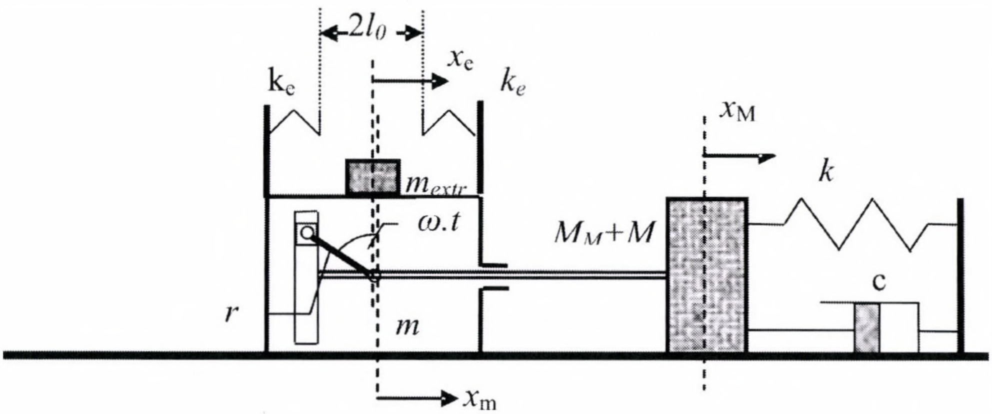

Figure 4. The model of the shaker-tree system with two unbalanced masses.

m_{extr} is the second unbalanced mass, kg

l_0, is the free amplitude of m_{extr}, m

k_e is the spring stiffness of the impacting surfaces between the unbalanced masses, Nm^{-1}

x_M, $\dot{x}_M$ and $\ddot{x}_M$ are the trunk displacement, trunk velocity and trunk acceleration in m, ms^{-1} and ms^{-2} respectively;

x_m, $\dot{x}_m$ and $\ddot{x}_m$ are the displacement, velocity and acceleration of unbalanced mass m in m, ms^{-1} and ms^{-2} respectively;

x_e ,$\dot{x}_e$ and $\ddot{x}_e$ are the displacement, velocity and acceleration of unbalanced extra mass m_{extr} in m, ms^{-1} and ms^{-2} respectively;

The relation between x_M and x_m is as follows:

$$x_m = x_M + r \sin \omega t$$
$$\dot{x}_m = \dot{x}_M + r\omega \cos \omega t \qquad 5$$
$$\ddot{x}_m = \ddot{x}_M - r\omega^2 \sin \omega t$$

Until x_m is smaller than l_0, m_{extr} has no effect on shaking amplitude. It doesn't move, the mass m_{extr} slides free, without contacting m via the springs k_e . The maximal value of it is X_m (Eqn.2)

If X_m is larger than l_0, the springs k_e contacts the mass m_{extr} and it starts to move together with m. The force acting in this case on m_{extr} is:

$$-F_{k_e} = -\frac{1}{k_e}(x_e - l_0 - x_m) \text{ or } -F_{c3} = -\frac{1}{k_e}(x_{dif} - x_m) \qquad 6$$

where $x_{dif} = x_e - l_0$

The kinematic equation for m_{extr}:

$$-F_{c3} = m_{extr}\, \ddot{x}_{dif} \qquad 7$$

Taking in account the effect of all participant elements, and making the necessary replacements, the following differential equations can be set up:

$$(M+m)\ddot{x}_M + c\dot{x}_M + (\frac{1}{k}+\frac{1}{k_e})x_m - \frac{1}{k_e}x_e = (m\omega^2 - \frac{1}{k_e})r\sin\omega t \qquad 8$$

From Eqns. (5), (6), (7) :

$$m_{extr}\ddot{x}_e + \frac{1}{k_e}x_e - \frac{1}{k_e}x_M = \frac{1}{k_e}r\sin\omega t \qquad 9$$

Expressing the function $x_e=x_e(t)$ from (8) :

$$x_e = k_e(M+m)\ddot{x}_M + k_e c\dot{x}_M + k_e(\frac{1}{k}+\frac{1}{k_e})x_M - k_e(m\omega^2 - \frac{1}{k_e})r\sin\omega t \qquad 10$$

Replacing it and its second derived ($\ddot{x}_e=\ddot{x}_e(t)$) into Eqn. 9, the following 4[th] grade linear inhomogeneous differential equation with constant coefficients appears:

$$A_1 x_M^{IV} + A_2\dddot{x}_M + (A_3+B_1)\ddot{x}_M + B_2\dot{x}_M + (B_3 - \frac{1}{k_e})x_M = (\frac{1}{k_e}r + B_4 - A_4)\sin\omega t \qquad 11$$

where

$$B_1 = M+m,\quad B_2 = c,\quad B_3 = \frac{1}{k}+\frac{1}{k_e},\quad B_4 = (m\omega^2 - \frac{1}{k_e})r$$

$$A_1 = k_e m_{extr} B_1,\quad A_2 = k_e m_{extr} B_2,\quad A_3 = k_e m_{extr} B_3,\quad A_4 = k_e m_{extr}\omega^2 B_4$$

We may look for the particular solution of (11) in the following form:

$$x_{Mp}(t) = a\sin\omega t + b\cos\omega t \qquad 12$$

Defining their derives $\dot{x}_{Mp}(t), \ddot{x}_{Mp}(t), \dddot{x}_{Mp}(t)$ *és* $x^{IV}_{Mp}(t)$, replacing them into (11), than arranging according the trigonometric functions, the following equation appears:

$$[A_1 a\omega^4 + A_2 b\omega^3 - (A_3+B_1)a\omega^2 - B_2 b\omega + (B_3 - \frac{1}{k_e})a]\sin\omega t +$$

$$+[A_1 b\omega^4 - A_2 a\omega^3 - (A_3+B_1)b\omega^2 + B_2 a\omega + (B_3 - \frac{1}{k_e})b]\cos\omega t = \qquad 13$$

$$= (\frac{1}{k_e}r + B_4 - A_4)\sin\omega t$$

Comparing the two sides of (13) and arranging them to a and b:

$$D_1 a + D_2 b = D_0$$
$$-D_2 a + D_1 b = 0 \qquad 14$$

In the above system of equations

$$D_1 = A_1\omega^4 - (A_3+B_1)\omega^2 + (B_3 - \frac{1}{k_e})$$
$$D_2 = A_2\omega^3 - B_2\omega \qquad 15$$
$$D_0 = \frac{1}{k_e}r + B_4 - A_4$$

From (14) the missing parameters of (12) :

$$a = \frac{D_0 D_1}{D_1^2 + D_2^2}$$
$$b = \frac{D_0 D_2}{D_1^2 + D_2^2} \qquad 16$$

The two parameters of (12) can be replaced by two other parameters:

$$a = X_e\cos\Psi$$
$$b = X_e\sin\Psi \qquad 17$$

where X_e is the trunk amplitude when the extra mass is in action. With these

$$x_e = X_e\sin(\omega t + \Psi) \qquad 18$$

where:

$$X_e = \sqrt{a^2+b^2} = \frac{D_0}{\sqrt{D_1^2+D_2^2}}$$
$$\Psi = arctg\frac{b}{a} = arctg\frac{D_2}{D_1} \qquad 19$$

The effect of the extra mass was studied by replacing real data into Eqns. 1-19. For the calculations below the following values were taken: M = 150-500 kg, m=123 kg, m_{extr}= 29 kg, r = 0.025 m, c= 4000 Ns/m, k= 5,4.E-06 m/N, k_e =4,6.E-06 m/N, l_0 = 0.018 m, ω= 81.7 1/s (f=13 Hz).

The values X_m, X_M and X_e in function of reduced trunk mass M are plotted in Fig. 5.

As it indicates, the trunk amplitude is changing at about 230 kg, when the extra mass comes into action: it increases significantly the trunk amplitude compared to the situation without extra mass.

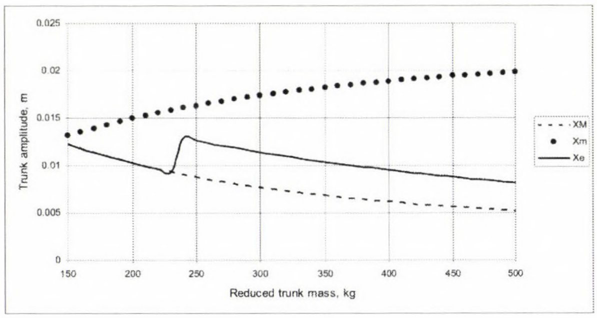

Figure 5. The change of trunk amplitude from X_M to X_e due to the effect of extra mass.

The experimental shaker unit

After setting up the theoretical background of the system, a shaker unit was designed (Fig. 6). As Fig. 6 shows, two identical thick steel discs were put over the bar of a slider crank type shaker. The discs were coupled via four steel tubes which determined the clearance $2l_0$. Changing the tube lengths, different $2l_0$ sizes could be set up. Eight rollers made possible the free move of the coupled discs along the shaker bar. The total mass of these elements was 29 kg.

Note, that the bar mentioned above is part of the unbalanced mass m, it vibrates together with the house of the slider crank.

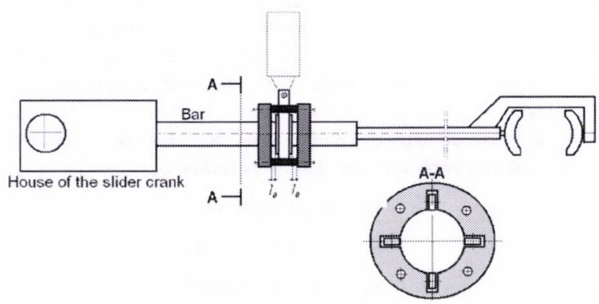

Figure 6. The set up of extra masses to the shaker bar

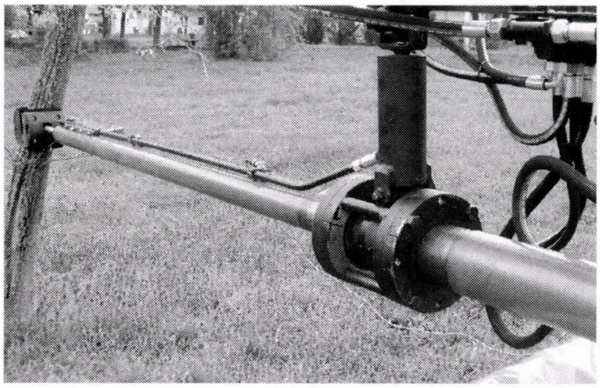

Figure 7. The extra masses on the inertia type shaker

Orchard tests

To control the behavior of the new shaker unit field tests were carried out in a 8 years old cherry orchard, near to Budapest. Two trees with different trunk diameter (135 and 210 mm) were shaken at 65 cm trunk height in 4 arrangements, each at 3 different frequencies. The arrangements were as follows:

1.: no extra mass on the bar, 2.: the extra mass is fixed to the bar (no separate moving of it), 3.: the clearance l_0 was set to 15 mm, 4.: the clearance l_0 was set to 30 mm. The frequencies

for each arrangement on both trees were chosen between 10 and 16 Hz. For each test the shaking frequency and the acceleration amplitude was recorded.

The reduced masses M of the two trees in test were calculated using the method, described by Láng in 2008, which gave for M_1 =280 kg and M_2=360 kg.

Result and discussion

The comparison of calculated and test results was made at 13 Hz shaking frequency. The calculated amplitudes were transformed in acceleration amplitudes using Eqn. 4.

All the different measured data were transformed to 13 Hz value using linear interpolation (Fig. 8). The interpolated values of the 3 repeats at every setup were than averaged (Table 1.).

The data indicate that the acceleration of tree no.1 is almost not influenced by the extra mass: much the same result at no mass, at 15 and 30 mm clearance. It is different for the tree no.2: at no mass and at 30 mm clearance the acceleration is similar; at 15 mm clearance it increases significantly (Fig. 9). With the above fruit tree and shaker machine parameters the effect of the extra mass starts at about 347 kg reduced tree mass.

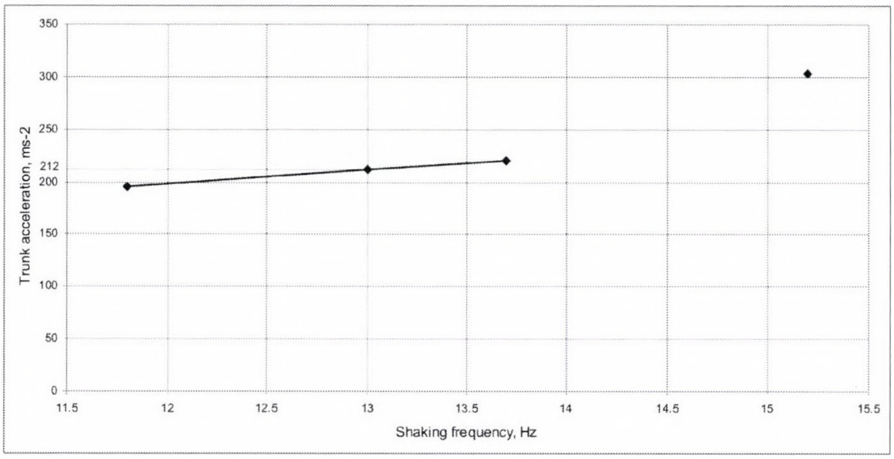

Figure 8. Linear interpolation of measured data to get the trunk acceleration at 13 Hz shaking frequency

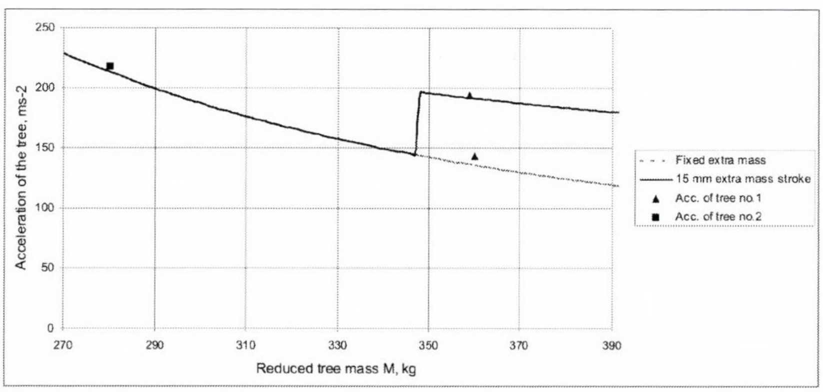

Figure 9. Calculated acceleration vs. tree mass curves and measured acceleration values on the trunk of the two trees.

Table 1. Average accelerations in ms^{-2} at the different test arrangements at 13 Hz shaking frequency

Arrangement	Without m_{extr}	l_0 =15 mm	l_0 =30 mm	l_0 =0 mm
Tree no.1, *Φ135mm*	213	209	218	245
Tree no.2, *Φ210mm*	145	198	147	204

Conclusion

The theoretical results, based on a kinematical model, as well as the orchard tests carried out on two different size cherry trees have shown, that an extra unbalanced mass increases the amplitude and acceleration of larger trees meanwhile the shaker input to the smaller trees remains unchanged. In the orchard tests the reduced mass of the smaller tree was 280 kg, the larger one 360 kg. The diagram of the kinematic model has shown that the 29 kg extra mass starts to increase the unbalanced mass of the slider crank type shaker at about 347 kg reduced tree mass. As a result of the above investigations it may be concluded, that the expansion of a slider crank type shaker by an extra unbalanced mass is a simple but useful method to achieve high detachment rates even at larger trees in orchard, without changing the shaker machine setup.

Acknowledgements

Thanks are due to the Hungarian Scientific Research Fund for the financial support of the above project.

