7th International Workshop for Young Scientists

BioPhys Spring 2008

Prague, Czech Republic, May 29-30, 2008

BPS

BOOK OF ABSTRACTS

Czech University of Agriculture
Praque, Czech Republic

Institute of Agrophysics Polish Academy of Sciences
Lublin, Poland

Slovak University of Agriculture in Nitra,
Slovak Republic

Szent Istvan University
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Visegrad Fund

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The purpose of the Fund is to promote development of closer cooperation among the V4 countries through supporting common cultural, scientific and educational projects, exchanges between young people, cross-border cooperation and tourism promotion.

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SCIENTIFIC BOARD

ORGANIZATION BOARD

INTRODUCTION

Dear friends and colleagues

This year, on May 29-30, 2008 the seventh BiopPhys Spring will be organised at our University. We will continue the previous tradition and open the workshop on these simple rules:

- two day workshop without social programme and free of fee
- open to young scientists up to age 35 year who will be able to present their results in Biological Physics and/or in Life Sciences using the physical methods as an important mean
- in English
- on 29 - 30 May, 2008 at Technical faculty of the Czech University of Life Sciences in Prague, Czech Republic
- the contributions could be submitted for publication in: *International Agrophysics, Research in Agricultural Engineering,* and/or *Scientia Agriculturae Bohemica*

It is my pleasure to invite you to our University Campus in the late days of May 2008. I think that I can express the same feeling of our co-organizers of this workshop:

Institute of Agrophysics of the Polish Academy of Sciences, Lublin, Poland
Department of Physics, Slovak University of Agriculture in Nitra, Slovakia
Department of Physics and Process Control, Szent Istvan University, Hungary

Otherwise, be sure that we all, the members of the Scientific Board and the members of the Organizing Commitee, are looking forward to our meeting here.

November 16, 2007

Jiri Blahovec
Chairman of the Scientific Board

LECTURES

WATER SORPTION IN FOODS AND AGRO-PRODUCTS

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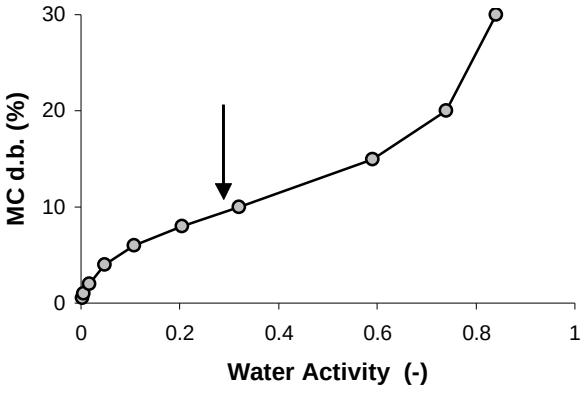
Moisture content of foods and agro-products plays important role in the foods and agro-products storing. Practical experience with storing the real foods and agro-products shows that rather the water activity than the moisture content plays controlling role in storing those products. Especially quality and shelf life of the products that are stored in a defined dried state are predetermined by their water activity. This conclusion is right in relation to both the main sources of the product deterioration, the microbial and enzymatic ones (Karel, 1975). On the other hand the water activity is influenced not only by a product structure and its water content but also by its temperature. These facts are the main sources of the high importance of the relations between moisture content and the water activity (and/or water potential) at constant temperature – i.e. the sorption isotherms.

The sorption isotherms are very variable in shape but the details of their shape influence strongly the product properties. This property stress attention of scientists to details of the sorption isotherms theory. The sorption isotherms are usually classified into five classes, but the agricultural and food products are usually described by typical sigmoidal type (type II of Brunauer's classification) with characteristic point of inflexion – see arrow in the figure.



For this type of sorption isotherm the following theoretical equations are used:

BET isotherm (Brunauer-Emmet-Teller -Brunauer, 1943) with two parameters based on multilayer surface sorption that is represented by the following equation:

$$\frac{a_w}{w(1-a_w)} = \frac{1}{w_m C} + \frac{C-1}{w_m C} a_w$$

where w is moisture content (d.b.), a_w water activity and C and w_m parameters. The C denotes strength of water bonds to the product surface whereas w_m denotes the MC corresponding to the formed surface water monolayer.
GAB isotherm (Guggenheim-Anderson-de Boer, Van den Berg, 1984) three parameter generalization of BET isotherm taking into account binding of non-monolayer water:

$$w = \frac{w_m (C-1) K a_w}{(1 - K a_w + C K a_w)} + \frac{w_m K a_w}{(1 - K a_w)}$$

with the same parameters as BET isotherms and new scale parameter K with values from interval (0, 1). It could be shown that the parameter C has to be higher than 2 for the isotherms with the point of inflexion and between 1 and 2 for the isotherms III of the Brunauers classification (Blahovec, 2004).
HH isotherm (Hailwood-Horrobin, Hailwood and Horrobin, 1946) four parameter equation based on monolayer surface sorption combined with solution sorption:

$$w = w_m a_w \left(\frac{1}{a_1' + a_w} + \frac{1}{a_2' - a_w} \right)$$

where w, a_w and w_m have the same meaning as in two previous equations and a_1‘ and a_2‘ are further two parameters.

Two components on the right side of H-H sorption isotherm can be understood as portions of water bound in the product due to surface sorption (the first component corresponding to the Langmuir’s isotherm of sorption into the monolayer) and product due to solution sorption (the second component corresponding to the generalized Raoult’s law). We can then speculate about so called superposition of different sorption sources in the product in some cases constructing new sorption isotherms under the following rule:

$$w(i.e.\ \ moisture\ \ \ content\ \ \ d.b.) = \sum w_i$$

where w_i are moisture components of different sorption origin. Of course when we take into account more exact and then more accurate sorption model, we will obtained more parameters that necessary to be under control in more complicated analysis. In some cases the superposition assumptions can lose their force and the cross-interaction terms have to be taken into account.

ACKNOWLEDGEMENTS

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MULTI-COMPONENT MODELLING OF ALFALFA DRYING

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During artificial drying of alfalfa the water concentration of leaves falls faster than that of stems as because of their different drying characteristics. It implies that applying the intermittent drying technology is beneficial to avoid large differences between the water concentrations of stems and leaves and so the quality degradation. In this paper a multi-component procedure is shown for alfalfa drying using the results of a physically-based modelling approach. The modelling should take into account the differences in the physical properties between stems and leaves of alfalfa and the heat and mass balances of the drying air and the material components, as well. The model is used to calculate the dynamic optimal operation for alfalfa drying in a thin and thick layer, as well.

Keywords: leaf, stem, solar drying, drying time, physically based model

INTRODUCTION

The intermittent drying technology can basically be used successfully in two cases. One case is when the materials to be dried have different components of alternate drying properties. Another case is when the internal energy of the material bed is used to continue the drying during possible intermissions.

Alfalfa is a plant used for animal feeding consists of two different components as leaf and stem. During artificial drying of alfalfa the water concentration of leaves falls faster than that of stems as because of their different drying characteristics. However, during the break periods (intermissions) of drying the water concentration of the components equalizes, i.e. drying of stems proceed to dry while leaves are being rewetted which finally yields a homogeneous product. It is the reason that the intermittent drying is beneficial to avoid large differences between the water concentrations of stems and leaves and so the quality degradation.

Using solar energy is a promising solution in attaining the technical, economical and environmental demands raised in the course of drying processes. It implies studying the fitting of solar radiation availability and the intermissions required during alfalfa drying.

MATERIAL AND METHOD

An optimal procedure is developed for alfalfa drying using the results of a physically-based modelling approach. The modelling should take into account the differences in the physical properties between stems and leaves of alfalfa and the heat and mass balances of the drying air and the material components, as well.