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MODELING OF DUCTILE FORMING OF FORGED ALUMINUM ALLOY

Csaba ÁRVAY[1], István OLDAL[2], Attila CSATÁR[3]
[1]Szent István University,
PhD School for Technical Sciences
[2]Szent István University,
Faculty of Mechanical Engineering
[3]Hungarian Institute of Agricultural Engineering

Forging is a forming process without any turning demand, which is used mainly for serial production of machine parts with high quality static properties. The aluminum alloy type

EN-AW-6082 has been analyzed in our study, where several specimens of this material have been modeled with finite-element-method (FEM), too. As a result the varying static properties as well as its correlation with the deformation features have been detailed. Two-directional ductile deformation of a 90mm height round material as well as a 88mm height one have been tested. First its height has been pressed down to 42mm, then the specimen has been deformed again at 42mm but now in perpendicular direction. Both deformation have been carried-out by flat-shaped tools. Based on these results several tensile tests have been carried-out, which have been modeled, too, and then its deformation properties have been calculated. Several samples have been forged-out from the specimen, and its local deformation and the variation of its mechanical properties have been analyzed.

Introduction

The usage of tempered aluminum alloys has become recently even more populate not only in the aerospace and automotive engineering but in the general and other engineering fields, too. The great advantage of these alloys is the low density, which is approximately one third of that of the steel, its high strength, which is near to that of the steel, and in addition some alloy has a tensile strength value of Rm > 500 MPa [9, 10]. The favorable corrosion properties of aluminum as well as its usability for welded structures are advantageous, too. Turning of this material is easy, but its properties can be improved by plastic forming, as the produced losses are minimal. The common manufacturing process of series of forged parts is the drop forging.

Plastic forming allows to achieve high strength, and the tempering forms a stable and high-strength material texture [8]. The literature gives a wide validity range for the technology parameters (temperature during manufacturing, temperature of homogenization, cooling rate during tempering, length and temperature of the tempering, rest time between two tempering stages, etc.) of these processes. In addition, there are other factors (rate and measure of deformation), that may affect the mechanical properties of the finished parts. The specimens in the experiment have been produced with a friction presser, where the most up-to-date settings of this high-tech manufacturing machine have been applied. The produced specimens have been produced with the highest strength because of the used tempering. In the same time a finite element analysis has been carried-out for tracking the deformation.

Material and method

The forging preparation of test specimens was carried-out according to the standards of small and medium series parts for the automotive industry under 20 kg. The basic material is usually round material, however complex parts can be produced from different profiles, which suits the production more likely. The two stages of refining are the hardening and the subsequent tempering, and both of them have decisively influence on the mechanical and on the strength properties of a finished part.

Production of specimens

The sample series have been produced by the blacksmith Alutech Ltd. according to its own industry standards applied for series part production.

- Accordingly round specimens of EN AW-6082 alloy were produced with 90 mm diameter and 88 mm height.
- The specimens were pre-heated at 500°C for forging [3, 4, 5].
- The upsetting was made at 44 mm length, which corresponded to a major deformation with a rate of φ=50%.
- Then tempering for refining was applied according to the valid industry standards.

The equipments used for the above test and for the preparation of specimens were as follows:

- Tempering of cut parts was carried-out in a BSN-made gas-fired tunnel kiln, where the temperature of each parts have been measured manually.
- A friction presser of VACCARI type PV270 was used for the above process (Fig. 1).

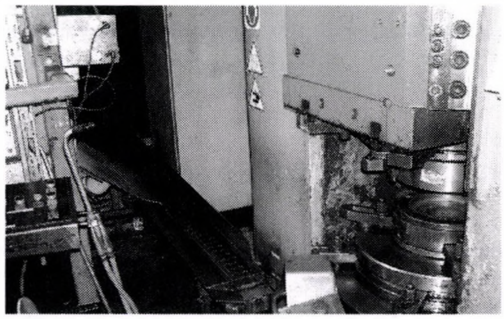


Figure 1. Friction presser of VACCARI type PV270

- An original upset tool used basically for industrial part production was applied during the experiments, which was heated up to 130°C, and the tool's temperature was kept always above 100°C during the production. Each tool's surface was emulsified before the part has been let to be broken down.
- The alloy was heated at a suitable temperature in a BALZER-made electric resistance heating furnace (Fig. 2) and when the tempering time was over the specimens were upset in water. All properties of the refining process have been listed in Table 1.

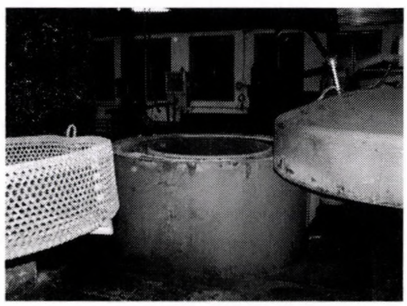


Figure 2. BALZER furnace

- The second step of the tempering and refining was the relaxing with a SCHMITZ-made gas-fired chamber furnace. Thus, both types of alloys were re-built into a T6 stage according to DIN EN 515, which is most appropriate for machine part production [6, 7] purposes.

Table 1. Properties of tempering

Alloy	Tempering Temperture (°C)	Tempering Time (min)	Temperure of cooling water (°C)
Properties of hardening			
ENAW 6082	520	126	25
Properties of relaxing			
ENAW 6082	180	390	Cooling with ambient air

Figure 3. The original specimen (above left) and the forged specimen (bottom right)

Input parameters of the numeric simulation

The formed material was modeled in the simulations as aluminum, and that of the tools as steel. The tools do not suffer permanent deformation during the forming, because the material strength is below its yield strength, hence these could have been modeled as linear elastic materials. The aluminum has had elastic deformation, that's why in this case bilinear elastic-plastic material model was used. Several working temperature were used during the production, where 100MPa yield strength and 1MPa tangent modulus were set as material properties. Multiple symmetry was taken into consideration during the modeling of the specimen geometry, therefore modeling of 1/8-part of the whole tool and specimen was enough, and corresponding constrains were applied onto the symmetry planes.

A real result requires the modeling of the contact problem in the finite element model, and for this sake two problems had to be defined between the part and both of the tools. Frictional contact was set between the bodies with a friction coefficient value of 0.1. The stiffness matrix was set to be re-calculated in each iteration step because of the large deformation and of the great vary of the contact surfaces during the modeling.

The model was built-up with 20-node hexagonal elements (quadratic approximation using polynomials), and if it were not possible due to the geometry settings, the 10-node tetrahedral elements (also quadratic approximation) were used instead of the 20-node one.

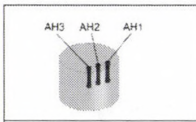
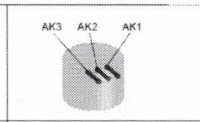
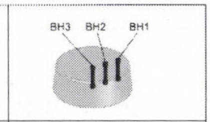
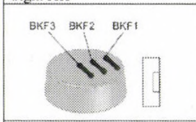
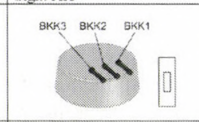
Measurement of mechanical properties

The mechnical measurements were carried-out by an INSTRON 5581 universal material testing equipment in the Hungarian Institute of Agricultural Engineering [1], which has been calibrated according to the MSZ[1]-EN 10002-2 standard. All measurements have been carried-out according to the MSZ-EN 10002-1 standard (Tensile test of metals at room temperature). The sample design was done according to the above standard, too, like the used jaws do.

The diameter of each specimen was 6 mm in a length of 20 mm. The testing rate was set according to the valid standards. The feed rate was 10 mm/min until the load reached 100 N, and then it was set at 10 m/min. All measurements were repeated three times. The sampling method of raw as well as of forged specimens can be seen in Table 2.

[1] MSZ = Hungarian National Standard

Table 2. Sampling from the raw and the forged specimens

 Sign: AH	 Sign: AK	 Sign: BH
 Sign: BKF	 Sign: BKK	

Results and discussion

The elastic forming

The strength and deformation have been calculated by a simulation done by the above parameters. Distortion and sliding surfaces are determinative during the processing in point of the granularity, so these features have been examined basically.

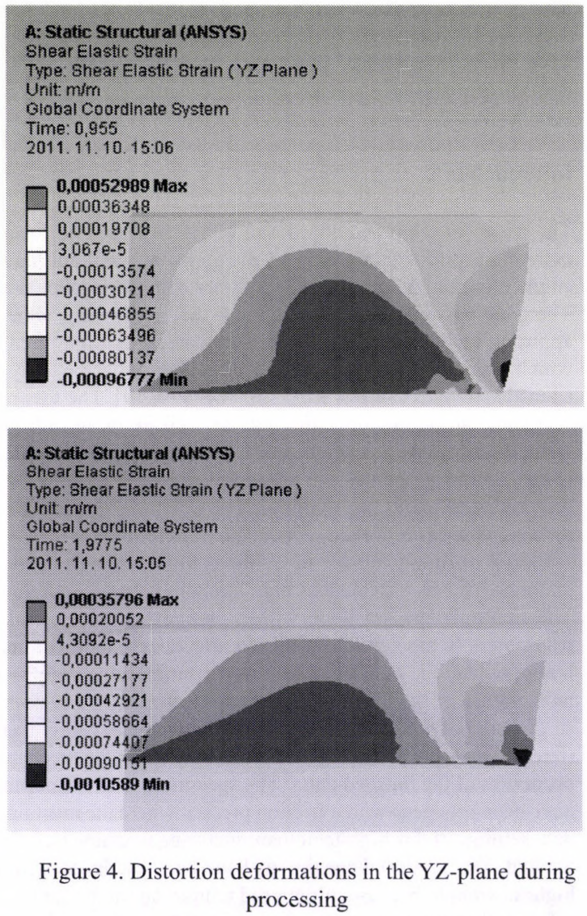


Figure 4. Distortion deformations in the YZ-plane during processing

The calculated deformations (see Fig. 4) show the presence of pushing cones, and the maximum deformations occur at the boundary of the cones. The deformation inside a cone is less because of the one directional processing. The distortions on the YZ-plane do not represent the entire deformation because of the axial symmetry of the part, but a numerical estimate of its value can be determined. The maximum distortion value calculated from the spatial strength state can be seen in Fig. 5. It shows that the deformation - especially at the beginning of the processing - was influenced by the pushing cones.

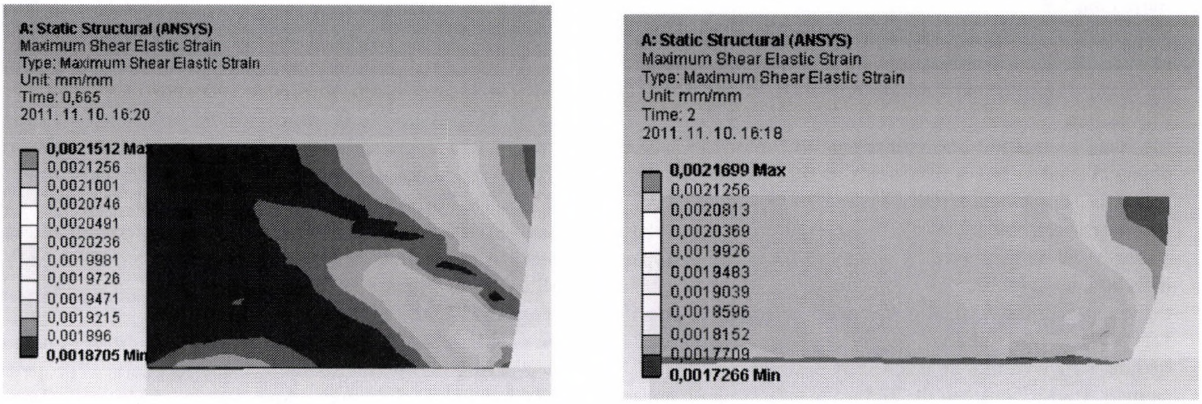


Figure 5. Absolute extreme of the distortion deformations during processing

Discussion of the tensile tests

Fig. 6 shows a tensile test of the raw material.

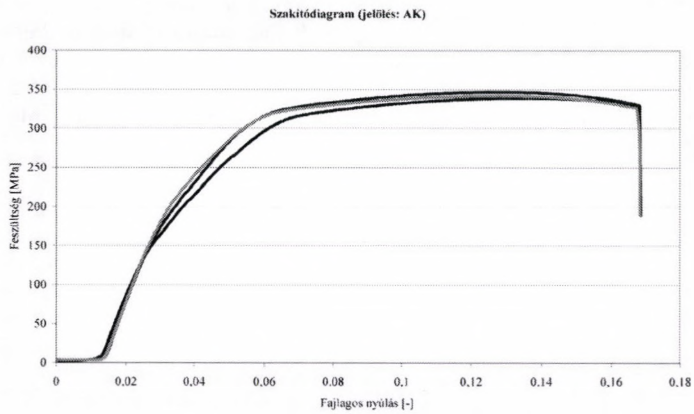


Figure 6. Tensile test diagram AK2 (material sample across a quarter of the diameter)

Table 3 summarizes the material strength test results taken from different locations of a sample in MPa.

Table 3. Material strength values of samples

	AK1	AK2	AK3	AH1	AH2	AH3
1	346,4	339,0	347,8	-	386,0	386,6
2	340,5	346,9	347,6	382,2	390,1	386,5
3	350,3	342,0	348,2	386,3	379,1	381,3
Average:	**345,8**	**342,6**	**347,9**	**384,2**	**385,1**	**384,8**

Table 4. Material strength values of forged samples

	BKK1	BKK2	BKK3	BH1	BH2	BH3	BKF1	BKF2	BKF3
1	335,6	327,3	340,3	319,9	330,2	331,8	356,2	340,1	337,6
2	348,6	342,7	345,2	326,6	333,2	322,6	346,9	344,7	342,1
3	357,0	338,5	340,1	333,7	335,8	350,9	334,4	344,4	341,5
Average	**347,1**	**336,1**	**341,9**	**326,7**	**333,1**	**335,1**	**345,8**	**343,1**	**340,4**

Conclusions from the results of the measurements and the calculations:

- the longitudinal material tensile strength was greater than the transversal one (the difference is approx. 40 MPa, which is more then 10%);
- according to Table 4 it can be determined, that the material texture has been homogenized through forging, furthermore the slight longitudinal strength reduction is due to the axial processing;
- the nearly constant strength along the diameter has been changed, and it has a maximum in the sample taken at its maximum deformation (BKK1; see Fig. 5);
- it can be determined, that the forging quality and the material strength can be improved by an other processing in any other direction, as before;
- the strength of the formed part is nearly identical to that of the high quality raw material, and it has homogeneous material texture, which cannot be reached by casting;
- sample "BKK1" has had the highest tensile strength under the transversal ones, and its location is identical to that of the calculated highest distortion in Fig. 5.

Acknowledgements

This research was supported by the Alutech Ltd. and by director Mr. János Pardi, respectively.

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REQUIREMENTS OF CONTROL INSTRUMENTS FOR SAFETY OPERATION OF BIOGAS PLANTS AND OF LIVESTOCK FARMS

T. VOJTELA, J. BAK, L. FENYVESI
Hungarian Institute of Agricultural Engineering (MGI)
Tessedik S. u. 4., Gödöllő, H-2100, Hungary
Tel.:+36 28 511-632, E-mail: vojtela.tibor@gmgi.hu

Abstract

Different gases originated from biogas plant can damage: – the health of the workers (labor hygiene effect), – the health and production of the animals of the neighboring livestock farm (animal health effect), – as well as can pollute the environment (ambient influent effect). The aims of this article are to provide current information: – about requirements for instruments of biogas plant and livestock farm, – about gas concentration limit vales related to environmental, labor hygiene and animal health effect.

Keywords

polluting gases, labor hygiene effect, animal health effect, ambient influent effect, requirements for control instruments

Introduction

The energy production, connecting to livestock farms happen in biogas-plants utilizing livestock manure originated from animal farms, begins nowadays in Hungary. The occasionally leaking biogas from biogas plant comprises: - 50-75 % methane (CH_4), - 30-45% carbon dioxide (CO_2), - and 2-8% other trace gases (O_2, N_2, H_2S, water vapor) (Bense. et al., 2009). In the case of cattle manure fermentation the biogas yield is only 0,56-1,5 m^3/animal unit/day. In the case of 50 % manure + 50 % maize silage fermentation the biogas yield is higher 1,2 – 3 m^3/animal unit/day. In the case of 10 % probable biogas leakage, that means 24-72 m^3/day methane and 15-40 m^3/day carbon dioxide exhausted to the ambient air. A dairy cow's annual carbon dioxide production is approximately 4 t/year, that means 5-6 m^3/day/cow carbon dioxide production daily. Out of gases mentioned before the exhaust gases of biogas engines contain carbon dioxide and water vapor (plus other trace gases: sulfur dioxide, nitric oxide, carbon monoxide, hydrocarbons, carbon black), and these are also out let gases to the ambient air. Theoretically the air demand of biogas engine for complete combustion is 5,7 m^3 air/m^3 biogas. The emission limit values of biogas plants are defined in case of particulate matter (PM), carbon-monoxid (CO), sulphur dioxide (SO_2), nitrogen dioxide (NO_2) and ozone (O_3) (Rasi et al., 2006). Each gas of biogas plant has separately effects but the gases included by biogas have common labor hygiene effect, animal health effects and ambient influent effect, and that is why it is so important to us to consider these interactions.

Materials and methods

Before entering biogas plant drains or for revision works in slurry containers (Figure 1.), multi-gas detectors must be used to protect personnel against combustible and toxic gases.

The following hazards must be monitored:

- Methane gas (CH_4) and air mixture, to prevent an explosion.
- Oxygen (O_2) deficiency, to make sure that entering without a breathing mask is possible.
- Hydrogen sulfide (H_2S), which builds up if organic processes are carried out without oxygen. Even small concentrations of hydrogen sulfide are toxic and act as a neurotoxin.
- Ammonia (NH_3) detection in the air means monitoring of animal houses in which animals and people work. The positive thing about small ammonia concentration that people recognize it by its unpleasant odor.
- Carbon dioxide (CO_2), a gas that builds up in all organic processes and, under certain geologic circumstances, even diffuses into a drain from the liquid manure or from a balance reaction with water.

The good confined space gas detector doesn't come from any one manufacturer; it's the instrument that good fulfills the requirements for confined space program of biogas (Figure 2) and livestock farm (Henderson, 2007); (Kleine, 2007); (Rasi et al., 2006).

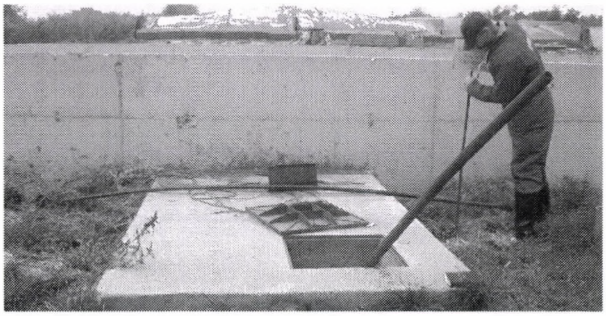

Figure 1. Slurry container neighbor of a biogas plant (Source: own collection)

Figure 2. Biogas-plant built in the neighbor of dairy farm. (Source: own collection)

Results and discussions

Sensory organs of people do not feel the increase of CO_2 concentration in the ambient air (Table 1.). Livestock Farm + Biogas Plant = concentrated CO_2 emission place. Production decrease in pig and poultry houses at 0,5 – 0,6 % CO_2 concentration. Measuring range needed in animals' buildings 0 to 20 /Vol.-% CO_2/.

Sensory organs of people feel already the 5-50 ppm NH_3 concentration in the ambient air (Table 2.). Pig Farms have considerable quantity NH_3 emission. Measuring range needed in animals' buildings 0 – 100 ppm NH_3 concentration.

Sensory organs of people feel already the 0,01-0,7 ppm H_2S concentration in the ambient air (Table 3.). Measuring range needed in animals' buildings 0 – 100 ppm H_2S concentration.

Sensory organs of people do not feel the increase of CH_4 concentration in the ambient air (Table 4.). Methane is a combustible gas. There is no measuring range needed in animals' buildings methane concentration.

Sensory organs of people can feel biogas, if it contains minimum 0,01-0,7 ppm H_2S (Table 5.). The presence of biogas is clearly and in time recognizable about the odor of rotten egg (because of the hydrogen sulfide) in the breath of air. Biogas in air can explode (EXPLOSION RISK), and can flames up (FIRE HAZARD).

Table 1. Carbon dioxide (CO_2) in the ambient air at Livestock Farm and Biogas Plant

Designation	Data, feature
Volume mass:	1,9768 kg/m^3 (1.5 times heavier than air).
Colour, odour:	- colourless, - odourless.
CO_2 accumulates in layers of air being near the flooring of deep lying and in sealed rooms.	
Main resources:	- the exhaled air by livestocks,
	- the decaying faeces and urine (e.g. in slurry tank),
	- the leaking biogas contains 25-50 % CO_2 (e.g. from the fermentor),
	- the exhausted gas of motor fuelled by biogas.
Effects of accumulating CO_2 concentration	- decreasing oxygen level in the air,
	- difficulties, in animals' and peoples' air changing.
Effects of increasing CO_2 concentration in the ambient air to the people	
0,03 % CO_2	fresh air,
0,07 % CO_2	ambient air in cities,
1 % CO_2	short term exposure level (STEL),
1 – 2 % CO_2	sleepiness,
near 3 % CO_2	headache, retching,
near 10 % CO_2	leading to comas,
near 20 % CO_2	dead in a few seconds,
0,3 % CO_2	EU-s threshold limit value (TLV) in animals' buildings and people's workplace.

Table 2. Ammonia (NH_3) in the ambient air at Livestock Farm and Biogas Plant

Designation	Data, feature
Volume mass:	0,7715 kg/m^3 (lighter, than air).
Colour, odour:	- colourless, - typical unpleasant odour.
Lyses:	properly lyric in water.
NH_3 is spread evenly in the ventilated air.	
Main resources:	- the decaying faeces and urine (e.g. in slurry tank),
	- the undigested feeding in faeces.
Effects of accumulating NH_3 concentration:	- shedding of tears, frequent sneezing, frequent coughing,
	- respiratory diseases.
0,002 % (20 ppm) NH_3	EU-s threshold limit value (TLV) in animals' buildings and people's workplace.
100 ppm NH_3	so unpleasant, that people start to panic.
17 Vol.%, NH_3	lower explosion limit (LEL) of ammonia.

Table 3. Hydrogen sulfide (H_2S) in the ambient air at Livestock Farm and Biogas Plant

Designation	Data, feature
Volume mass:	- heavier, than air.
Color, odor:	- colorless, - its odor reminds people to odor of rotten egg.
Main resources:	- from the anaerobic degradation of protein,
	- from slurry channel being under the slatted floor,
	- the leaking (not sculptured) biogas contains 0,1-1,0 % H_2S (e.g. from the fermentor).
Effects of accumulating H_2S concentration:	- irritation to mucous membrane , - bronchitis,
	- very strong toxic effect, - pneumonia.
Effects of increasing H_2S concentration in the ambient air to the people:	
0,01-0,7 ppm H_2S	people can already feel the odor,
3-5 ppm H_2S	people feel intolerably and uncomfortably themselves,
10 -15 ppm H_2S	during several hours H_2S causes conjunctiva and mucous membrane irritation,
50-100 ppm H_2S	within one hour it causes conjunctiva and mucous membrane irritation,
0,5 ppm H_2S	EU-s threshold limit value (TLV) in animals' buildings and people's workplace.

Table 4. Methane (CH_4) in the ambient air at Livestock Farm and Biogas Plant

Designation	Data, feature
Volume mass:	0,7168 kg/m^3 (lighter, than air).
Color, odor:	- colorless, - odorless.
CH_4 is spread evenly in the ventilated air. Methane and air can create an explosive mixture.	
Main resources:	- originates from ruminants within rumen-fermentation, it exhausts as flatus to the air of stable,
	- the leaking biogas contains 50-75% CH_4 (e.g. from the fermentor, from the biogas pipeline).
Effects of accumulating CH_4 concentration:	- even in high concentrations it does not cause decrease of livestock production or health deterioration of livestock,
	- it practically never reaches the explosive mixture concentration in stable.
5 Vol.%, CH_4	lower explosion limit (LEL) of methane.
17 Vol.%, CH_4	upper explosion limit (UEL) of methane.

Table 5. Biogas (methane CH_4+ carbon dioxide CO_2 + hydrogen sulphide H_2S = gas mixture)

Designation	Data, feature
Volume mass:	- biogas contains fundamentally three different gases (CO_2 and H_2S are heavier than air), - biogas is a mixture of different gases like methane, carbon dioxide, hydrogen and hydrogen sulphide, - the volume mass of biogas depends on the rate of contained gases.
Colour, odor:	- colourless (CH_4 and H_2S, CO_2), - odorless (CH_4 and CO_2), - odor of rotten egg (H_2S).
The lighter component of biogas (CH_4) is spread evenly in the ventilated air. The methane part of biogas and air can create an explosive mixture. The presence of biogas is clearly and in time recognizable about the odor of rotten egg in the breath of air.	
Main resources:	- the leaking biogas (e.g.. from the biogas pipeline),
	- the leaking biogas (e.g. from the fermentor).
Effects of accumulating biogas components to livestock and people:	- under sufficient concentration and duration the breathed biogas can cause poisoning death (because of hydrogen sulphide, H_2S) or suffocating death (because of carbon dioxide CO_2),
	- under sufficient concentration and duration the breathed (free from sulphure) biogas can cause suffocating death (because of carbon dioxide CO_2), - the breath in sweetened biogas can cause suffocating death (because of carbon-dioxide CO2) on account of lack of oxygen.
Biogas in air can explodes, if	- in the air and biogas mixture the rate of biogas is between 6-12%,
	- there is an ignition source with more than 700 ° C temperature.
Biogas in air can flames up, if	- in the air and biogas mixture the rate of the biogas is more than 12%,
	- there is an ignition source with more than 700 ° C temperature.

A CO_2 can be dangerous monitored by the oxygen concentration (decline or displacement of the CO_2 concentration). The ambient air contains 20% oxygen and 80% nitrogen. If the carbon dioxide concentration increases, oxygen and nitrogen are displaced by the carbon dioxide in a 4:1 ratio (Table 6.)

To decrease the oxygen concentration by 1%, the carbon dioxide concentration has to increase by 4%. Oxygen monitors activate the alarm at 17% volume. By this time, the carbon dioxide concentration has already reached a concentration leading to death.

The best confined space gas detector doesn't come from any one manufacturer; it's the instrument that best fulfills the requirements for your confined space program. Choosing the design that best fulfills the requirements for your specific program. Price should not be the sole determinant. Suggested criteria for instrument selection:

- sensor selection,
- sample-draw versus diffusion,
- classification for intrinsic safety,
- batteries,
- durability,
- datalogging versus non-datalogging,
- included accessories,
- warranty,
- operability,
- instrument performance specifications,
- alarms,
- calibration,
- evaluate before purchase.

The best instrument in the world is the one that's the best for your own individual conditions of use.

Table 6. Oxygen and nitrogen concentration in the ambient air according to increasing carbon dioxide concentration (Kleine, 2007).

Gas concentrations in the ambient air			
Carbon dioxide **(CO_2)** /Vol.-% /	Oxygen **(O_2)** /Vol.-% /	Nitrogen **(N_2)** /Vol.-% /	Effects of CO_2 to the people
0	20	80	no
4	19	77	headache, retching
8	18	74	leading to comas
12	17	71	comas
16	16	68	dead in seconds

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SPECTORADIOMETRIC AND HYPERSPECTRAL SAMPLING AND DATA PROCESSING METHODOLOGIES IN MODERN AGRICULTURAL PRODUCTION

K. D. SZALAY[1], L. FENYVESI[2]
[1]Doctoral School of Engineering,
Szent István University
Páter K. u. 1., Gödöllő, H-2103, Hungary
Tel.:+36 70 935 47 99,
E-mail: szalay.kornel@gmgi.hu
[2]Hungarian Institute of Agricultural Engineering
Tessedik S. u. 4., Gödöllő, H-2100, Hungary
Tel.:+36 28 511-601,
E-mail: fenyvesi.laszlo@gmgi.hu

Abstract

The field- and laboratory spectroradiometry are indispensable components of airborne hyperspectral remote sensing by giving reference information for image processing. At the same time, 'in' and 'ex situ' ground spectroradiometric measurements can be used for analysis in various application fields in a self-contained manner, too. In this paper, we present the ASD Field Spec®3 MAX portable spectroradiometer together with its role in airborne remote sensing and the main methodological details of the field- and laboratory spectroscopy.

Keywords

spectroradiometric and hyperspectral sampling, data processing

Introduction

The dynamic development of the different remote sensing technologies resulted in the hyperspectral imaging spectroscopy, which is one of the most advanced technologies in optical remote sensing.The hyperspectral technological capabilities of the Hungarian Institute of Agricultural Engineering provides wide opportunity for obtaining quantitative relationships between the environmental or physiological parameters of vegetation cover or the soil quality parameters and those spectral characteristics. The AISA DUAL hyperspectral airborne twin-sensor system has the advantage of being able to operate in the full optical wavelength range of 400 nm to 2450 nm and, thus, providing several times more information as sensors operating in the visible range alone, by revealing phenomena which exhibit diagnostic absorption features in the shortwave infrared bands. Remote sensing of Earth's surface involves all evaluation methods which work without touching the object. The only physical connection between the observer and the object is the electromagnetic radiation. With the use of the hyperspectral remote sensing we record the refletced flux radiation form the studied surface on hundreds of narrow, adjacent bands. Simoultaneously, on these bands gray-scale pictures are made and recorded separately. The technology provides broad opportunities of evaluating local or global processes or balances according to the various aspects. It has also greatly improved the efficiency of data utilization and created new perspective for modern information management in precision agricultural production by satisfying the growing demand toward data and information. This data recording method resulting in the so called data cube (see Fig. 1) where high resolution of spectral information is assigned to all spatial pixel of data cube and spectral characteristics of the surface can be mapped by high definition geometrical sampling method on up to hundreds of adjacent spectral bands.

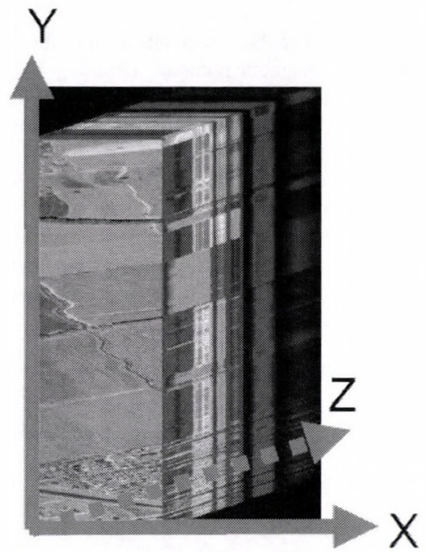

Figure 1. Hyperspectral data cube

The integration of in-field and laboratory spectroradiometric measurements is adequate for analyse large areas in a fast, precise and economic way (Milics et al. 2010, Milics et al. 2011a, Késmárki-Gally et al. 2009). Unlike airborne imaging data in-field or laboratory spectral sampling results in one pixel, which contains the mean reflectance of the instantaneously scanned surface. In this study we are introducing two sensors which extend the detectable visible light (Lágymányosi and Szabó 2009, 2011) to NIR – near infrared – and the SWIR – shortwave infrared – and able to operate in the full optical wavelength range of 400-2450 nm (AISA DUAL) and 350-2500 nm (ASD Fieldspec®3 MAX). The coordinates of in-field examinations are recorded so the ground spectrum can be fitted to the adequate pixel of the hyperspectral airborne image that is an important element of subsequent evaluation processes. The number and the quality of in-field measurements determine the final accuracy of the airborne images. This technology is adequate to analyse vegetation in a fast, precise way (Fenyvesi 2008, Yang et al. 2009, Milics et al. 2011b, Virág and Szőke 2011). Using this new-generation data monitoring and sampling methodology, we can obtain quantitative relationships between the environmental or physiological parameters of vegetation cover (Tolner et al. 2010, Szalay et al. 2011, Balla et al. 2011), soil quality parameters (Máthé et al. 2010, Tolner 2011) and different source of soil contaminations (Csorba and Jordán 2010), or climate attributes (Erdélyi 2009, Tarnawa et al. 2011) and the features of reflectance spectra (Csorba 2011). The Department of Water and Environmental Management of the University of Debrecen, Centre For Agricultural and Applied Economic Sciences, (Burai and Tamás 2005, Kőmíves et al. 2006) and the Institute of Agricultural Engineering of the Hungarian Ministry of Agriculture and Rural Development (hereafter referred as Institute) operate the AISA DUAL sensor system of the Finnish Specim Spectral Imaging Ltd., a unique remote sensing system in all Europe, collectively (Szalay et al 2010). In the year of 2010, the Institute of Agricultural Engineering bought an ASD Fieldspec®3 MAX field spectroradiometer expanding the available data acquisition systems. The Hyperspectral Working Group established in the Institute offers new generation of data acquisition methods. Beyond the scientific application of the technology we offer our service to work out the adequate hyperspectral methodologies according to the requested agricultural, industrial or other scientific projects.