In order to follow entirely the moisture change in the components and finally to determine the moisture and temperature distribution along the height of an alfalfa in a fix-bed layout, separate models for the drying of the leaf and stem components of alfalfa were used including their particular sorption isotherms. These models were combined with air mass and enthalpy balance equations for the fixed bed.

RESULTS

To the solution of the model it is required a partial differential equation system consisting of six equations referring to the six unknown variables as the moisture contents and temperatures of both components and, additionally the relative humidity and temperature of the drying air.

If both the sorption and desorption isotherms of the components are available then the model can be used for the calculation of the rewetting phase during the course of the drying.

Using a block-oriented approach to practically solve the model, a thin layer block can be defined on the basis of space discretization of the governing partial differential equations. The discretization step interacts with the accuracy to be achieved, but at the same time a model with too small discretization steps cannot be easily used for control purposes.

When considering the possibilities for simplifying the model, it is important to retain the physically based concept. In order to avoid numerical complexity, a model reduction procedure was considered and applied to obtain an approximate physical model.

CONCLUSIONS

In order to describe the moisture distribution of alfalfa during the drying process a multi-component (leaf and stem) physically based model is essential. During the breaks in drying rewetting process in stem components could appear which can be calculated with the knowledge of sorption and desorption isotherms of both components.

The physically based models serve detailed useful information on the moisture and temperature distribution of the drying bed which is very important in the stage of design.

The model is easily applicable for operational, optimization and control purposes along with the benefit of keeping the physically based concept.

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PHYSICAL METHODS IN ENVIRONMENT PROTECTION AND AGRICULTURE

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Significance of the physical methods of investigations of properties of materials and the processes involved in the agricultural production and post-harvest processing are discussed. Some examples of applications of the monitoring, computer modeling and measuring methods are indicated.

Mass and energy exchange in soil-plant-atmosphere system and agricultural products is of great importance for environmental and technological processes, regulation of physical, physical-chemical and biological properties of soil and plant structures, optimal fertilization systems. Specific and complex character of modeling of physical processes in environment and agriculture is to find these parameters for a broad range of interacting objects as atmosphere, soil, plant, machine, product and to include their individual features as: colloidal and polydispersive composition, capillary, cellular or tissue build up, temporal and spatial variability, non-homogeneity, biological activity.

Description of the mass and energy flow in a porous medium is the main goal of many branches of science and technology. The statistical-physical model of mass end energy transfer formulated on the base of the fundamental physical laws is the good example of application of physics for solving problems of contemporary agriculture. The model enables the following porous medium properties to be considered: hydraulic, diffusive, thermal and electrical [4].

One of the purpose of monitoring and modeling is to provide tools for optimal resources utilization and management. Computer data bases and maps of the physical properties of arable soils can serve as an example. The maps may be used for evaluation of hazards and agricultural damage, e.g. crop yield losses connected with temporal water saturation of soils, estimation of ecological damage connected with nitrogen losses due to denitrification and the emission of nitrous oxide to the atmosphere, prediction of negative ecological and agricultural effects of climate changes [5].

One of the main task of modern agriculture is production of high quality and healthy food with preserving natural resources. One of the most investigated issues related to food quality is food texture. Texture of plant foods can be attributed mainly to the structural integrity of the cell walls. A lot of texture attributes are connected with sound. It was indicated that the acoustic emission

method can be applied to quality evaluation of fruits and vegetables. Comparison of the acoustic emission method with firmness and sensory analysis proved that both can be used successfully for instrumental analysis of apple texture [6].

Production of high quality cereals grain and oil seeds is an important task of agriculture. Large-scale comprehensive studies curried out in the Institute of Agrophysics on winter rape indicated the possibilities of considerable decrease of qualitative and quantitative losses during harvest and post-harvest processing. The mechanical strength, weather conditions during harvest, adjustment of harvester according to two previous factors were found to be the most influencing the qualitative and quantitative losses. Finally adaptation and adjustment of combine harvesters according to findings of basic study has been provided for agricultural practice [3].

An important task is preserving high quality of stored materials. Extensive study indicated that limiting time of storage of rapeseed depends on the temperature, the moisture content of seed and the seeds quality [1]. Experimental and theoretical analysis of physical processes in granular plant materials during storage and handling indicated their significance for materials quality [2].

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NUMERICAL MODELLING OF WOOD DRYING

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The drying is one of the most important post-harvest methods for the agricultural products, mainly used for quality conversation. But is some cases (e.g. for wood used as energy source) it is even more important. As the drying experiments are quite long (specifically under environmental circumstances) the modelling can help to predict the drying time for a given final moisture content. In the presentation the set-up of a model together with the necessary measurements is introduced.
Keywords: drying, moisture content, modelling, measurements

INTRODUCTION

Nowadays the environmental protection and the use of the renewable energy resources have greater and greater importance. Among the renewable energy resources the role of the biomass is very important and, among them the energy forest can have a bigger role even in Hungary as the agricultural fields with low quality can be used to produce energy plants, e.g. energy forest.

The presented research results are in connection with the wood of the energy forest, too. The wood of the energy forest can not be used immediately because of its high water content. During the research the modeling of the drying of the wood and some measuring methods of the drying were studied. Parallel to the modeling measurement were carried out to determine the important material properties, some of them is presented.

MATERIAL AND METHOD

During the modeling of the drying of a stem a differential equation system was set up and –in absence of an analytical solution- numerical methods were used for the evaluation. For this purpose he finite element and the finite difference method were considered, and finally the later was chosen. For the numerical solution difference boundary conditions were tested, finally a moisture content dependent, combined boundary condition was developed.

For the wood with peel a two layer resistance model was set up. The numerical models were tested with physical properties from different measurements, and the results were compared with drying experimental data.

With the use of drying model of a stem a model of a pile was set up, in which the stems in the different parts of the pile could be modeled and average properties for the pile were possible to get.

To validate the developed model measurements were carried out. Among them, the moisture content measurements were the most important with 3 year old willow stems, a part of them with peel, and the other part without peel.

RESULTS

For the modeling the physical principles of the drying process were taken into the account. On this basis four balance equations were developed, the energy and mass balance (heat and mass transport) equations of the wood and the surrounding air.

For the most important equation describing the wood moisture content different solution methods were tested, as solution based on the Bessel functions, finite element and finite difference methods.

For the unpeeled wood a resistance model were elaborated where beside the resistance of the peel an average resistance of the wood was calculated. From the overall resistance the time constant of the drying process was determined.

During the modeling different boundary conditions were used. The most simple constant boundary value was used only for the long time modeling when the boundary value goes down to the equilibrium one. For the beginning of the process a constant flux rate and a solution with the partition coefficient was used. Finally the combination of the developed condition was used by determining in every step the limiting factor of the process.

After the moisture content function is known, the whole model for a bulk can be calculated with the finite difference method. The values of the air humidity and wood and air temperature for the bulk model can be calculated under different conditions.

CONCLUSIONS

In the paper a modelling of the drying of wood stems are presented together with the developed numerical modelling and boundary conditions. The results were compared to measured data.

From the modeling the properties (wood moisture content, wood and air temperature, air humidity) of the whole pile can be calculated, and so the drying process of the whole pile can be described. The bulk model can be used to simulate the very long drying process during relatively short time. These calculations can be used to calculate the optimum size of the pile, which is the optimum wind speed during the forced drying, etc.

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INVESTIGATION OF FOOD MATERIALS PHYSICAL PROPERTIES DURING TECHNOLOGICAL PROCESSES

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INTRODUCTION

Food materials are very complicated biological materials – they have complex chemical composition (proteins, lipids, saccharides, additive components), structure, phase (food or their components are dispersed systems), conformation, etc. Food materials are in the macroscopic as well as in the microscopic scale a considerably inhomogeneous, capillary-porous, wet dispersed medium. It is well known that the water influence dominates among the others effects that have impact on properties of food materials. Important factor is also the material's temperature, but the most significant is the influence of the presence of free or bound water, different binding energy in each water bond (chemical, physical-chemical and physical) in the material and sorptive properties of the materials. Influence of physical properties on the time and on the history of the external conditions is a characteristic feature of biological materials. Moisture content and temperature are the most important physical properties that influence physical, and physiological processes running in the food materials.