Materials and methods

The AISA DUAL airborne twin-sensor has the potential of detecting the electromagnetic radiation in the wavelength range of 400 to 2450 nm with sub-meter level of spatial precision. During the flight the geographical coordinates and the position of the plane are recorded by Oxford RT-3000 GPS/INS system. Beside the DUAL mode both sensor can be operated solely depending on the aim of examination.

The ASD Field Spec®3 MAX portable spectroradiometer (see Fig. 2) can widely be used for both in-field and laboratory measurements, too. The specification of the instrument is presented in Table 2.

Figure 2. Az ASD Field Spec®3 MAX

Table 2. System parameters

	ASD Field Spec®3 MAX
Spectral range (nm)	350-2500
Spectral resolution (nm)	3-10
Sampling interval (nm)	1,4-2
Scanning time (milliseconds)	100
FOV (degree)	1, 8, 25
Detectors	Si, InGaAs

By using the spectroradiometer – beside it's solely application, without airborne measurements – it is possible to correct and validate the airborne data with in-field and laboratory measurements. For laboratory examinations we constructed a unique light-isolated cabinet (see Fig 3.) which makes possible to achieve outstanding precision, since the disturbing environmental light is shielded and the undesirable reflexions from the interior of the measuring cabinet are minimized by the appropriate arrangements of the implements (see Fig 4.). The special material of the sample stage and the cabinet's interior result in minimal reflectance over the whole electromagnetic spectrum detected by the spectroradiometer (350-2500 nm).

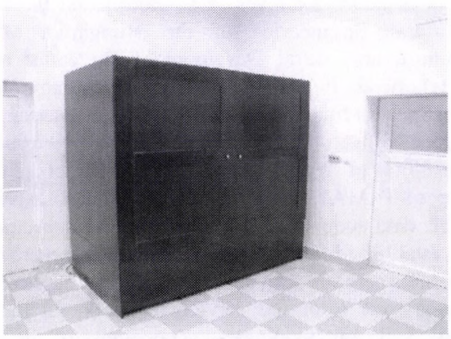

Figure 3. Light-isolated cabinet

Figure 4. Experimental arrangement

The proper geometrical arrangement during the in-field measuring process – the measuring process should be taken outside of and perpendicularly to the principal plain – and the appropriate number of white reference highly improve the precision. Both for airborne and field data acquisition fair sky and high angle of incidence are optimal.

Based on the application of hyperspectral technology ex situ measurements were carried out to identify the spectral differences of winter wheat treated with various nutrient dozes. 'Alföld 90' winter wheat variety was studied in agronomic replicated blocks. The half of the plots received 80 kg ha^{-1} nitrogen fertilizer in form of ammonium nitrate (0-0-36), the others did not received any mineral fertilizer. Wheat ears and kernels from all plots were gathered and analysed in laboratory according to its spectral characteristic with spectroradiometer in the wavelength of 350 to 2500 nm.

While wheat ears were illuminated by and studied with the use of Pro Lamp (Fig 5.) kernel samples were studied with the use of Plant Probe sensor-head (Fig 6.).

Figure 5. Pro Lamp

Figure 6. Plant Probe

The pre-procession of data were made with ViewSpecPro software. Further process steps were carried out with ENVI image analyser software.

We used continuum removal to normalize reflectance spectra in order to compare individual absorption features from a common baseline.

Results and discussion

During the evaluation of the wheat ears with spectroradiometry, we worked with computed mean reflectance spectra of the treatments. Red colour represents the nitrogen fertilized, while green the unfertilized parallel. According to these curves the spectral characteristic of the different treatments are diverge (see Fig 5.), but the deviation of those seems independent according to the differences generated by the mineral fertilizer.

By removing the continuum of the curves we found a characteristic interval between 1650 nm and 1800 nm (see Fig 6.).

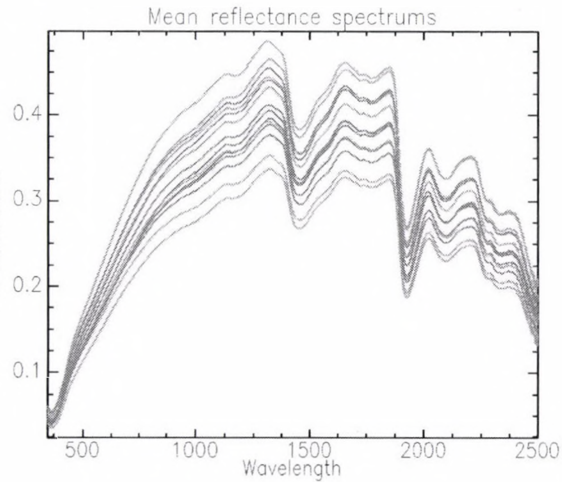

Figure 4. Mean curves

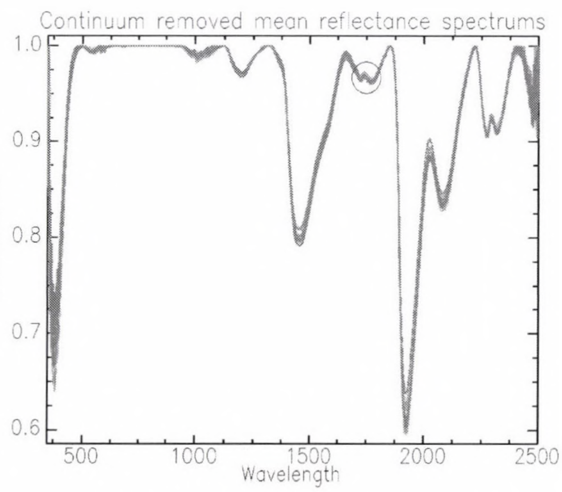

Figure 5. Continuum removed mean curves

After removing the continuum we performed Principal Component Analysis on the dataset of the relevant interval to find the hidden information in the dataset (Fig 6.).

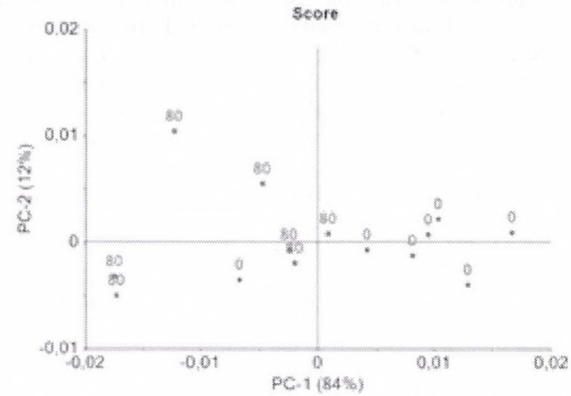

Figure 6. Principal Component analysis

The analysis indicated the presence of one decisive factor based on which the different treatments can be separated. The 84 % of the variability is explained by the first Principal Component.

The evaluation of wheat kernels – with the above described method – resulted in the same correlation in the wavelength interval of 500 to 800 nm. In this case the kernels 98 % of the variability is explained by the first Principal Component.

Conclusion

Since beside the different nitrogen treatment all factors were constant during the experiment we do accept the hypothesis that the decisive factor is the differing quantity and quality parameters of the wheat variety generated by the diverse nitrogen fertilizer treatment. These changes resulted in such spectral differences as well which were detectable with spectroradiometer in form of wheat ears and kernels as well. Among the analyzed reflectance curves after removing the continuum of the spectra we found two characteristic intervals at the wavelength range of 500 to 800 nm (wheat kernel samples) and 1650 nm to 1800 nm (wheat ear samples) at which the treatments became distinguishable. By evaluating the most important parameters of the winter wheat such as yield, protein, wet gluten content and farinographic value with conventional laboratory technology the interrelation between spectra and nutrition application can be clarified. After the appropriate calibration and validation process the spectral methodology can greatly assist in describing and tracking the current dynamics of nutrient supply and plant up-take in a fast and economic way. The defined correlations based on laboratory 'ex-situ' measurements can be greatly implemented in the 'in situ' in-field and airborne hyperspectral imaginary resulting in time and cost effective, precise sampling method which can exquisitely be applied in the modern agriculture.

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SYNERGY OF OPTICAL INSECT COUNTER AND MOBILE ROBOT

Z. BLAHUNKA, D. FAUST, Z. BÁRTFAI
and R. LEFÁNTI
Szent István University
Páter K. u. 1., Gödöllő, H-2103, Hungary
Tel.:+36 28 522-000,
E-mail: blahunka.zoltan@gek.szie.hu

Abstract

Optical insect counter is a new product of our Faculty. It's a high tech application. Using ferromon traps, the flying insects come into the trap. An infra camera is looking the trap. High speed video processing discovers the insects. Video processing calculates the size of the insects and the speed (sign of speed is the direction: in or out). The result is transmitted to the central database, to calculate all insect in an area, field.

Mobile robots can locate the traps more positions, fields. Using GPS receiver every counted insect has position information too (size, speed).

The synergy of using optical insect counter and mobile robots enhanced the coverage of one unit. With these time share method, one trap can measure more position.

The centralized processing can filter the information for fields. Calibrating the alarm levels (for example exponential growing by 10% 5 times, or linear growing by 5% 3 times, ...) makes an alarm email or SMS when a specific size of insect (specific type) has dangerous increasing population.

Keywords

optical insect counter, mobile robot

Introduction

Optical insect counters are new high tech applications. It consist many interesting technology: infra camera, high speed video processing using FPGA technology, National Instruments robust field computer: CompactRIO, finally PHP, MySQL web technologies to store the information and present graphs, alarms. We introduce the system details.

Mobile robotic is another exciting technology. Mobile robots are able to move stand-alone mode. With energy harvesting (for example solar panel) they are able to work without traditional external electric power. Mobile robots can use to carry different instruments. In this paper the special instrument is an optical insect counter.

To filter the insects in different position, the database also stores GPS geo positions.

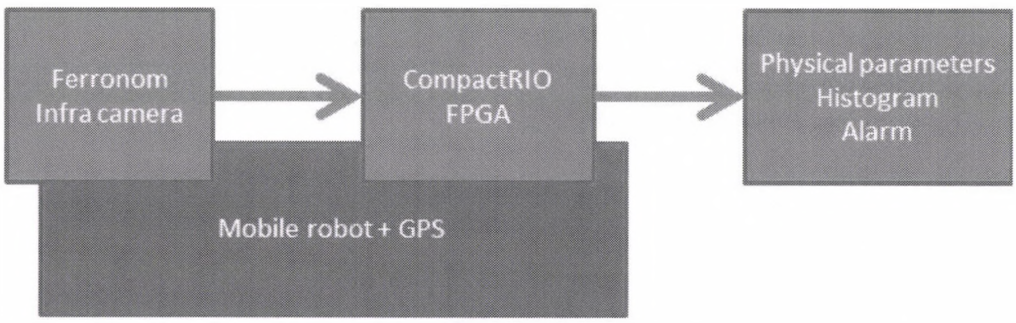

Figure 1. System design, synergy of optical insect counter and mobile robot

The synergy of the previous 3 technology (optical insect counter, mobile robot, GPS) extends the coverage of the counter. The insects have a typical "working hours". One time share option is using optical insect counter in one position with different ferromons. Of course using mobile robots the different working hours can be in different places.

Optical insect counter

There are many different insects, what makes agricultural production losses. There are many technologies to protect against them. One big question to apply the protection is: WHEN? The correct answer, when the insect population is starting growing. We introduce a population calculation method, which count the insect in a ferromon trap. The insect is detected, and using the elapsed time calculated the insect size (length, width) and speed. A central database makes statistical report for a given size of insects.

Infra camera

As earlier said, every insect type has typical working hours. This can be day or night. The optical sensor should see 24 hours a day. That is why we choose infra camera. The camera unit consist an analog infra camera. To process the video signal this unit converts the frames into 3 digital signs. The video processing is simplified to scanning only two lines from the whole picture. It is also a developing area to use high speed line scanners.

The 3 digital signs are the selector of the two lines. The third line is a digitalized video signal. Digitalized means this is a distorted analog video signal. When an insect is at the line: the digital value is high. When the trap is empty the digital value is low.

The video input device makes this conversion. Because of limited power supply this unit use CMOS components. The next unit is working on TTL logical level, so the interface has to convert the signal levels.

Video processing (FPGA)

To find an insect in a video line is a very fast algorithm. One line is 60 μsec long. To measure the width of the insect signal, it must be very punctual to calculating elapsed time between the edges. Rising edge is the beginning of an insect picture, falling edge is the end of the insect.

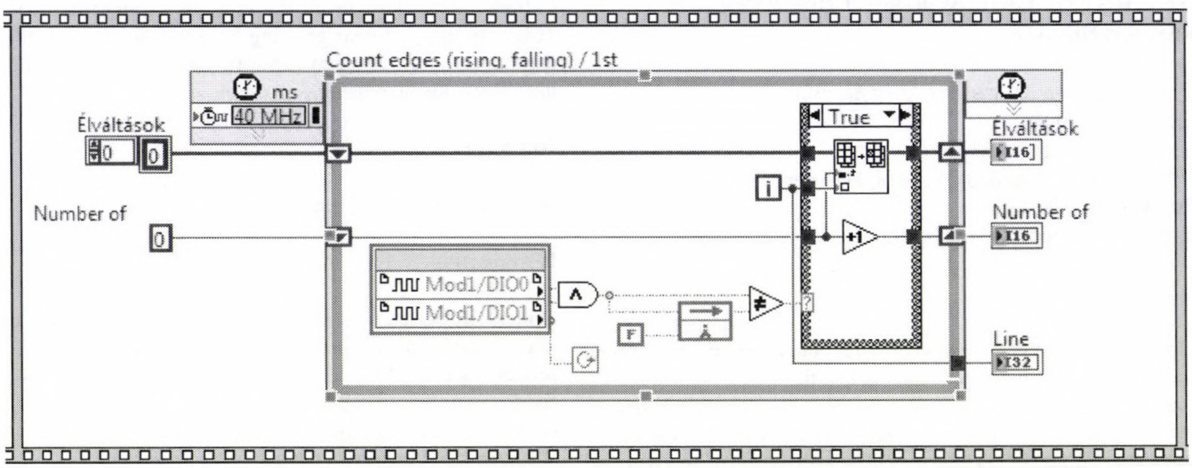

Figure 2. LabVIEW FPGA code for detect edge changing

FPGA technology is a good choice for a fast speed real-time solution. FPGA makes hardware from software. The program code runs in a special hardware what makes exactly what software tells. There is no processor in FPGA, the elementary logical gates makes connected to build a logical gate array. LabVIEW make easy to this coding. Simple graphical code can run on FPGA hardware.

Figure 2 shows the video processing block diagram. The loop works at 40 MHz. It means one line is about 2400 clock cycle. (There are special video signs, so one line is shorter than 60 μsec). Also 2400 count is enough to calculate the insect width.

The pink box symbolizes the digital input signals. DIO1 is the selector signal. The loop is running while the selector is high/true. DIO0 is the digitalized video signal. The AND gate controls the video signal enabled when the select is enabled. The feedback node gets the value from the last loop. Not equal node means the edge changing. When the video signal is not equal with the previous value, this is the edge. The case structure shows the true case. In this case the loop counter store in an array, and increment the array store position.