Temperature is one of the main controlling factors used in food processing. Typical thermal food processes (pasteurisation, sterilisation, baking, boiling, drying, cooling, and freezing) induce some physical and chemical processes in the material such as vaporisation, melting, freezing, crystallisation, crystal modification, denaturation, chemical reaction (oxidation), etc. In addition temperature is the value which influences nearly each property of the material. Knowledge of physical properties is basic condition for describing food material's behaviour during a food processing.

STUDY OF ELECTRICAL PROPERTIES

Determination of electrical properties is utilized in a wide range of disciplines and industries. A brief compendium of electrical properties utilization of granular and powdery agricultural and food materials is presented in this paper. Electrical properties of granular and powdery materials are influenced by various factors. The most important are moisture content and its distribution in materials, temperature, density, volume or bulk density. The relationship between the resistivity,

conductivity, capacitance, relative permittivity and various influencing factors are described.

The electrical conductivity measurements are utilized at the salinity of soils and irrigation water determination. Biological material properties are determined from their leachates too. The conductivity measurements are applied for determination of various characteristics of agricultural materials and food (frost sensitivity, chilling and freezing tolerance, moisture content, seeds germination, mechanical stress, …). Investigated materials are very various, for example grains, seeds, meat, sugar, milk, wood, soil, fruit and vegetable, infected food. The utilization of dielectric properties is also described; for example in agricultural materials and food quality sensing (moisture content, maturity of fruit, potential insect control in seeds, radio frequency heating…). The classification of permittivity measurement techniques is mentioned.

STUDY OF THERMOPHYSICAL PROPERTIES

The brief characterization of biological granular materials is presented. The influence of the presence of the water in these materials is shown. The moisture content and the temperature are the most important physical properties that considerably influence not only material's properties but physical and physiological processes running in the biological materials as well. Physical processes running in materials during processing are reviewed. Some of the thermal processes are described in details. Basic thermophysical properties – the specific heat, the thermal conductivity, the thermal diffusivity, the heat transfer coefficient – are defined and overview of measurement methods is given. Principle of the thermal conductivity measurement method – hot-wire method, which is suitable for biological granular materials and experimental apparatus is described in details. Methods of thermal analysis – thermogravimetry and differential scanning calorimetry are presented and principles of the modern measuring equipments – DSC calorimeter and TGA analyser are described. Some results of the specific heat at the constant pressure measurement and results of the thermal conductivity measurement of biological granular materials are presented. Thermophysical properties are the important information for the analysis of the material's behaviour during processing, temperature dependency of the specific heat gives information about endothermic or exothermic processes in the material and temperature dependency of the thermal conductivity provides information for instance about heat transport running in the material.

Knowledge of thermophysical properties is basic condition for the following detailed analyses of the optimal material storage and the thermal processing regime proposal. Influence of the thermophysical properties on the effectiveness of the thermal processing is discussed.

ORAL CONTRIBUTIONS OF YOUNG SCIENTISTS

BRUISE RESISTANCE OF APPLES (MELROSE VARIETY) UNDER VARIED LOADING CONDITIONS

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The supply chain of apples from harvest to consumers includes a number of commercial operations like, packaging, sorting, repeated transportation and storage. In each operation, apples are exposed to bruises and other damages that can not be eliminated even at high precaution measures taken. The economic effects of apple damages are tremendous as even a slight bruise allows bacteria to penetrate inside fruit, while fungi and moulds to develop there. Reduction of a bruise damage rate means not only economic benefits but healthier food of better esthetic values as well as decreased environmental contamination.

Apple bruise damage is caused by fruit dropping from different heights and impacting hard surfaces of machines. That results in dynamic stress wave transfer within the material. Application of the objective parameters like, bruise threshold (the drop height at which bruise begins to occur for apple of given mass, shape and impact surface), resistance to bruising (the ratio between impact energy and bruise volume) and threshold of material plastic flow (maximal dynamic stress at which no further bruise damages are observed) facilitates the assessment of apple susceptibility to impact loading.

The present paper includes the results of the impact researches on the apples Melrose variety (obtained from the Agricultural University Experimental Station in Lublin) dropped onto the force sensor from different heights. There were recorded the force-time profiles, bruise area and volume as well as specimen mass. To determine susceptibility to bruise and the threshold of plastic flow in material, the CHMI technique (constant height multiple impact) was adopted. The studies included healthy and not-deformed apples of mass within 167g – 265g and a diameter from 76,6mm up to 91,8mm. The first research series was performed a day after harvest, while the second – after 4-week storage at approx. 20^0C temperature. There were chosen the following five impact heights: 20mm, 35mm, 50mm,70mm, 80mm.The heights guaranteed the bruise incidence at dropping as

the bruise threshold established earlier for the studied variety ranged within the limits of 14-18mm.The test was done in five replications for each impact height.

On the grounds of the present research results, it was stated that in the case of bruise resistance coefficient (BRC) in the function of impact height for fresh and stored apples, bruise resistance proved the lowest for the low impact heights (20mm) and it increased several times along with the drop height elevation. It appears to be a disadvantageous effect, giving evidence of Melrose apples highest sensitivity to bruise at impact from low heights. There were also observed higher values of BRC for fresh apples within the whole range of the heights investigated.

There was proposed a model for stabilization of rebound height course for apple through approximation of mean heights of each rebound for varied impact heights.

$$H_{reb} = A(1 - e^{-\frac{Ni}{B}})$$

where: H_{reb} – rebound height, N_i – consecutive impact, A and B - constant

On the basis of B coefficient value referring to fresh apples, a plastic energy accumulation rate was shown to be slower than for after-stored fruits. Apples after storage reach the rebound stabilization status more promptly, what is more, higher stabilized rebound value was also found for fresh apples (A). That proves a higher percentage of elastic deformation for the fruits at the rebound stabilization state. It is clear because there is more fluid in the intercellular spaces of fresh apple tissues which gradually migrates to the areas transferring lower loading during the successive rebounds. The proposed mathematical formula of approximation of rebound height in the consequent impacts by the exponential function facilitates interpretation of a rebound stabilization phenomenon and thus, its coefficients possess the physical interpretation.

SOIL HYDROPHOBIC – REASONS OF ITS FORMATION AND HYDRO – GEOMORPHOLOGICAL CONSEQUENCE.

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INTRODUCTION

Soil hydrofobicity can cause many damaging implications such as: lower water infiltration, soil erosion and inhibition of plant growth. There are a lot of factors which can regulate soil hydrophobicity. Soil temperature, fungi, soil microorganisms, soil structure and clay content. Each of these factors influence in a different way – it may decrease or increase soil hydrophobicity.

PHYSICO-CHEMICAL REASONS OF WATER REPELLENCY AND ITS OCCURRENCE IN SOILS

A water-repellent soil (or hydrophobic soil) does not wet up spontaneously when a drop of water is placed upon the surface.

The physical properties of water can be explained by the combination of two forces creating surface tension. Water has strong cohesive forces (attraction of water molecules to themselves) helping to hold water drops intact. It also has adhesive forces (attraction of water molecules to other substances) which cause the water to spread out and cling to other surfaces such as soil particles. The compounds causing repellency in soil are polar compounds with hydrophobic (water repellent) and hydrophilic (water attractant) ends. During dehydration the shape of the compound changes, so that the hydrophobic surface is exposed to the air/water in soil pores. This then creates a hydrophobic layer preventing the spread of water over the soil particles. (Doerr et al., 2000)

When soil moisture is above a critical value (which is different for every soil), the water repellency effect is temporarily eliminated. When it falls below this critical value, the soil returns to a hydrophobic condition. The time taken for water to infiltrate increases for repellent soils. It takes as little as 3 to 6 % hydrophobic materials in the soil matrix to cause non-wetting problems.