The loop is finish when the select signal goes false. After it the code give back all of the edge changing position, number of edge changing, and the whole line size.

FPGA programming has a limitation, to use only fix sized array. That's why we should give back the number of edges.

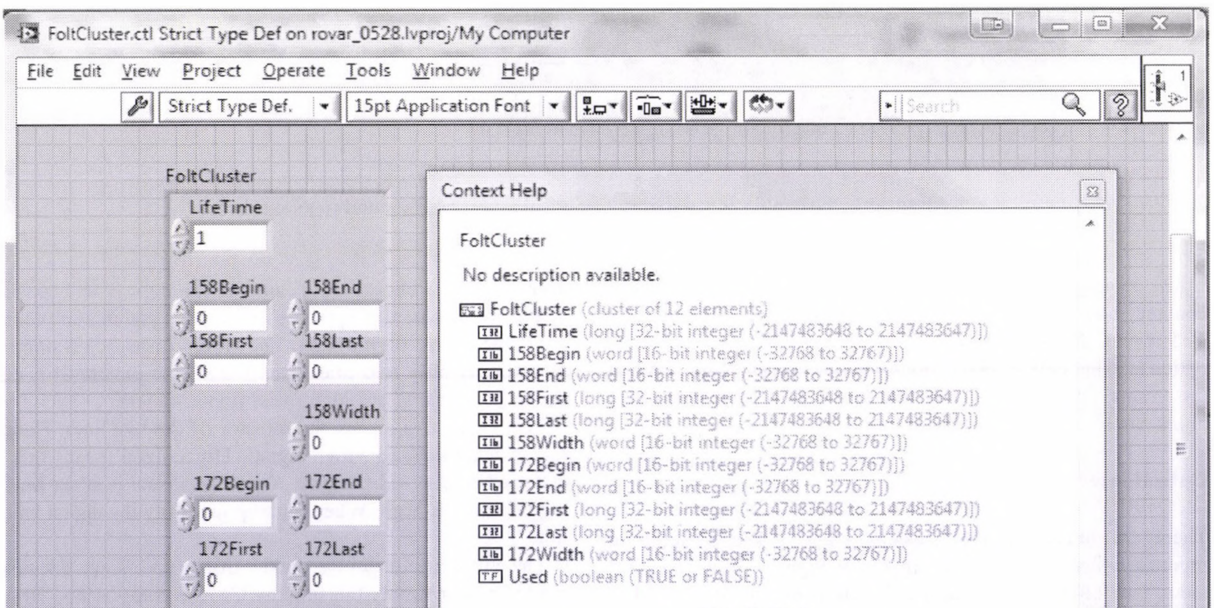

Figure 3. Insect internal data structure

Figure 3 shows the data structure of one insect. The insect can come from two different ways (from the first selected line or the second selected line) and also can leave the camera two directions. There is no rule what will be the first and last.

When both lines are empty, it means no insect in the camera. When the insect arrives one line detect the other line is empty. When the whole insect is before the camera both line detected. When the insect is leaving the camera only one line can see the insect. Finally when both lines are empty again, it means the end of the insect.

The previous scenario is about only one insect. Of course there can be more insects are moving before the camera, moving different directions. The data structure in the figure 3 can store all information about insect arriving and leaving.

Finalizing loop detect when an insect leaving the inspected area. In that case this data structure must be store. For testing it appear in the monitor. The main storage is a centralized web based MySQL database. The data transfer is using URL parameters. Browsing the storage input page, the complete structure stored in the MySQL table.

Using online database require continuous internet access. This makes too much energy. There can be batch process to send the insects by hourly.

Web database

The web part is made by PHP using MySQL database.

The storage input page stores all input information. Figure 4 shows the measured table. There are some special fields, some fields for security. GPS longitude and latitude can be NULL when no GPS unit connected, or GPS signal is not valid. There is a default GPS location for every unit.

For security reason (also can be filtering) at the table the sender IP address is stored. This can be a security filtering, that a special IP range is acceptable. SenderApp is another security fields. Figure 4 shows Mozilla Firefox browser as a sender application. This values are not comes from National Instruments hardware. These values come from optical insect counter test web page. For test reason there is web page where can simulate insect data input.

MeasureID UniqueID	UnitID Mérőeszköz sorozatszáma	Date Mérés dátum	Time mérés ideje	158First Belépés	158Last Kilépés	172First Belépés	172Last Kilépés	Width Szélesség	GPSLong GPS északi	GPSLat GPS keleti	SenderIP Erről az IP-ről jött	SenderApp Küldő applikáció
121	faust1	2011-02-28	20:08:20	1	23	4	25	127	*NULL*	*NULL*	94.44.68.75	National Instruments LabVIEW
122	faust1	2011-02-28	20:09:24	1	23	4	25	127	*NULL*	*NULL*	94.44.68.75	National Instruments LabVIEW
123	faust1	2011-02-25	10:23:00	1	30	4	33	123	47.123	19.543	94.44.65.22	Mozilla/5.0 (Windows; U; Windows NT 6.1; hu; rv:1.
124	faust1	2011-02-25	10:23:00	1	30	4	33	123	47.123	19.543	94.44.72.215	Mozilla/5.0 (Windows; U; Windows NT 6.1; hu; rv:1.

Figure 4. MySQL table. Original measured values

There is a table for original data. There is another table for processed information. Every unit has conversation info. Length and width information can calculate from the measured data and these conversion rates.

$$v = \frac{s}{t} = \frac{d}{\frac{n}{FPS}} = \frac{d \cdot FPS}{n} \qquad 1$$

Speed can be calculated using equations 1.

- d is unit specific distance, physical distance between the two lines (constant),
- FPS camera parameter (constant)
- n is the impulse different between the first and second line.

Using this equation the speed and direction can be calculated. The values can be positive or negative depends on which direction arrive the insect. There are two speed value, incoming and outgoing. If the signs of these values different, it means the insect NOT cross the camera.

After the measured values are converted to physical parameters, we are able to filter the insect by typical insect size and working hour. The reports table stores these filter parameters. Reports are generated regularly (for example every day). If the number of insect (it depends the population) are growing, the alert system is sending the report highlighted the dangerous population/numbers. Traditional protecting methods should be applied that case.

Mobile robot with gps

As figure 1 shown, the optical insect counter can be mobilized by mobile robots. One trap can count not only one place. The mobile robot can carry the trap on the border of a field. Also the mobile robot can carry the trap to another field.

To manage different fields there is a field border table in the database. Mobile traps also can be filtered by time schedule. Using mobile robots extend the coverage of one optical insect counter unit working area.

Possible working extension with mobile robot:

- one field more point,
- more field,
- more measuring points for different working hours.

Figure 5. Mobile robot is moving on fields to mapping with laser scanner

The Pioneer P3-AT mobile robot is able to move on off road environment.

Some parameters of the mobile robots:

- Weight: 11,8 kg (with 3 batteries)
- Axial distance: 275 mm
- Wheel diameter: 225 mm
- Wheel width: 80 mm
- Width (by wheels): 400 mm

Conclusions

Optical insect counter is very useful instrument. The special hardware convert the infra camera video signal into digital signals. High speed video recognition discovers the insects in the camera. The developer algorithm can detect more insect simultaneously, and insect can move different directions.

After detecting an insect the web database convert the counter values into physical distance and speed. The insects can be filtered by size, working hour, GPS position and field area. The reports shows the number of counted insects which is depend on the insect population. Increasing population makes an alert to use protection against the insects.

To carry optical insect counters need mobile robot with off road capabilities. Pioneer P3-AT is a good choice. This mobile robot has advanced navigation system for moving in a changing environment. Using mobile robots extend the coverage of traps.

Nomenclature

CMOS	Complementary metal–oxide–semiconductor
CompactRIO	The National Instruments robust field computer, controller
FPGA	Field-programmable gate array
FPS	Frame Per Second
IMU	Inertial measurement unit
MySQL	open source, multiuser, multithread SQL relational database server, see: SQL
Pioneer P3-AT	All Terrain mobile robot
PHP	Hypertext Preprocessor
URL	Uniform Resource Locator
USB	Universal Serial Bus
SQL	Structured Query Language

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3D SCANNING AND COMPUTER ANALYSIS OF MORPHOLOGICAL ASPECTS FOR AGRICULTURAL APPLICATIONS

I. SZABÓ, L. KÁTAI and R. CSOMAI
Institute of Mechanics and Machinery
Department of Machine Design, Szent István University
Páter K. u. 1., Gödöllő, H-2103, Hungary
Tel.:+36 28 522-080, E-mail: szabo.istvan@gek.szie.hu, katai.laszlo@gek.szie.hu, csomai.roland@gek.szie.hu

Abstract

In our research work we tested the conventional methods made moldboards.

Below the testing processes are presented, covering practical and mathematical applications. The used tools and the examined mouldboard will be presented. This article summarizes the objective and empirical results that can be gleaned from the results and conclusions.

Keywords

agricultural, 3D scanning, mouldboards, surface analysis, crop

Introduction

The mechanization of the agriculture was already significant from the end of the 19th century and this sector's technical development accelerated rapidly. Our topic's subject is the mouldboard which is an important component of the soil tillage plow. The mouldboard has got a special free surface. For editing these surfaces we have to use specified methods.

Modeling the surfaces or their numerical description is not as simple as the determination of an elementary geometry such as a description of a flat or a cylinder surface. However the editing of these multi curved surfaces can be divided into elementary geometrical sections. Before the appearance of the computer science, planning the mouldboard was based on handmade edits, then after finished the testing of the prototypes it was able to develop through experience.

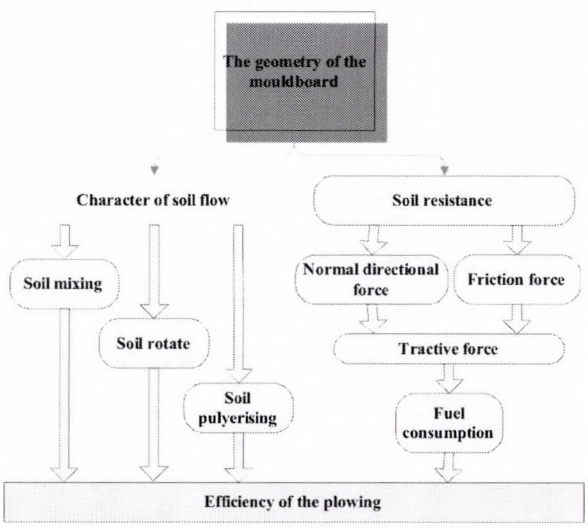


Figure 1. Effect of the mouldboard's geometry to the plow's efficiency

Nowadays with the high capacity computational background is not only possible to product a computing geometry, but testing the geometry of the mouldboard effect for the soil flow. The first picture represents the effect of the mouldboard's geometry to the plow's efficiency. All these requires to testing the geometry of the mouldboards. We made morphological tests in our own edits and geometric models, furthermore with digitizing the existing mouldboard we recognized the function of the definig parameters of the plow. Of imaging methods, the 3D laser scanning imaging method is used in the recent decades at testing the free surfaces after production. For the investigations we studied the preparation of the existing techniques than selected the most suitable system of tools and methods.

So the actuality of the topic is the research of the "old" conventional device with a "modern" geometric modeling tool.

Methods and materials

In our study we performed several practical measurements and scanning by different types of mouldboards, to lean on theoretical knowledge. The second figure demonstrate sub-elements of the research process in high scale.

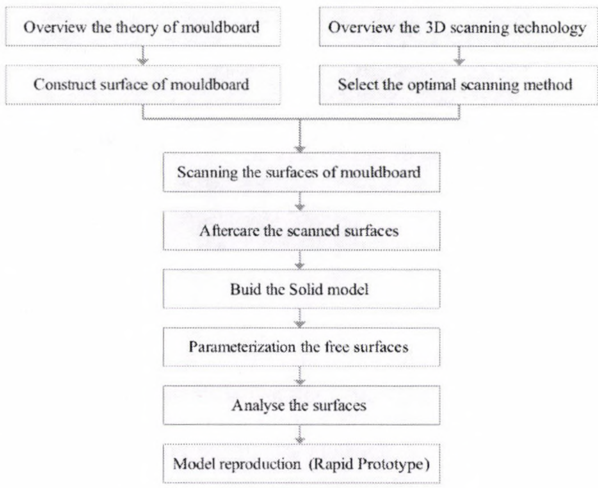


Figure 2. Sub-processes of investigation

Applied devices

To carry out the computerized testing was required to use a complex toolbox. In the process of digitalization we converted the analog signals to digital signals. In our researches we used several attributes, according to the current model. Besides the software's project files (*. stl) file extensions were used during the scanning and post productions. In the parametric editing system the CAD system's own (*. sldprt) extension was applied. For the math tests, determine the n-degree polynomials (*. obj) extension was used.

We used ZScanner 700 for the three-dimensional scanning of mouldboards, this can see upper. The laser scanner is a device which have two cameras, a laser unit and with an auxiliary light. This scanner can map digital surfaces with reference point. The device's accuracy is 50μm normal to the laser line and 100 μm parallel to laser. The scanner's available highest resolution is 0,2 mm.

As closing the research work, we prepared a real scale-model with a rapid prototyping manufacturing system. We used a ZPrinter 350 three-dimensional printer in this workflow, the third picture shows this device.

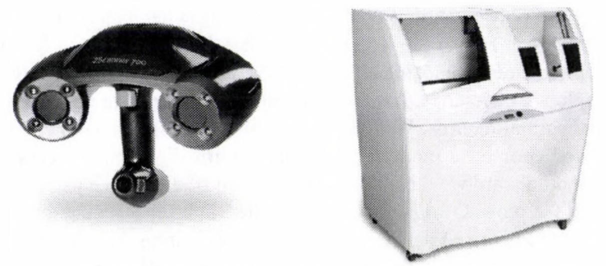


Figure 3. ZScan 700 and ZPrinter 350

Materials of the research

In our research work we tested four different kinds of mouldboards as is seems in the 4th picture. We were chosen for the tests the culture and the half-twisted mouldboards which are used in the Hungarian agriculture. These mouldboards are made by Kühne. The samples were old and new as well so we could observe the abrasion characteristics. We were digitized all the sample's surfaces, but we only defined the culture mouldboard's control curve.

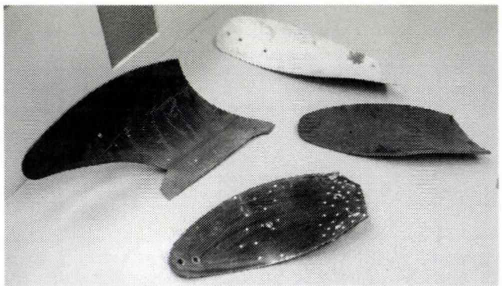


Figure 4. The four different kinds of moudboard

The topic and the main goals of the research could be recorded if we know the necessary tools and methods. The final result of the research work is not just the determination of numerical results, but also a development of the method itself and an automatable process.

Based on these the desired goals can be fixed in the following three points.

- The numerical description of the mouldboard's surface.
- Compare an edited and a digitised mouldboard's parameters.
- To discover the limits and possibilities of the 3D scanning.

Research

Our investigations can be divided in three parts. To editing and scanning the mouldboard and the determination of the control curve. During the editing we have done the necessary calculations to the determinate the constructional sizes. We were made these starting from basic and empirical data. The geometric model's construction was made in CAD system. With the standard editing we wanted to set up a reference next to the digitized mouldboard. We would like to demonstrate the authenticity of modeling with this.

Mouldboard editing

In the standard editing should clearly define the type of soil and the type of machining. The first table includes these parameters. The width and depth of the plowing determinate the mouldboard's necessary sizes. Each angle range determinate the plow's character of tillage, the measurement of the rotate and pulverising.

Table 1. Basic parameter for mouldboard editing

The plowing depth	a= 270 mm
The width of the plow	b= 350 mm
Angel between the plow and the furrow	α= 30°
The angel of the main component	γ_0= 42°
The last component angel	γ_t= 47°

The following three equation (1. 2. 3.) illustrate the necessary contexts for the basic editing illustrated in figure number 5..

$$h=\sqrt{a^2+b^2}=\sqrt{(270mm)^2+(350mm)^2}=442[mm] \quad 1$$

The "h" as a diagonal slice of the soil, determines the necessary height of the mouldboard.

To rotate a suitable piece of soil, an accurately created bending radius is needed. Therefore the minimal and maximal bending rays had to be determined with calculation. With the calculation on picture number 5 can be editing the mouldboard's projection of working surface.

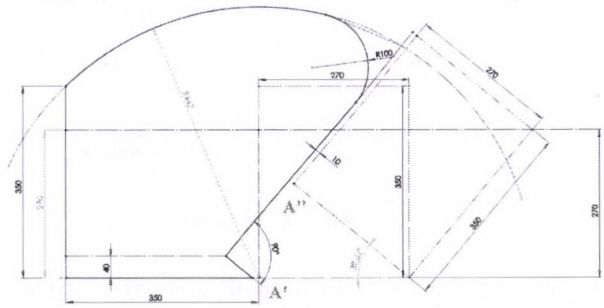
$$R_{\min}=\frac{b}{\left(\frac{\pi}{2}-\alpha\right)\cdot\cos\gamma_0}= \quad 2$$

$$\frac{35mm}{\left(\frac{\pi}{2}-0{,}52\right)\cdot\cos 42^\circ}=459{,}7\ [mm]$$

$$R_{\max}=\frac{b\cdot\sqrt{k^2-1}}{k^2\cdot\left(\cos\alpha-\frac{\cos\gamma_0}{\sqrt{k^2-\sin^2\gamma_0}}\right)}= \quad 3$$

$$=\frac{35mm\cdot\sqrt{1{,}4^2-1}}{1{,}4^2\cdot\left(\cos 0{,}52-\frac{\cos 42^\circ}{\sqrt{1{,}4^2-\sin^2 42^\circ}}\right)}=667{,}7\ [mm]$$

In the editing can be seen the case of dimensional editing the mouldboard's surface can be performed by two surfaces. The closed surface specify the mouldboard's outer contour, the opened surface forms the working surface with the control curve and assistant components.



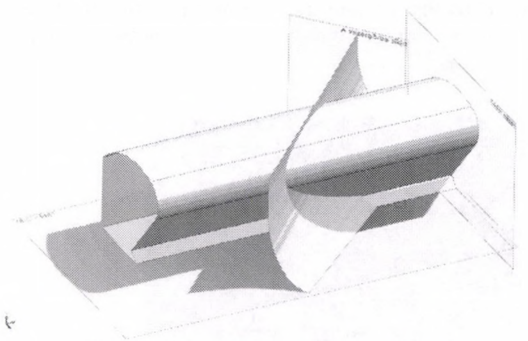


Figure 5. The edited culture mouldboard

Mouldboard scanning

The chosen mouldboards are made with the previously described editing procedures. Without documentation, the free surfaces with this digitizing procedure can be reconstructed in a unique way. For the digitalization the model's surface had to be matte, and had to be added the necessary reference points.

The model prepared by the laser scanner is build up from a point cloud in the first step, which can be converted to surface or solid models with the model-building steps used by Reverse Engineering as W. Wang (2011) describes it.

In picture number 6 there are four different kinds of mouldboard's rough surface. These are suitable for the production of solid models after the appropriate post production.

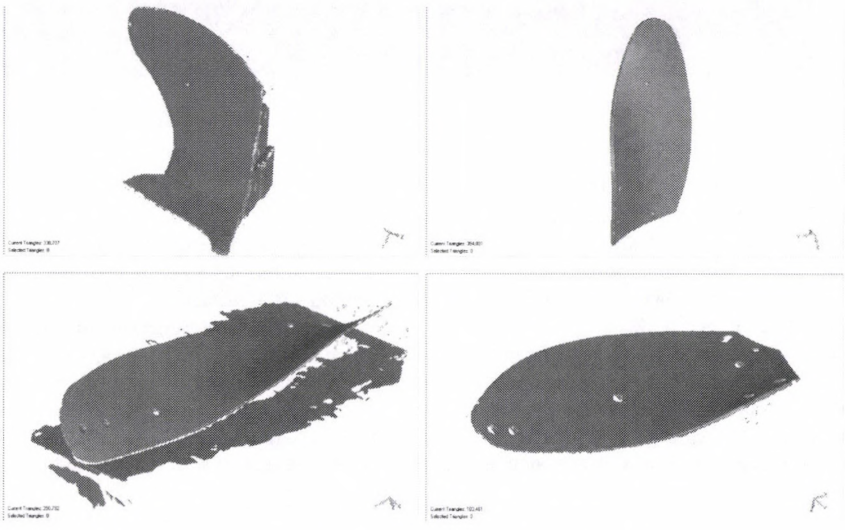


Figure 6. The four different kinds of scanned surfaces

There are not discussed the practical steps of scanning but it is important to note that the NURBS-based surfaces have been suitable from the triangulated surface models to product the relevant control curve. During the NURBS- based surface description each control points are special (W) which only locally influences the curve's editing. The rational based theory of the curve and surface description (P. Radhakrishnan, 2008) és (G. Farin, 2002) described as an interpolation, where the direction of continuous curves matching with weighted points.

$$P = (W_i X_i , W_i Y_i , W_i Z_i , W_i) \qquad 4$$

Control curve editing

Based on the mouldboard's control curve can define the mixing, rotating and pulverizing (Bánházi J., 1984). The assistant components are turning around the control curve. At the case of culture mouldboards according to the editorial principles the mouldboard is located at 2 / 3. The plain engraving created here, gives the line of the control curve. On the left side of the 7th picture there is the edited, on the right side there is the scanned mouldboard's control curve's point recording. As the mouldboards have got continuously curved surfaces, the control curve can be described with second instance polynoms.

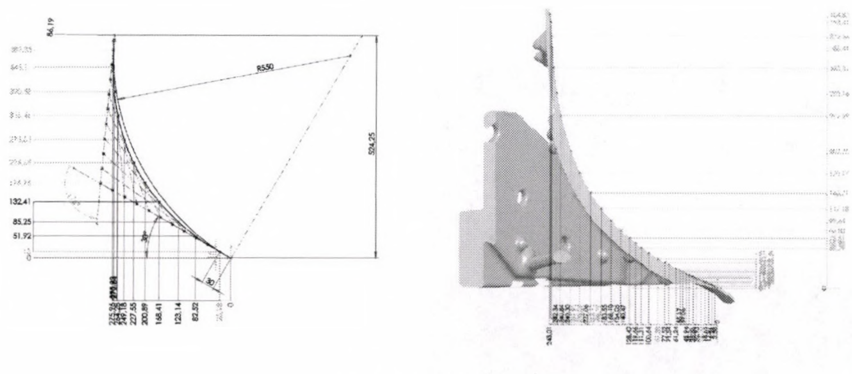


Figure 7. The point cloud

In the 8th picture are shown the polynomials are fitted to the points which are recorded in the surface. The diagram shows that the **horizontal** axis L (deepness of the parabola) and the **vertical** axis H (height of the parabola). When editing the mouldboard, the parabola of the control curve is characterized by with these parameters.

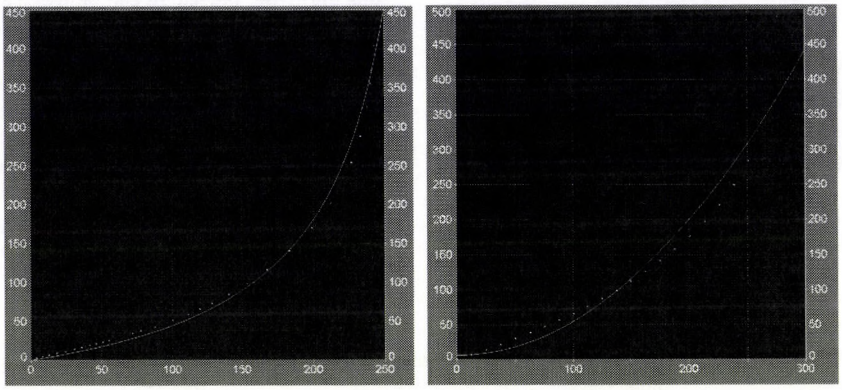


Figure 8. The control curves from scanned and edited mouldboard

To fitting the polynom we are using 100-100 points and 20 are control points all of these. The two following second instance equation shows that the two cultural designed surfaces can be characterized and comparable with their control curve.

Scanned: y = 0,00585x2 - 0,2548x + 0 R2 = 0,9653

Edited: y = 0,006x2 - 0,3x + 3,889 R2 = 0,9528

The differences of the deepness and highness suggests to the planned difference between depth and width of the plowing. The constant parameter of the equation describes the vertical axial position. With coordinate transformations both curve can fit to the 0, so depend on the y angle's rate of change comparable in the two cases.

Results

The test's objective results are the control curves describing second instance polynomials, equations. As we know the control curve the mouldboard become reproducible without documents and provide identification of export opportunities.

We proved the applicability of the digitization process with the similarity of the edited and digitized control curves of the mouldboards. The scanned control curve's: $y = 0,00585x^2 - 0,2548x + 0$ and the edited control curve's: $y = 0,006x^2 - 0,3x + 3,889$ character is similar.

For the mouldboards analysis and development we created a new modeling method during the test. Currently the system is able to semi-automatic process. A quick analysis is possible with it.

To complete the research work we created the digitized mouldboard's realistic model at M1: 5 scale, it can be seen in the 9th picture.

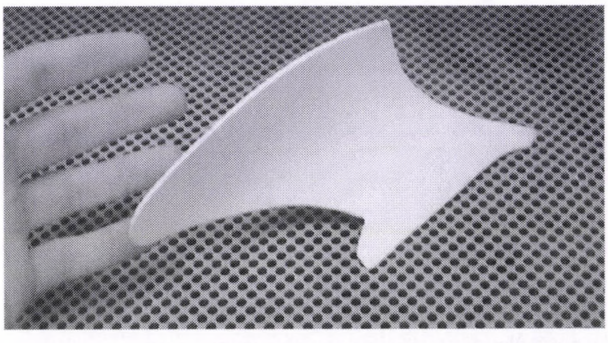


Figure 9. Scale-modell of the plow

Conclusions

This form of usage of the digitization process seems to be the optimal solution to product geometry of free surfaces like the mouldboard's surface.

The used method seems suitable to describe each control curves which is not a self-serving process, but also may be a well-written key for solving review and improvement problems. Taking this advantage it can be used during the operation monitoring and the abrasion rates are detectable along the surface. These mouldboards could be re-planable as the results of these improvements.

The further development of the used method could be the basis of optimization tasks based on genetic algorithm work surfaces.

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SAMPLING METHOD DEVELOPMENT FOR MEASURING TILLAGE INDUCED CO_2 FLUX

János Péter RÁDICS, István J. JÓRI
Department of Machine and Product Design,
Budapest University of Technology and Economics
Muegyetem rkp. 1-3., Budapest, H-1111, Hungary
Tel.:+36 1 463-3511, E-mail: Radics.Janos@gt3.bme.hu

Abstract

The concentration of greenhouse gases in the atmosphere has increased steadily since about 1850. From the 280 ppm concentration in the 19th century, the industrial activity raised this value by 30-35% to 380-400 ppm till now. A substantial part of the total increase so far has been attributed to deforestation, conversion on farmland, and other agricultural activities. There are many methods used by researchers to measure CO_2 flux after different tillage tools and methods. Our research is made to measure the effect of different tillage methods on the CO_2 flux from soil and to evaluate the effect of conservation tillage tools on CO_2 emissions. Beside of these the research aim is to exactly determine the CO_2 emission savings of conservation tillage methods and intelligent tillage machines.

Our research has shown that the use of the environment-oriented, mulch -tillage methods can play a major role in reducing of greenhouse gas emissions by increasing the rate of organic matter oxidation.

One of our objectives were to develop a reliable and method to measure the short and long term effect of different tillage methods on the CO_2 flux after tillage.

Introduction

Carbon dioxide flux from soil is an important factor in the increasing of the concentration of greenhouse gases in the atmosphere. Any increase in soil carbon has important benefits for the sustainability and productivity of the agro ecosystem. CO_2 is one of the most important greenhouse gases, because increase in its concentration causes about 50% of the total radiative forcing (Rodhe, 1990).

Improved agricultural practices have great potential to increase carbon sequestration and decrease the net emission of carbon dioxide and other greenhouse gases, but available information has not been synthesized in a form that policy makers and land managers readily can use to mitigate CO_2 emissions in relation to the potential greenhouse effect.

There is many literature data about the

Intensive agricultural production systems that include intensive tillage result in soil degradation and erosion that impacts soil, water, and air quality. The effects of conservation tillage and residue interactions on greenhouse gas fluxes and soil carbon should be evaluated. Soil scientists have studied the dynamic nature of soil carbon from an agronomic perspective, but not from an environmental context. Thus, more information is needed to advance the current understanding of how agricultural production systems can be modified to enhance environmental quality.

We need direct measurements to quantify CO_2 flux as affected by agricultural management practices. Information is needed on both the short-term effect of agricultural management decisions and the long-term effects, as they may affect global climate change. (Jori, 2004)

Limited measurements are available on CO_2 evolution immediately after tillage in the field. Gas fluxes were measured using closed chamber system. The atmosphere immediately above the soil surface is enclosed by the chamber and the change in concentration of CO_2 or N_2O one hour after closure is measured. This change is a result of net emission from the soil and enables gas flux to be determined, using both manual and automated closed chambers. (Jori et al., 2004) The manual chambers (Clayton et al., 1994.) were cylinders of diameter 0,4 m, pushed into the soil to a depth of 50 mm and with the head space enclosed with an aluminium lid. Gas samples were taken in syringes or aluminium sampling tubes and subsequently analyzed in the laboratory by gas chromatography.

The CO_2 flux from the tilled soil surfaces was measured using a large portable chamber described by Reicosky, (1990), and Reicosky and Lindstrom (1993). Measurements for CO_2 flux were initiated within 5 min of the last tillage pass. Briefly, the chamber (volume of 3.25 m^3 covering a horizontal land area of 2.67 m^2) with mixing fans running was moved over the tilled surface until the chamber reference points aligned with plot reference stakes, lowered and data rapidly collected at 2-s intervals for a period of 80 s to determine the rate of CO_2 and water vapor increase. After the appropriate lag times, data for a 30-s period was used to convert the volume concentration of water vapor and CO_2 to a mass basis then linearly regressed as a function of time to reflect the rate of CO_2 and water vapor increase within the chamber expressed on a unit horizontal land area basis.

Our former study has shown that the examination of only the short term influence of tillage on soil CO_2 emission can lead to faulty implications because it did not give enough information about all consequences of tillage operation. Analyzing the long term (Figure 1.) emission of soil CO_2 has shown that short (e.g.3-5hours) measurement data can be extrapolated to calculate long term emission data considering soil temperature, moisture content and tillage intensity.

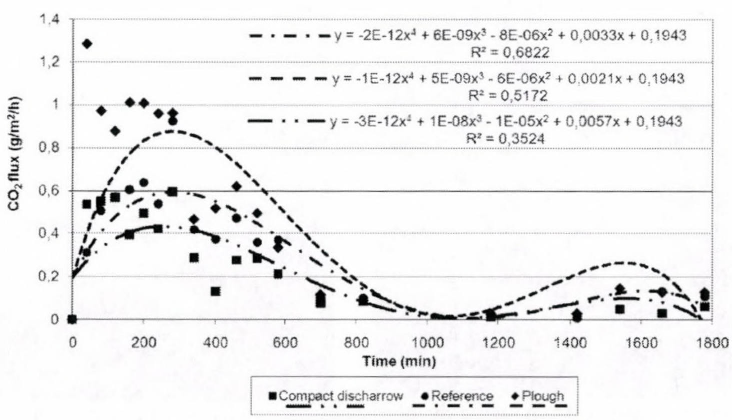

Figure 1. Long term (30 hour) emission of CO_2 after tillage

Studies in the past years were pointed on the importance of correct measurement techniques. The cumulative method, where the emitted CO_2 is collected for hours or longer in the same chamber covering the same area of soil surface, according to our measurements can change the natural environment of soil under the sampling chamber. (Rádics, Jóri 2006) Therefore to get correct result of the investigation the method with ventilated sampling chambers have to be used, where the chambers were emptied after each measurement and the sampling was followed on a new place on the test plot where the emission was unaffected before the measurement.