Soil water repellency is caused by organic compounds derived from living or decomposing plants or microorganisms. Hydrophobic substances occur in many life forms. The identification of the specific compounds causing water repellency has continued to be a focus of soil research in the last decade. However, despite advances in analytical techniques, identifying the exact substance s responsible in a given soil has yet to be achieved. Furthermore, how these compounds are

bonded to soil particles also remains unclear. A complicating factor in such studies is the natural abundance of various, potentially responsible substances in soil. For example, from just one sampled soil, Almendros et al. (1988) extracted 93 organic compounds, many of which were hydrophobic.

SOURCES OF HYDROPHOBIC SUBSTANCES

In many studies, the occurrence of water repellency has been associated with particular vegetation types. Plants most commonly associated with water repellency seem to be certain evergreen tree types. In particular, trees with a considerable amount of resins, waxes or aromatic oils such as eucalyptus and pines are well represented, both within and outside their native environment.

The association of water-repellent with certain plants may not always be direct. Water repellency has also been associated with fungal growth and soil microorganisms, which in turn can be associated with specific vegetation types.

Apart from investigating the direct influence of vegetation and microorganisms on water repellency, research has also attempted to establish general relationships between soil organic matter and/or organic carbon content and the degree of water repellency (DeBano, 2000)

There are also non-biological factors affecting water repellency such as: soil temperature, fire, soil texture and clay content. Researchers claim that coarse textured sandy soils are more likely to become repellent as they have a relatively low surface area compared to finer materials. However, certain clay soils have been found to become repellent as the coatings have formed on aggregates of fine material.

Soil water repellency reduces the affinity of soils to water so that they resist wettings for periods ranging from a few seconds to hours, days or weeks. In addition it can often cause many damaging implications to plant growth and hydrological and geomorphological repercussions. These include the reduced infiltration capacity of soils, enhanced overland flow and accelerated soil erosion, uneven wetting patterns, development of preferential flow and the accelerated leaching of agrichemicals. In consequence it can lead to inhibition of plant growth (Doerr at al., 2006)

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INFLUENCE OF THERMAL TREATMENT ON MECHANICAL PROPERTIES OF APPLE TISSUE AND MODEL CELL WALL

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The mechanical properties of fruit depend largely on the conditions of their storage and on the technological process parameters, such as temperature. Cell walls are considered as the main structural component affecting the mechanical properties of fruits and vegetables.

To examine and to simulate the effect of various factors on the mechanical properties of cell walls, model cell walls with chemical composition and structure that would be equivalent to those of natural cell walls may be used. Primary cell walls are build of polysaccharides which compose above 90% of dry matter, structural protein, enzymes, mineral compounds and phenolic esters. Cellulose, pectin and hemicelluloses are the main cell wall polysaccharides. The structure of cellulose which is produced by the bacteria *Gluconacetobacter xylinus* is considered to be highly similar to cellulose network occurring in plant cell walls and because of that fact bacterial cellulose is used as model material of primary cell walls. Bacterial cellulose networks can be enriched with another compounds of natural cell walls, i.e. hemicelluloses and pectin, which permit the study of the effect of individual compounds on the properties of cell walls.

Ripening, technological processes and handling of fruit and vegetables cause changes in the texture and cell walls polymers organization. In food industry one of the most often applied processes is thermal processing. Plant food is preserved by means of storage temperature decreasing or elevated temperature treatment (blanching) which improve specific quality attributes of fruit and vegetables. Thermal processing causes irreversible changes in food texture what can be effected by modification of cell walls under the influence of reduced or elevated temperature.

The aim of the work was determination of an influence of thermal treatment on mechanical properties of model cell walls an apple tissue as the exemplary fruit tissue.

Bacterial cell walls were produced by means of *Gluconacetobacter xylinus* bacteria strain which is producing cellulose. Bacteria cultures were incubated in culture medium containing pectin and xyloglucan which is the compound from the group of hemicelluloses characteristic for apple cell walls. On the basis of

chemical composition analyses it was stated that composition of model materials is similar to that of cell walls isolated from apple. The macroscopic dimensions of the artificial cell walls allowed to use them for mechanical testing.

Apple samples and materials produced were treated in temperatures 2-70ºC in buffer simulating the ionic conditions in apple juice. Uni-axial compression test for apples and uni-axial tensile test for films of model materials were performed to study the mechanical properties of these materials after thermal modification. All the tests were performed using the testing machine Lloyd LRX in 10 repetitions.

On the basis of the mechanical tests an influence of temperature on mechanical properties of model materials and apple tissue was observed. The failure stress from tensile test of all the model materials decrease under the influence of elevated temperature. The biggest temperature effect on tensile strength was indicated for the composite composed of bacterial cellulose and pectin. The tendency to increase of the strain at maximum stress for all the model materials was observed. Failure stress obtained in compression test of apple tissue depends on the temperature. In low temperature (2-40^{o}C) linear decrease of failure stress was visible and strong decrease was indicated at 50^{o}C. This dependence is comparative with native bacterial model materials, where the biggest changes of mechanical properties were observed at 50^{o}C. It can be stated that mechanical properties of model materials are correlated with natural apple tissue when temperature change.

ACKNOWLEDEMENTS

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FAILURE STRESS AND THE BLACKSPOT OF POTATO TUBER TISSUE DURING STORAGE

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INTRODUCTION

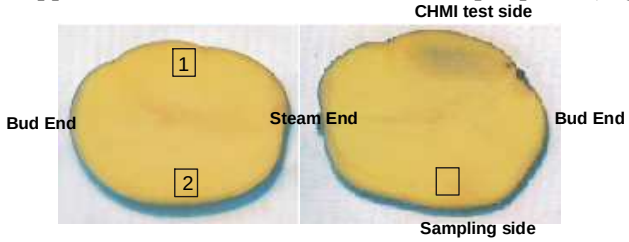
The appearance of blackspot bruising of potato tuber is one of the major problems in research and practice. Research conducted so far indicates that internal changes of this type in parenchyma tissue are phenomena being results of mainly external loading during harvest, transport and storage. Blackspot appears most frequently in the outer core tissue as a result of damage of cellular membrane, without fracturing the cell walls. The failure stress of cell walls, therefore, is one of the factors that determine the susceptibility of potato tubers to inner blackspot. The aim of the research is finding the relationship between the failure stress of outer core tissue and the blackspot of potato tuber tissue.

MATERIALS AND METHODS

Three potato varieties were used for the present experiment: Asterix, Irys and Mila harvested in 2007. The outer core was indicated in the potato tuber.

The experiment was performed at four storage periods: after 3, 4, 5 and 6 month of cold storage. 30 tubers were used at the each period (10 tubers per variety). The universal testing machine Lloyd LRX for determination of the mechanical strength was used. The CHMI technique was used for blackspots triggering.

The failure stress was determined on cylindrical samples - 10 mm of diameter and 13 mm of high. The samples were cut from two sides in tuber (Fig. 1a.). If blackspot appeared after CHMI test, the sample for compression was cut only from the opposite side of the tuber to the blackspot place (Fig. 1b.).



a) b)

Fig. 1. a) sampling places for determination of the failure stress, b) sampling plases for finding relationship between the failure stress and the blackspot existence.

RESULTS

The comparison of failure stress for sampling places from opposite sides of the tubers (Fig. 1a) has shown that the difference is less than 10% and they are not significant (p>0,05). The failure stress of outer core tissue linearly increases during storage (p<0.05) for all tubers both with blackspot (bs) and without blackspot (no bs). In general, the failure stress for tubers with blackspot (bs) is higher then for tubers without blackspot (Fig. 2).

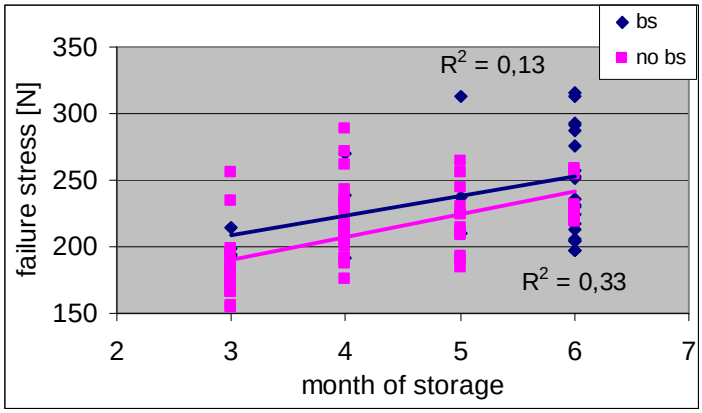


Fig. 2. The relationship between failure stress of outer core tissue and blackspot exists in potato tuber tissue during storage, **bs**-blackspot, (p=0,035), **no bs**-no blackspot, (p=0,001).

CONCLUSIONS

1. The failure stress of outer core tissue collected from two opposite sides of tuber is similar.
2. The failure stress of outer core tissue linearly increases during storage.
3. The susceptibility to the blackspots increases if the failure stress is increases.

SOME RHEOLOGIC AND THERMOPHYSICAL PROPERTIES OF BEER SAMPLE

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Physical properties particularly mechanical, rheologic and thermophysical are important to know at quality valuation and protection of food materials. Automatically controlled processes at manufacturing, at handling and holding require exact knowledge about physical quantities of materials. Results from measuring of rheologic and thermophysical properties of beer are shown in this paper.

Measuring of rheologic properties of beer was performed by digital viscosimeter Anton Paar (DV-3P) and principle of measuring by this viscosimeter is based on dependency of sample resistance against the probe rotation. Sample of beer was stored in special cool box in temperature 3 °C and was measured in different days during two weeks. Measurements were done after the temperature stabilization from 7 °C to laboratory temperature. Dependencies of dynamic viscosity on temperature and on time of storing are described. Dependency of dynamic viscosity on temperature can be described by Arrhenius equation. Temperature dependencies of dynamic viscosity of beer are decreasing exponentially and in this temperature range almost linearly for all measurements (Fig.1).

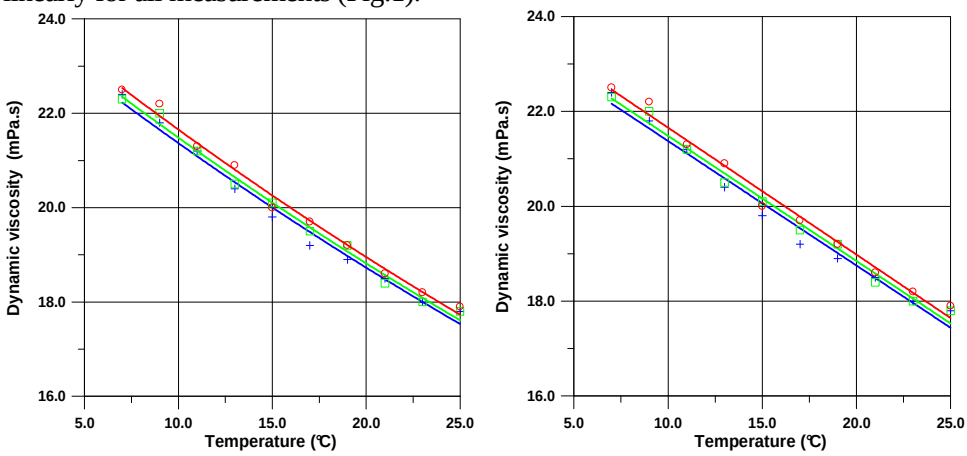

Fig.1. Dependencies of dark beer dynamic viscosity on temperature after different time of storing : first measurement (+), second measurement after one week of storing (□), third measurement after two weeks of storing (○). (exponential function on the left side, linear function on the right side)

Coefficients of determination are bit higher in case of decreasing exponential function than in decreasing linear function. Arrhenius equation has decreasing exponential shape, so the dependency of dynamic viscosity on temperature can be described by it. Dynamic viscosity of sample had increased a bit with time of storing (Fig. 1).

One of the most important thermophysical parameters are temperature, thermal conductivity and thermal diffusivity. For thermophysical parameters measurements was used Hot Wire method. There were measured relations between thermal conductivity and thermal diffusivity in temperature range (10–25) ºC by instrument Isomet. The results of measurements showed that temperature stabilisation process had influence to variation of thermophysical parameters. All measured relations during temperature stabilisation have linear increasing progress (Fig. 2-3). For measurements of thermophysical parameters was used instrument Isomet. This instrument is working on principle of hot wire method. The simple measurement consists of measuring the temperature rise, time evaluation of an electrically heated wire embedded in a tested material. The thermal conductivity is derived from the resulting change in temperature over a known time interval.

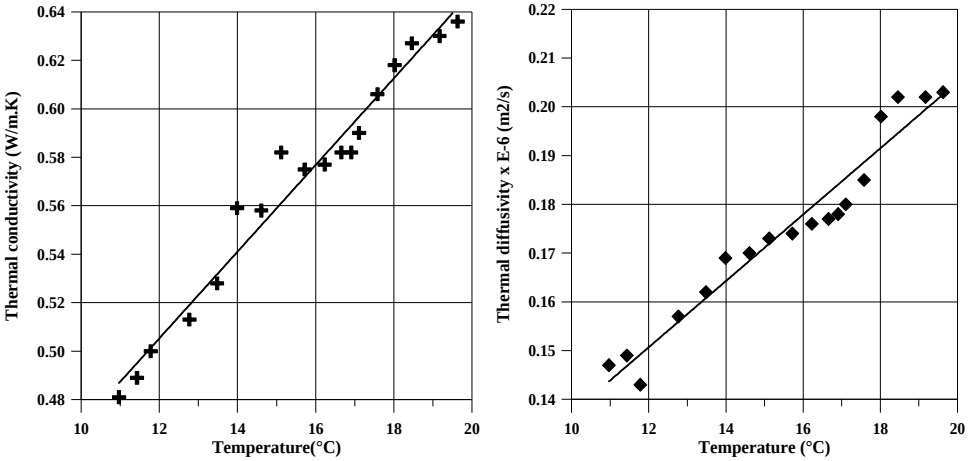

Fig. 2. – 3. Relations of thermal conductivity and thermal diffusivity to temperature for beer during the temperature stabilisation

The ideal analytical model assumes an ideal – infinite thin and infinite long line heat source (hot wire), operating in an infinite, homogenous and isotropic material with uniform initial temperature. If the hot wire is heated for the time t = 0 with constant heat flux q per unit wire length, the radial heat flow around the wire will occur. Mathematical model requires ideal, infinitely long thermal source (hot wire) surrounded with infinitely homogenous and isotropic medium with

constant starting temperature T_0. If in time $t = 0$ there starts radial heat flow q in measured material, so temperature $T(r,t)$ will have during time t increasing progress in distance r measured from hot wire and from time-temperature function thermophysical parameters are calculated.