Earlier measurements have also shown that the measurements were more reliable by using chambers with larger basic area and higher volume-area coefficient. Therefore new sampling chamber have to be developed, to get an easy sampling method with more accurate result.

Materials and methods

The studies were made in county Somogy near Mesztegnyő (Table 1.). The first study was conducted on sandy sandy clay soil on wheat stubble in August 2011. The second study was initiated on clay soil on sunflower stubble in September 2011.

The measurement term was 4 hours, the sampling period was 15 minutes and started after the tillage operation immediately. Tillage treatments were done with middle-deep loosener and field cultivator.

The air CO_2 concentration and temperature was measured and registered before every cycle, to determine the exact value for soil CO_2 flux characteristics.

The influence of tillage on soil CO_2 evolution was assessed by recording two series of successive measurements. Each series included a pre-tillage measurement to assess „reference" flux uniformity, followed by two different past-tillage measurement to compare fluxes along tilled and undisturbed plots. The sampling was made on the plot by random settlement.

Soil CO_2 flux was measured in situ using the calibrated TESTO 535 CO_2 tester. We used 8 litre polyethylene sampling chamber (chamber ID:C02) as by the initial studies in early years (Figure 2.). The result of the earlier studies have shown that the measurements are more reliable using chambers with larger basic area and higher volume-area coefficient, therefore a new chamber (chamber ID:C03) was developed (volume:27 litre) (Figure 3.). Due to the larger volume and height of the sampling chamber, homogenization of the gas content was required. Therefore integrated ventilators with low air flow were applied. To isolate the examined area the frame of the sampling chamber was 5cm deep inserted into the soil.

To validate earlier years experiences the former cumulated method was also used, to compare the results of the new chamber with the earlier results. The validation of the new chamber was made also by the ventilated method where the chambers were emptied after each measurement.

Table 1. Site and treatment specification

No.	Operation/ Date	Weather condition	Machine	Working depth, cm
1.	Primary tillage on wheat stubble 08.09.2011	Dry, sunny, 28-31°C	Middle-deep loosener	38-42
2.	Stubble mulching on sunflower stubble 09.17.2011	Dry, sunny, 25-28°C	Field cultivator	14-16

Figure.2 TESTO 535 CO_2 tester and "C02" portable chamber

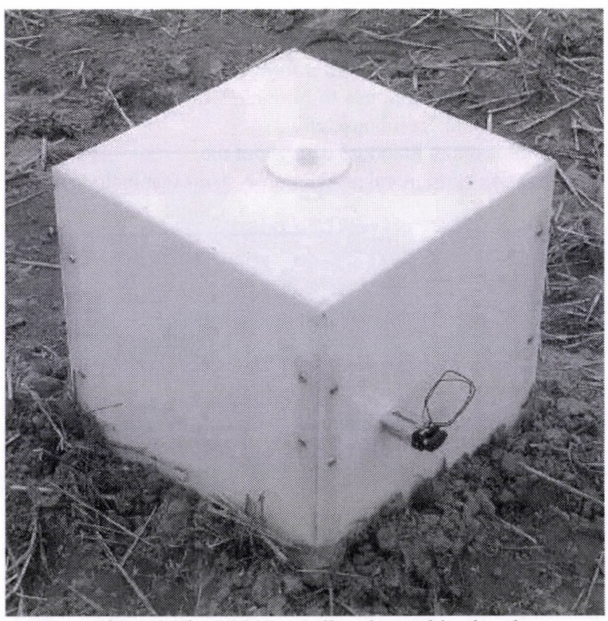

Figure3 The "C03" ventilated portable chamber

Fig.4 Middle-deep loosener

Fig.5 Field cultivator

Result and discussion

Evaluation of the trends of measured data has shown that the results are identical with the former research. The emitted CO_2 in the first study was higher than in the second one, because the research was made in summer with high temperature (28-31°C) on loosened field (Figure 4.) and at lower temperature (25-28 °C) on cultivated field (Figure 5.), which is a less intensive treatment.

The deviation of the average of data getting from C02 and C03 chambers (Figure 6-7.) is smaller than the deviation of data getting from C02 chambers. Furthermore the average of the deviation of data getting from C03 is more smaller than the getting one of C02.

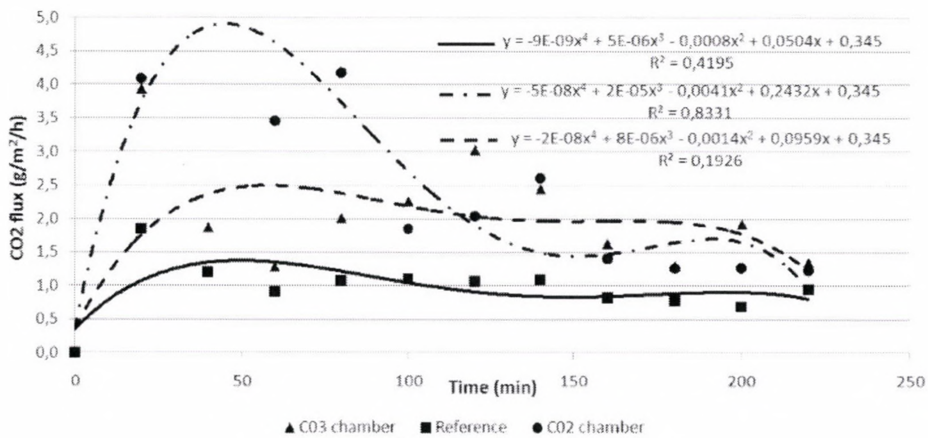

Figure 6. Results of the first study (loosener)

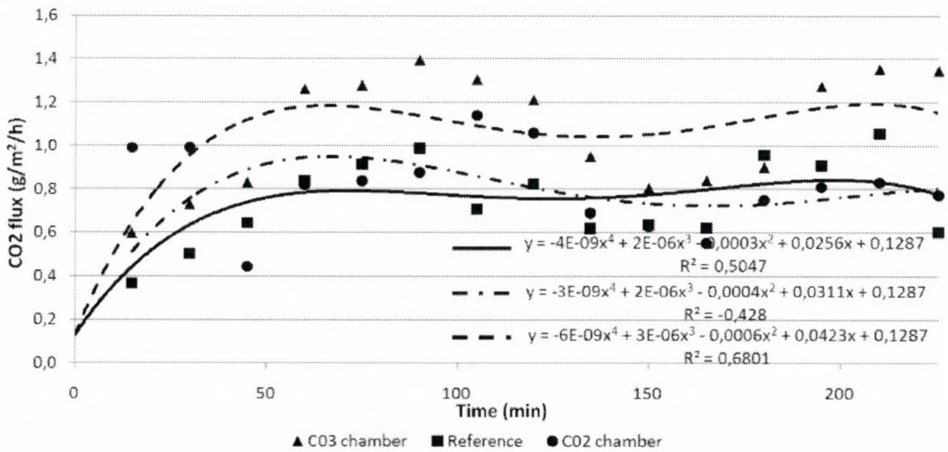

Figure 7. Results of the second study (cultivator)

In order to compare the result of early research to the new one we have done measurement also with the C03 chamber using the cumulative method. Based on the result of former study it can be stated, that the cumulative method is usable to compare the effect of the different tillage operation only.

There is an advantage of cumulative method, that not necessary to empty and resettle of chambers in the case of comparison of different tillage operations. Using this method the time consumption can decrease significantly and the number of measurement can increase as well.

The getting result has shown, that the reliable measurement time of C03 chamber can be longer with 50% using the cumulative method than the C02 one As a result of new system the comparison of different operations can be done more accurate.

Conclusions

There is a great need to determine exactly the amount of tillage induced CO_2 loss of different tillage practices. Investigated the results, the study has shown that the new developed sampling chamber is suitable to determine adequate soil CO_2 emission of different soil types and treatments.

The evaluation of data has shown that the C03 chamber provides more reliable result, because this chamber with the cumulative method can be used for a longer time.

Further studies should be done with the C03 chamber to have enough information to determine correctly the CO_2 savings of conservation tillage methods.

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ANALYSIS OF ANIMAL HOUSING SYSTEMS IN TURKEY

I. OZTURK[1], H. I. YILMAZ[2], H. B. UNAL[1], R. C. AKDENIZ[3]
[1]Ege University, Faculty of Agriculture, Department of Agricultural Structures and Irrigation, Izmir/Turkey
[2]Suleyman Demirel University, Faculty of Agriculture, Department of Agricultural Structures and Irrigation, Isparta/Turkey
[3]Ege University, Faculty of Agriculture, Department of Agricultural Machinery, Izmir/Turkey

Abstract

Turkey has 11 million cattle and 27 million small ruminants according to the statistical data of 2009 which indicate high livestock production potential. Extensive applications are common throughout the country on dairy and beef cattle and also sheep and goat farming. Problems related to poor structural properties of animal shelters and failed to control of environment make negative effects on these farming applications. But in recent years with the increasing of the promoting livestock of the state, semi-intensive and intensive applications have become widespread. Although modern shelters are being built in these new farming applications, some design failures are caused the adverse effects on the animal welfare and hence animal production. Furthermore, manure management practices in big capacity farms have gained great importance in terms of human and animal health and also environmental control. Accordingly, buildings and facilities related to evolution of manure as biomass became a current issue in livestock farming systems.

In this paper, animal housing systems on cattle and small ruminant farming in Turkey were examined in terms of structural aspects. In this context, housing systems, milking systems and manure management structures and facilities were analyzed according to the structural design and mechanization. This analysis focused on the factors related to animal shelters to be taken into account for successful and sustainable livestock farming.

Keywords

Barn, shelter, manure management, mechanization.

Introduction

Turkey has especially suitable natural resources and ecological conditions for the production of cattle, sheep and goats; in the year 2009 it had 11 million cattle and 27 million sheep and goats (TUIK, 2011).

Stress originated by various factors can cause a reduction in productivity in animals by slowing down vital functions. The sources of such stress are principally climatic, physical and social factors. Of these, climatic stress can affect animals adversely through the climatic conditions under which they are housed, while stress from physical and social factors is directly related to the physical planning and design of the housing environment Moreover, the type of planning and design has a direct effect on the creation of climatic conditions both within the housing and in additional structures (Ugurlu and Uzal, 2004).

Even though the genotype of the animals is very good, if the housing design and the environmental conditions where the animals are living are not suitable, productivity can never reach the levels desired. The main factors affecting animal productivity are 30% genetic and 70% from feeding, housing and environmental conditions (Can et al., 2010). Research in this topic has shown by observation and examination that optimum productivity can be obtained in animal housing constructed and operated by taking into account project criteria, local conditions where the housing is constructed, and the type of animal rearing (Can et al., 2010; Bardakcioglu et al., 2004; Unal and Yilmaz, 2006).

As well as increasing animal productivity in the short term by arranging environmental conditions at optimum levels, an improvement in productivity can be obtained in future generations by improving the animals' genotype. For this reason, suitable environmental conditions must first be ensured in housing in order to understand the animals' genetic capabilities (Hellickson and Walker, 1983; Can et al., 2010).

Taking all of the above into consideration, it can be clearly seen that the type of design is of the utmost importance in the planning of animal production structures in order for production performance to be high and for a productive operation.

In this study, an analysis is made of housing systems recently constructed in Turkey for cattle, sheep and goat production. Housing, milking systems and waste management setups are evaluated with regard to structure and mechanization. At the same time, elements which should be taken into consideration in housing systems for successful and sustainable animal rearing are considered.

Cattle farming

Turkey has a pattern of agriculture mostly based on small family farms using mainly extensive production techniques. In this way, cattle farming are generally small-scale, and housing planning takes little account of local and climatic conditions. Farms with this kind of animal housing have significantly low productivity and cannot attain efficiency in feeding, milking and hygiene. In order to overcome these problems, a solution must be found to planning and infrastructure problems on these farms (Kaygusuz and Tumer, 2009; Can et al., 2010).

Structural characteristics for dairy cattle housing in the seven different regions of Turkey were determined in researches in recent years. The results are summarized in Table 1. In the most of the farms in research areas are closed type (76%) and have tie barn systems (67%).

In Turkey in general, closed and tie barn system is not recommended for dairy farming. In this type of housing in particular, problems emerge such as the inability to ensure environmental control or to make use of mechanization. A more suitable solution would be housing which would protect the animals from heat and the sun in summer and merely from rain in winter according to local conditions, and be constructed on an open or semi-open plan from light materials and orientated according to the prevailing winds of the area. This would be more suitable from the point of view of both production and economics. Such housing would provide advantages not only in terms of hygiene, animal health, nutrition and labor costs, but also in the costs of construction (Bardakcioglu et al., 2004; Uzal and Ugurlu, 2006; Kaygusuz and Tumer, 2009; Can et al., 2010).

Many studies have found that not enough use is made of mechanization for waste disposal in Turkish cattle farming, and that especially in enclosed housing where animals are kept standing and tethered and cleaning is carried out by means of a shovel and wheelbarrow, labor requirements are increased. It has also been found that in the various regions of Turkey, little consideration is taken of necessary conditions in the choice of location for animal housing. It has been established that on this kind of farm, mistakes are made in the choice of location for animal housing, buildings are not located in a convenient way in the farm yard, and ancillary facilities, especially those for the storage of liquid and solid waste, have been neglected. It was found that in the choice of location, construction and operation of manure storage facilities, no account is taken of their capacity and distance from human habitation or of prevailing wind direction and rainfall as set out in national standards. Manure is generally stored directly on the ground and uncovered in farms which do not have a manure pit, causing problems such as seepage of the liquid in to the soil, disease, smell, and flies. It is stated that the animal housing on most of such farms is located within the farm yard and adjacent to human dwellings. The places where solid and liquid waste is stored are usually next to the animal housing, and it was emphasized that these manure heaps are very close to neighboring farms and that they caused environmental problems. It was found that haphazard manure storage had adverse effects on human and animal health (Akdeniz, 1984; Ucak et al., 2000; Bakir, 2002; Bardakcioglu et al., 2004; Karaman, 2005; Atilgan et al., 2005a, 2005b and 2006; Yaslioglu and Arici, 2005; Onal and Ozder, 2008; Ozturk, 2009; Kaygusuz and Tumer, 2009; Can et al., 2010). For this reason, there is a need for modern manure management practices and structures for the disposal and storage of waste and for its exploitation as biomass.

Table 1. Structural Characteristics of Cattle Housing in Dairy Farms in the Various Regions of Turkey as Determined by Different Researches

Research Area	Structural Characteristics of Cattle Barns				Reference
	Construction Type		Housing System		
	Closed (%)	Open/Semi-open (%)	Tie Barn (%)	Loose/Free Stall system (%)	
Van	100	0	100	0	Bakir, 2002
Aydin	48.7	51.3	30.3	69.7	Bardakcioglu et al., 2004
Tokat	100	0	100	0	Karaman, 2005
Bursa	78.8	21.2	42	58	Yaslioglu and Arici, 2005
Tekirdag	91	9	91	9	Soyak et al., 2007
İzmir	11	89	8	92	Ozturk, 2009
Giresun	100	0	100	0	Tugay and Bakir, 2009
Average	76	24	67	33	

It was found that, in contrast to the insufficient mechanization in waste management, mechanization is employed in milking on the majority of farms. However, efficiency has not been achieved in milking due to structural problems in housing (Onal and Ozder, 2008; Bardakcioglu et al., 2004; Can et al., 2010).