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EFFECT OF Pb-STRESS OF CATION EXCHANGE CAPACITY AND SURFACE CHARGE OF SPRING BARLEY

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The object of research were of roots spring barley of Ukrainian Peyas variety. The plants grew in three replicates in a nutrient solution, prepared according to Marshner and Romheld [1983] at pH=7, in 16/8 hours (day/night) diurnal cycle and at temperature regime of $20/16^0$C. At the beginning of the tillering stage, $Pb(NO_3)_2$ was introduced to the nutrient medium in the amount of 320 mg per 1 dm^3 of the solution and the pH of the containers with Pb^{+2} was lowered to 4.5. The control setup consisted of containers free of Pb^{+2} ions at pH=7 and 4.5. Plants incubation period was 10 days.

From physicochemical point of view, the quantities such as the cation exchange capacity (CEC) and the value of the surface area (S) determine to a great extend sorption properties and transport of water and mineral elements (also toxic elements) through root of plants. On the base of potentiometric titration curves measurements, it is also possible to determine degree of heterogeneity of variable surface charge. The surface charge is described in term of dissociation reaction of surface functional groups.

The lead is for plants completely unnecessary element. Every stress conditions are signal for a plant to initiate in its cells a number of different biochemical processes. Anatomical and biochemical changes under the stress are reflected in several physicochemical characteristics of the root.

The aim of the present study was to determine the effect of pH and lead ions on surface charge properties of barley roots including CEC, the dependence of surface charge on pH.

The titration curves for the studied roots were determined using auto-titrator Titrino 702 MS. Samples of 0.0500 ± 0.0001g (dray mass) of the barley roots were equilibrated overnight with 20.00 g of 1mol dm^{-3} NaCl solution. Prior to the titration, pH of every sample was adjusted to 2.95 with 1 mol dm^{-3} HCl after 5 minutes mixing. The suspension was titrated using 0.1 mol dm^{-3} NaOH in 1mol dm^{-3}. $NaCl_2$ solution with the rate of 0.01ml / min. The amount of the titer consumed between pH 3 and 10 was recorded with the step of 0.1 pH unit.

To determine of CEC of studied roots, the method described by Morvan et. al. [1979] was applied. The amount of moles of consumed basic is taken as the value of CEC.

The roots of studied plants, cultivated without added lead ions at pH=7 and PH=4.5 have practically the same charge. Therefore, it can be deduced that an increase of protons concentration in the nutrition has not significant influence on charge of studied root tissue. Only after addition of lead ions to the nutrition, the curves of the charge Q versus pH change their course. Usually, different protections mechanisms act simultaneously with different intensity depending on sensitivity of a plant. Therefore it is difficulty in an unambiguous manner to explain reasons of observed changes of physicochemical properties in the studied roots.

Under the influence of lead ions, the total variable charge (Q) and cation exchange capacity (CEC) of roots increased. However, the total acidity of roots surface did not exhibit essential changes. Also, no significant differences were observed between roots growing without lead ions at pH=7 and pH=4.5. In addition to titration, water vapor isotherms were measured for the roots of the plants.

Table 1. Variable charge of characteristics of the studied barley roots

	control	pH4.5	pH7+Pb	pH4.5+Pb
CEC ($mM\ g^{-1}$)	0.546±0.12	0.537±0.29	0.594±0.004	0.604±0.01
Qv, $mM\ g^{-1}$	0.871±0.01	0.863±0.01	0.912±0.006	0.91±0.003

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PERFORMANCE MODELLING OF A COMBINED SOLAR HEATING SYSTEM

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This paper introduces a physics-based block-oriented mathematical model that can be used for the performance evaluation of a particular solar heating system for an outdoor swimming pool. Determination of the substantial energy and efficiency values of the system are based on the influencing solar irradiance, ambient temperature and wind conditions. All of these data can be either modelled or measured for the block-oriented model which is a good tool for efficiency-based improvements. It is also stated that the model not only takes into account all the substantial effects on energy and efficiency performance but also can be used generally for modelling any similar system.
Keywords: solar energy, physically based block-oriented model, swimming pool

INTRODUCTION

In view of the possibility of harnessing solar energy in swimming pool applications and the increasing amount of such installations, it is important to develop the efficiency of such solar heated systems. In order to improve any simple or combined solar heating system, physically based mathematical modelling is an exact, theoretically overseen tool. By applying it we can improve effectively the efficiency of such applications based on either meteorological measurements or perhaps more generally on meteorological models.

This paper introduces a block-oriented type physically based mathematical model realised by the MATLAB® software package.

MATERIAL AND METHOD

The particular combined swimming pool system has been installed at the campus of Szent István University (SIU), Gödöllő, Hungary in order to preheat water for an outdoor swimming pool. In the idle period of the swimming pool operation the system provides domestic hot water to a kindergarten nearby. The main system components are the flat plate solar collector field (with a total area of 33.3 m^2, oriented to the south and its inclination angle is 45°), a plate heat exchanger and a 700 m^3 outdoor swimming pool. An auxiliary gas heated boiler is also included operating in the same time with the solar heating when it is necessary to maintain the required temperature for the swimming pool.

Monitored data are the specific solar irradiance on collectors' plane (W/m^2), ambient temperature of the collectors and the pool, input and output temperatures of the collector array, temperatures of the heat exchanger (inlet side the collector

loop fluid and outlet side the swimming pool water) and the volumetric flows in both loops. It can be noted that in case of pumping the input temperature of the heat exchanger's outlet side coincides with the pool temperature. On the basis of such measurements the total solar irradiation, the solar energy directly produced by the collectors and the directly utilized solar energy by the pool was calculated.

A block-oriented mathematical model of the combined solar heating system has been elaborated and realized by the MATLAB® software package. The model takes into account the all the substantial effects on energy components influencing the efficiency and energy performance of the subsystems. On the swimming pool the main energy components are determined as evaporation, radiation, convection, conduction, recovery water, heat losses, active and passive solar gains. The irradiated energy on collectors' plane, transferred energy in the heat exchanger and relevant losses are also determined. The possibility of auxiliary heating is also involved in the model.

The main system components are separately developed in different sub-models which can be used together or independently mainly for simulation purposes. Having relevant measured data the identification of system parameters are also available along with the developed model as optical efficiency or overall heat loss coefficient in the collector, in the heat exchanger or evaporative mass transfer coefficient in the swimming pool sub-models.

On the other hand the model can be used independently of any measurements but on the basis of meteorological mathematical models which simulate irradiance on collectors' plane and on the pool surface, ambient temperature, relative air humidity and wind velocity. This possibility is also fully worked out in the model.

RESULTS

Presenting some particular results it has been concluded that there are significant fluctuations in the pool temperature as the evaporative or radiation loss parameters changed within the bounds of possible values and the used recommendations in the references. In kindergarten operation the pipe losses decrease in a certain extent the utilized solar energy as their sum length is more than 140 meters. On the kindergarten side a validation based on measured data has been carried out for clarifying the model accuracy during predicting the solar storage outside temperature. It can be also stated that the developed model structure is flexible therefore it can be used generally for modelling of similar systems.

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METHOD FOR CHARACTERIZATION OF DISTRIBUTION OF CONTACT NORMALS IN 3D GRANULAR ASSEMBLY

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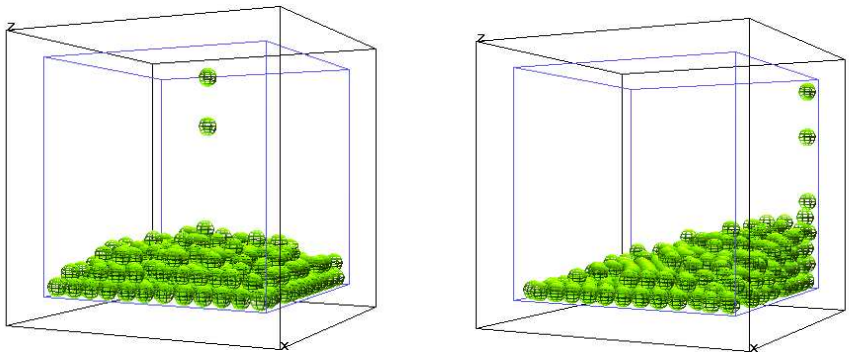
Increase in availability of computers of high computational power resulted in more extensive application of numerical techniques to investigations of granular materials in 3D systems. The progress of technology allowed for application of more realistic contact models.