In the past few years, various types of government support for animal rearing has enabled the establishment of large-capacity intensive animal-rearing operations, in particular those with 1000 or more cattle with up-to-date housing construction with air-conditioning and the intensive use of mechanization in milking and manure management. These kinds of farm contribute to the national economy in terms of animal production. However in the barns constructed beyond the control of agricultural engineers; some designing faults are observed such as inappropriate barn construction type and dimensioning of structural elements incorrectly.

Sheep and goat farming

Animals like sheep and goats are generally kept in covered or open pens to protect them from the weather and from attack by wild animals. Housing should take account of animal welfare as well as environmental considerations and production systems. In providing these conditions the economy of animal housing at farm level and the nature of the animals should not be ignored (Taskin et al., 2010).

The type of housing for sheep and goats will vary from one country to another and even from one region to another in accordance with factors such as the purpose of the animal rearing and the season when the animals give birth. For example, if births take place under harsh climatic conditions more sheltered housing construction will be needed, but if it takes place in the grazing season, more elaborate construction will be required (Dawkins, 2004; Caroprese, 2008).

In research examining sheep and goat farming in the various regions of Turkey, it was found that pens used as animal housing were usually basic structures not conforming to planning criteria, or that on some farms sheep were kept on the ground floor of two-storey buildings or mixed in with cattle. It was found that pens were mostly of the covered type, that building construction in certain areas was similar, and that some pens were still constructed from mud brick. Most housing had serious constructional problems from the point of view of planning criteria. Also it was stated that sufficient account had not been taken of the necessary planning principles in the construction of the pens, and that none of the buildings constituting the animal housing followed the necessary principles relating to location and planning. It was pointed out that there were great shortcomings and errors in the design of pens and buildings used as animal housing, which made it impossible to provide animals with the right environmental conditions, thus adversely affecting productivity and thereby profitability (Unal and Yilmaz, 2009; Sisman et al., 2009; Kocaman and Gunal 2007; Paksoy et al., 2006). Determined structural features of pens in some regions of Turkey are summarized in Table 2. The majority of the pens (71%) in the research area are closed type. In such pens construction costs are increases and also difficulties have been encountered in ensuring a successful environmental control.

Sheep and goat farming in Turkey especially for small enterprises is generally carried out in an extensive or semi-intensive way. This type of farm generally has poorly-constructed pens or similar buildings as animal housing. In order to ensure efficiency and profitability in these farms, providing appropriate environmental conditions and modernization of the pen systems has great importance. In recent years, through government support for animal rearing, large-capacity commercial enterprises established more modern pens. Mechanization and environmental control are better in these shelters. However some designing faults are encountered adversely affecting the construction cost and animal welfare.

Table 2. Structural Characteristics of Pens in the Various Regions of Turkey as Determined by Different Researches

Research Area	Pen Type		Reference
	Closed (%)	Open (%)	
Bolu	67	33	Sisman et al., (2009)
Tekirdag	55	45	Kocaman and Günal (2007)
Kahramanmaras	91	9	Paksoy et al., (2006)
Average	71	29	

Conclusion

In Turkey, especially on farms which practice traditional family animal-rearing, animals are kept in housing which is constructed without proper regard to local and climatic conditions, in conditions which are detrimental to animal welfare and which cause conditions of stress. Shelter constructions are usually closed type and have a heavy construction which is unnecessary and has designing faults.

It is well-known that every extra investment spent on housing construction is repaid with an increase in productivity. For this reason, it is necessary to examine in detail before commencing construction factors such as the number of animals to be kept on the farm, the planning of animal productivity and production, physiological needs, the necessary amounts of equipment and its technical characteristics, and local geographic and climatic conditions in order to reap the expected economic benefits from the housing.

Therefore instead of the traditional structures in the construction of shelters, constructions designed to ensure a successful environmental control is needed.

On the other hand, it is to be noted that participation in various kinds of organizations such as cooperatives and associations is increasing and that with the help of these organizations the level of use of mechanization in such operations as waste cleaning, and recognition of the need for such housing provisions as separate birthing areas has also increased.

To overcome the designing faults, farmers should cooperate with agricultural engineers and universities in the beginning phase of the project. In this context, through cooperation between cooperative or organizations related to animal husbandry and universities, developing of suitable shelter designs for the region is needed. Application of these projects by the members of the organizations will provide significant contributions to sustainable livestock farming.

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COMPREHENSIVE ASSESSMENT OF FUTURE ENERGY NEEDS AND THE ROLE OF ALTERNATIVE ENERGY SOURCES

Sándor MOLNÁR, Márk MOLNÁR, and Anita CSÁBRÁGI
Department of Informatics, Szent István University
Páter K. u. 1., Gödöllő, H-2103, Hungary
Tel.:+36 28-522-000,
E-mail: Molnar.Sandor@gek.szie.hu

Abstract

In this paper the potential future energy demand is evaluated based on the newest results, and is matched with our available energy reserves. Emphasis is placed on the possible role of biofuels and non-conventional fossil energy sources, which among others, include shale gas, tar sand, oil shale, and methane-hydrates. The concept of energy return on energy invested (EROI) is briefly presented to provide a methodological background for comparative assessment of different energy sources, and a comparison is given for the respective energy sources. Afterwards the energetical potential of non-conventional energy sources is assessed by their availability and other characteristics.

Keywords

energy supply, alternative energy sources, renewables

Introduction

Growing global energy needs and the oil production peak

Evolution of future energy demand shows rising tendency according to various forecasts (IEA, EIA, Shell). The future energy mix incorporates significant amount of fossil energy sources, thus underlining European energy dependence. According to a wide range of renowned experts a serious plunge in oil supply and/or soaring energy prices is expected in the near future. This is of key importance, as crude oil is the most important energy source in a global perspective. About 35 percent of the world's primary energy consumption is supplied by oil, followed by coal with 25 percent and natural gas with 21 percent (WEO, 2010). Transport relies to well over 90 percent on oil, be it transport on roads, by ships or by aircrafts. Therefore, the economy and the lifestyle of industrialised societies relies heavily on the sufficient supply of oil, moreover, probably also on the supply of cheap oil (Molnár M., 2010). Fig. 1. demonstrates the growing gap between existing crude oil reserves and reserves yet undeveloped or not explored.

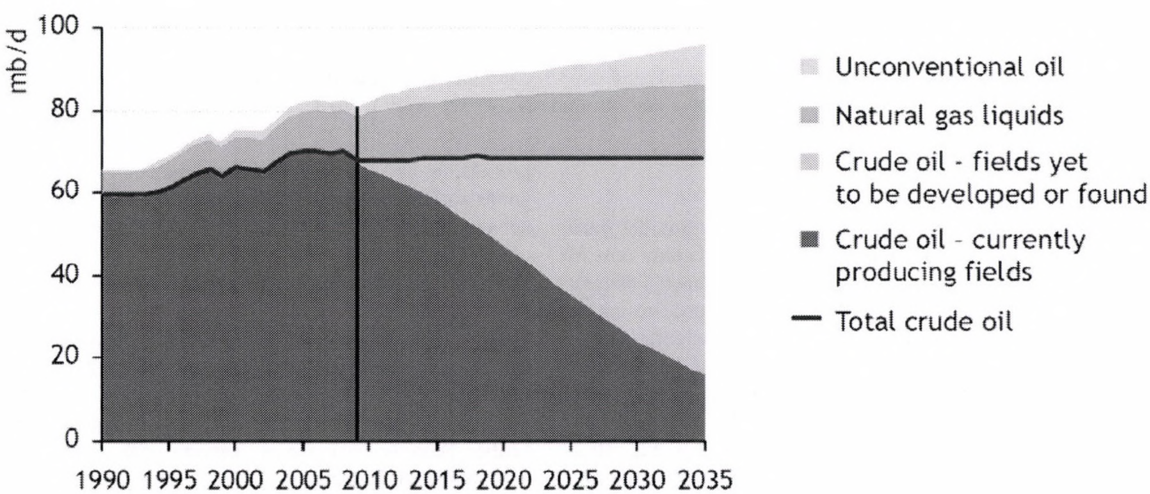


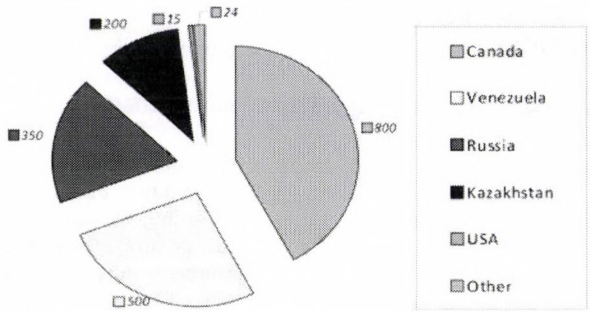
Figure 1. World oil production by type, source: WEO, 2010

Thus, there is a growing market demand towards alternative sources of energy. Renewable and non-conventional energy sources can provide an alternative, yet the extent they can enter the picture is not clear.

What is unconventional oil?

No simple definition exists, however one can define unconventional oil either based on its API gravity, or its geological setting in its reservoir. Here we follow the IAE's definition, which simply enlists these resources as bituminous and extra heavy oils from Canada, Venezuela, or oil shales and distillations from coal-to-oil and coal-to-gas processes. The common attribute of these fossil sources is that unconventional oil resources are huge, multiple times larger than conventional resources, but projects require large upfront capital investments, and expected greenhouse gas emissions are higher per barrel produced on a well-to-wheels basis. The overall scale of bituminous and heavy oil resources exceed 1900 billion barrels in terms of ultimately recoverable resources (as a comparison, the estimated oil consumption of mankind to date is in the range of 1000 billion barrels). Fig. 2a-2b. presents the breakdown of these resources per country.

As it is clear from the above, unconventional oil can play a significant role in providing for future energy demand. Yet, as with oil shales and oil sands the environmental costs can be significant: land and water usage plays a key role in projects. This underlines the relatively slow evolution of expected production trend, show for oil shale in Fig. 2b.



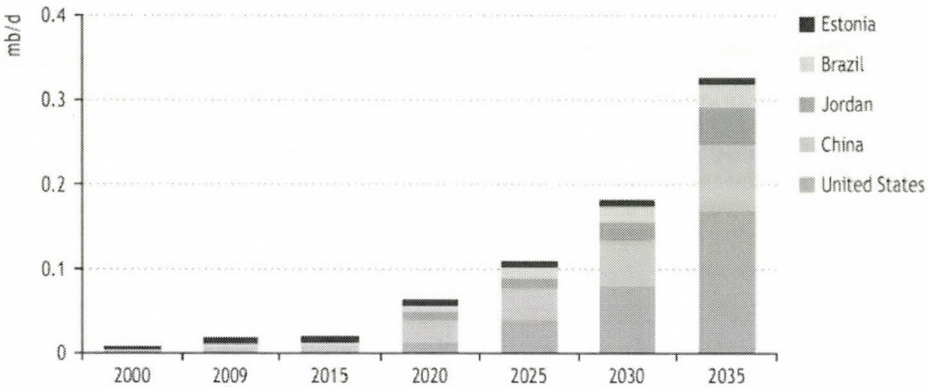


Figure 2a-2b. Reserves in billion barrels and expected production trends of unconventional oil resources (extra heavy and bituminous), source: WEO, 2010

Definition of eroi

For an energy process to be feasible, the energy it provides must be higher than the energy it requires. When the energy cost of recovering a barrel of oil becomes greater than the energy content of the oil extracted, production will be discontinued, no matter what the monetary price may be. This requires the definition of the "energy cost" of energy, and the introduction of the so-called EROI (Energy Return on Investment, Cleveland et al., 1984; Cleveland, 2005). In short, the EROI is defined as the ratio of the energy that is obtained as output of a given energy extraction process to the total energy that is invested for its extraction, processing, and delivery, including the energy embodied in the goods and machinery used. The lower the EROI, the smaller the net advantage provided by a given energy source.

Biofuels and concerns of energetical returns

Fossil sources provided high EROI's in the past, up to 100:1, but values have been declining down to the present 20:1, as shown by Cleveland (2005), due to the exploitation of the most favourable and higher quality fossil reservoirs, and are expected to decrease further. Table 1a-1b. gives an overview of the energetical benefit of certain energy sources.

Table 1a. Energetical return on energy invested for various energy sources, source: theoildrum.com

	EROI (v:1)	*Year*		*EROI (v:1)*	*Year*
Oil and Gas	>100	1930	**Hydropower**	>100	n/a
Oil and Gas	30	1970	**Wind turbines**	18	n/a
Oil and Gas	11-18	2005	**Geothermal**	n/a	n/a
Global oil production	35	1999	**Tidal energy**	n/a	n/a
Natural gas	30	2005	**Flat Plate Solar**	1,90	n/a
Coal	80	1950	**Concentrating Collector Solar**	1,60	n/a
Coal	80	2000	**Solar PV**	6,80	n/a
Bitumen from Tar Sands	2-4	2008	**Ethanol (sugarcane)**	0,8-10	n/a
Shale Oil	5	2008	**Corn-based ethanol**	0,8-1,6	n/a
Nuklear	5-15	2008	**Biodiesel**	1,30	n/a

Table 1b. Efficiency of biomass usage in biofuel production, source: Pimentel, 2008

Energy efficiency	Corn	Sunflower	Wood
Energy output/(direct and indirect) energy input for substrate	3.82	2.59	4.24
Energy output/(direct and indirect) energy input for biofuel	**Ethanol**	**Biodiesel**	**Methanol**
(a) Use of residues as energy source, credit for feedstock	1.5	1.21	(*)
Net-to-gross energy ratio	**0.33**	**0.17**	(*)
(b) Use of residues as energy source, no credit for feedstock	1.15	0.98	1.1
Net-to-gross energy ratio	**0.13**	**<0**	**0.09**
(c) No residues as energy source, credit for feedstock use	0.65	1.51	(*)
Net-to-gross energy ratio	**<0**	**0.34**	**(*)**
(d) No residues as energy source, no feedstock credit	0.58	1.16	(*)
Net-to-gross energy ratio	**<0**	**0.14**	**(*)**

As the above figures show, there is a large extent of uncertainty coupled with biofuels. Table 1b. shows very alarming results from a compilation of a biofuel assessment study (Pimentel, 2008). The analysis shows that biofuels are, essentially, not yet a viable alternative based on economic, energy and environmental aspects. The constraints are not simply technological, but also based on the large scale consequences of biofuel programmes, although improved efficiency in the conversion process and reduced use of fossil fuels in agricultural production might slightly improve the present figures. In particular, when crop production and conversion to fuel are supported by fossil fuels in the form of chemicals, goods and process energy, the fraction of the fuel energy that is actually renewable (i.e. the net energy available) is negligible. On the other side, if a fraction of the biofuel is fed back to the process, in order to make it independent of fossil fuel inputs, the demand for land, water, fertilizers and labour is amplified accordingly, thus increasing the competition with other uses for the same resources. In fact, the growing population of the planet, coupled with the demand for better nutritional quality in developing countries is likely to increase the demand for water and high quality land, even without cropping for energy. Similarly, the decrease of carbon dioxide emissions per unit of fuel delivered is negligible when the process is supported by biofuels in alternative to fossil inputs. For these reasons, biofuels should not be regarded as a contribution to the solution of the problems related to Europe's strong dependency on fossil fuels. In fact, fossil fuels are used in all phases of the biofuel production chain, with the consequence that the energy yield is very low. Therefore, the real fossil fuel savings of a large scale biofuel production, the reduction of the anthropogenic greenhouse emissions and the increase of energy security would be very modest.

Conclusions

Future challenges of energy supply can be met in many alternative ways. There are nevertheless portentous signs that the unconventional oil production can bring about significant environmental harm if undertaken on a large scale. Examining biofuel production, the disadvantages of a large scale biofuel production in terms of land requirement, environmental impact (deforestation, loss of wild and agricultural diversity, over use and contamination of water, etc.) and economic impact (increase in the price of cereals) would be relevant. Pessimistic though the present situation may sound, a margin of hope remains in the advent of second-generation biofuels derived from ligno-cellulosic biomass as these are expected to raise the energy yield by almost one order of magnitude.

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