The visualization of contact network and distribution of contact normals in 3D particulate system still posses a great challenge. The proposed method is based on color representation of the probability of containment of contact normal in the fixed range of angles in spherical coordinates system. The method was applied for analysis of results of numerical simulations with discrete element method (DEM), proposed by Cundall and Strack [1] in 1979. Simulations of filling rectangular and cylindrical bins centrally (fig. 1a) and eccentrically (fig. 1b) were conducted with open source code PAPA downloaded from Stuttgart University website. In both cases coefficients of interparticle friction μ=0,3 and μ=0,6 were used.



a) b)

Fig. 1. Filling of test box centrally a.) and eccentrically b.).

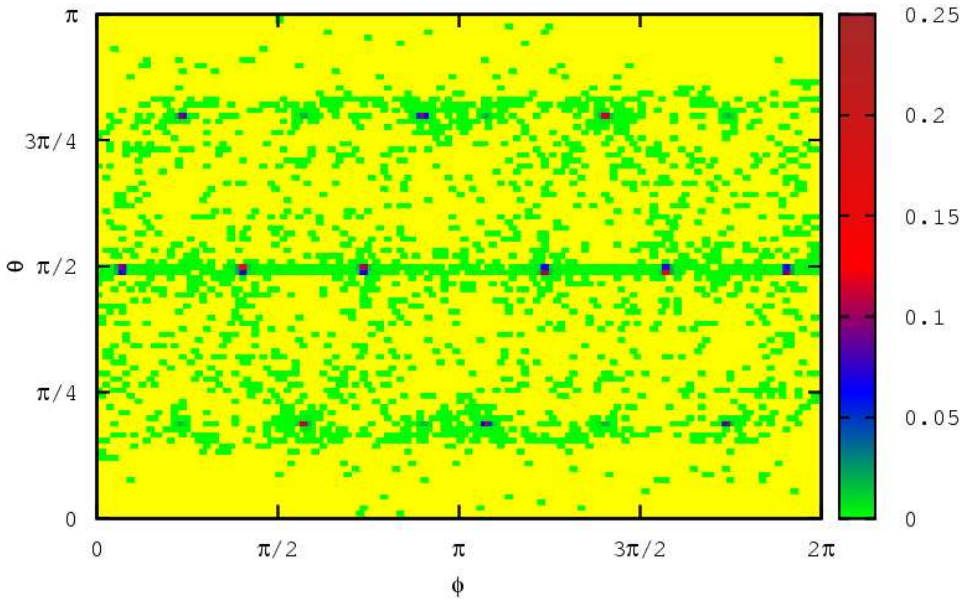


Fig. 2. Distribution $p(\theta,\varphi)$ of probability p of contact normals versus angles θ and φ in cylinder eccentrically filled with 1200 spheres projected as a color map

Figure 2 shows an example of distribution of contact normals projected as a color map. The axes represent angles of contact vector in spherical coordinates, φ in horizontal plane and θ in vertical plane. For computation of probability map was divided on 2x2 degrees squares. The minimum probability is represented by green color and maximum one by brown color, yellow color is used when no contact is detected at given square.

The method is currently used for monitoring evolution of distribution of contact normals in the course of filling the test chamber.

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THE INFLUENCE OF VARIOUS CONCENTRATIONS OF LEAD AND CADMIUM ON EARLY GROWTH OF MAIZE AND RYEGRASS-PLANTS

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Heavy metal phytoextraction is a soil remediation technique which implies the optimal use of plants to remove contamination from soil. Lead and cadmium are the most widely spread heavy metals and enter plants mainly through the root system. Plants must thus be tolerant to heavy metals, adapted to soil and climate characteristics and able to take up large amounts of heavy metals [3, 5]. Root length and diameter distribution are important characteristics to be considered when describing and comparing root systems. Cd affects root growth at lower concentrations than Pb. Increased concentrations of Pb and Cd cause detrimental effects to plants, especially they alter growth.

Primarily, Cd and Pb enter plants from soil via the root system. At the root surface, Cd^{2+} and Pb^{2+} bind to the carboxy-groups of mucilage uronic acids. Mucilage binding restricts metal uptake into the root and establishes an important barrier protecting the root system [4]. The ability of mucilage to bind heavy metals decreases in the cation series: Pb^{2+}> Cu^{2+}>Cd^{2+}>Zn^{2+}. The uptake rate of heavy metals depends on the pH value of the soil solution, the organic matter content in the soil, and the concentrations of other ions

The experiment was conducted to investigate the effects of pollution with lead and cadmium on early growth of maize and ryegrass-plants. The daily increase of plant height, plant mass, root length and thickness were measured during 14 days. Plants were growing in water solution of various concentrations of lead, cadmium and in a mixture of lead and cadmium. Overall growth of the investigated plants were affected by lead and cadmium, however there was different impact of solutions of these metals according to their concentrations. Root length and diameter of plants from experiment were calculated using image analysis algorithm and the public domain NIH Image program. Washed roots were placed on glass plate and scanned using high-resolution scanner [2].

We saw that stronger effect for daily growth of plants has addition for solution different concentration of $CdCl_2$ than $Pb(NO_3)_2$. The decrease in plant mass, resulting from HM (heavy metals) toxicity is stronger for fresh than dry

mass. This indicates a decrease in the amount of water stored by plants probably as a result of reported lowering of the content of compounds maintaining turgor and cell wall plasticity by lead and cadmium [1]. There was stronger reduction of root mass than shoots for both HM and this reduction was more apparent for higher concentrations of HM. Root growth inhibition for maize was stronger by cadmium than lead for low heavy metals concentrations and an inverse relation was observed for highest concentrations. And for ryegrass-plants stronger effect was by the highest concentration of cadmium, but for lead we can observe similarly effect for root growth.

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Authors thank dr A. Szatanik-Kloc from IA PAS Lublin for help in experiments.

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APPLICATION OF ELECTRONIC TONGUE TO KETCHUP SAMPLE ANALYSIS

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Lately Electronic Tongue instrument is applied for controlling quality quite often. The Alpha ASTREE Electronic Tongue instrument was developed for the analysis of taste and dissolved organic and inorganic chemicals that are typically found in liquid foods. The objective of this work was to distinguish different ketchup samples and to compare the results received by the Electronic Tongue with the human sensory evaluation. Therefore, six ketchup samples were measured with the Electronic Tongue. According to the results and our experience the ASTREE Electronic Tongue is a useful tool that is suitable for the analysis of ketchup and other liquid foods.
Keywords: electronic tongue, electrochemical sensor, ketchup analysis, DFA, PLS

INTRODUCTION

There is a need for the performing exact and objective tests to determine taste characteristics of different liquid foods. Therefore, the objective of this work was to determine the suitability of the instrument for measurement of ketchup samples and to analyze the correlation between the sensor signals and the results of sensory panel.

MATERIAL AND METHOD

Six different commercial ketchup samples were measured. The experiments were performed with the Alpha Astree Electronic Tongue, which has been designed to analyze, recognize and identify complex dissolved organic and inorganic compounds in liquid foods. The system principle is to follow the human tasting procedure. The system is built to be able to measure up to 7 electrochemical sensors at the same time. The sensors are composed of an organic coating being sensitive to different flavors to analyze the samples and a transducer, which converts the response of the membrane into signals that will be analyzed.

The six ketchup samples was censure by ten sensory panelists, too.

The evaluation of the measured results was performed by multivariate statistics.

RESULTS AND DISCUSSION

Discrimination Function Analysis was able to show the difference between the six ketchup samples (Fig. 1).

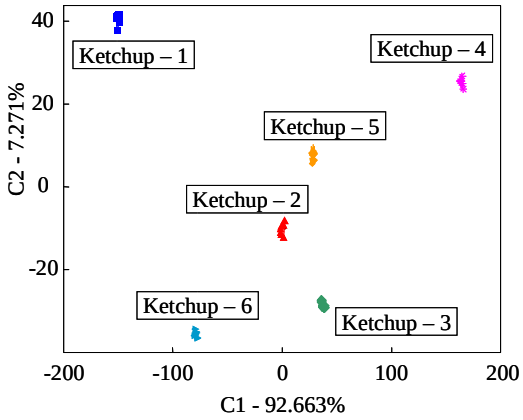

Fig. 1. Discrimination Function Analysis of six ketchup samples

The correlation was high between the results of the measurements with the Electronic Tongue and that of the sensory evaluation (Fig. 2).

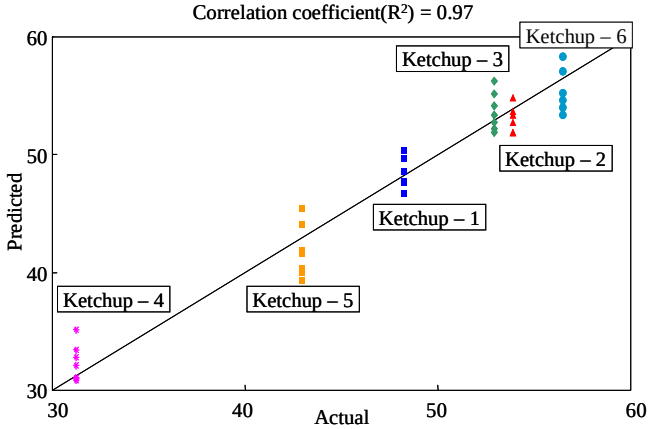

Fig. 2. Partial Least Square Regression the instrumental results versus the sweet taste according to the sensory evaluation

CONCLUSIONS

Discrimination Function Analysis was able to show the difference between the six ketchup samples. The standard deviation of results of Electronic Tongue was smaller than the results of human sensory panel, but the correlation was high.

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POTATO DMA AT TEMPERATURE BETWEEN 30 AND 90^{o}C

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DMA of single cantilever raw potato specimens (length 2cm, cross section 5 x 3 mm) were testet at temperatures 30-90 ^{o}C. The process started at temperature 30 ^{o}C and the increasing branch up to 90 ^{o}C were followed by decreasing up to the initial temperature. The humidity of air during the whole process was under control and were constant. The research were oriented to check the reproduction of the measurement at air humidity between 70 and 90 %. The results show that the best data reproduction was obtained at humidity 90 % where the information on starch gelatination is well observed.

THE EFFECT OF pH ON THE SOIL RESPIRATION PROCESSES OF TECHNOGENIC TERRITORIES OF FORMER SULPHUR MINES IN NEMYRIV (UKRAINE) AND JEZIÓRKO (POLAND)

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Within the Pre-Carpathian sulphur-bearing basin located in the Pre-Carpathian Foredeep and occupied territory within Western Ukraine and South-Eastern Poland sulphur was mined by two methods: by open-cast mine and by underground sulphur melting. Both methods brought a negative influence to the environment. The negative changes on the territories of sulphur mines by underground sulphur melting in Nemyriv (Ukraine) and Jeziórko (Poland) resulted in the technogenic transformation of the natural landscapes and vegetation, destruction of fertile soils, pollution of the environment by sulphur compounds, acidification, chemical changes and pollution of the soils, surface and underground waters. Excess of sulphur in soils of the former sulphur mines gives rise to several transformations that are dangerous for soil microbes and plants. Strong soil acidification – as a result of sulphur oxidation to an aggressive sulphuric acid - causes soil chemical degradation, heavy metals mobilization, secondary deficit of P and K and changes of soil biochemical processes for example soil respiration activities.

The soil samples were taken from experimental plots located at a different distance from the sulphur boring-well: from 20 m, 120 m and 260 m (podzolic soil in the spruce-oak-pine forest) in Nemyriv, and 10 m, 40 m and 200 m (podzolic soil in the pine-birch forest) in Jeziórko. The investigated soils were not managed or reclaimed and underwent natural self-restoration processes. The podzolic soil profiles in forests neighbouring sulphur mine in Nemyriv and Jeziórko were not disturbed during sulphur excavation and were regarded as controls.

The increase of topsoil pH towards the natural forest is determined. All soils showed a typical increase of pH with depth 0 -10 cm and 10 - 20 cm. In Nemyriv the values of soil pH were about 3.03 - 3.13 and 3.23 - 3.63 at the distances of 20 m and 120 m from the boring well, respectively. Podzolic forest soil at the distance of 260 m from the border of the sulphur mine area showed pH of 4.26 - 4.51. In Jeziórko soil pH on the experimental plots located at 10 m and 40 m from

boring-well was 1.75 - 2.12 and 3.9 - 4.28, respectively; for comparison, control podzolic forest soil at the distance of 200 m showed pH of 4.6 - 5.1.

This unnaturally low reaction of technogenic soils left after sulphur mining by underground sulphur melting indicates that soil biological habitat was completely destroyed. Strong soil acidification caused the significant decrease of soil microbial biomass and afterwards it caused the decrease of soil respiration processes. In Nemyriv, the soils at the distances 20 m and 120 m showed the soil respiration activity of 1.91 - 1.74, and 1.64 - 1.25 mg CO2-C kg^{-1} 24 h^{-1} respectively. The soil respiration activity of the forest soil neighbouring sulphur mine in Nemyriv was relatively high, in upper and deeper horizon equalled to 4.73 and 2.91 mg CO2-C kg^{-1} 24 h^{-1}, respectively. In Jeziórko, the intensity of soil respiration was 4.23 - 2.54 mg CO2-C kg^{-1} 24 h^{-1} at the distance of 40 m and decreased down to 1.3 - 1.34 mg CO2-C kg^{-1} 24 h^{-1} at 10 m. Thus, the drastic, 5-16-fold lose of the soil respiration activity (in comparison to forest soil) was observed in upper horizons (0-10 cm) of soils located on the area closer to the boring well in Jeziórko: soil respiration activity of the control forest soil was 11.97 - 21.29 CO2-C kg^{-1} 24 h^{-1}.

The tendency to mitigation of unfavorable changes in soil parameters with increasing distance from the boring well was observed. Results of this study suggest that the low soil respiration activity in technogenic soils of the sulphur mining areas did result from a damage of soil microflora due to the detrimental conditions of polluted soil ecosystem, for example strong soil acidification.

SOIL PROPERTIES RETRIEVAL FROM SPACE

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Soil moisture (SM), land cover and soil surface roughness are key factors to understand water cycle and energy exchange between ground and atmosphere. In spite of this, the mentioned properties are measured only in local scales. SM has large spatial variability and measuring it in a classical way is very time consuming. The knowledge about relations between land cover, SM and soil surface roughness is strongly limited to particular types of environment. Therefore, extending it in the range of environmental diversity and large scales is a good motivation for interpreting satellite data. The basic advantages of this method are: a wide region of measurement, spatial continuity and a wide range of applications (cartography, surface deformation detection, crop production forecasting, land cover mapping, monitoring disasters such as forest fires, floods, etc.). The main disadvantage of satellite images interpretation is difficult analysis and uncertainty in absolute measures, which creates the need of ground measurements to validate satellite data (so-called “ground-truth problem”). One of Earth Observation satellites is ENVISAT (Environmental Satellite) with Advanced Synthetic Aperture Radar (ASAR) device on board. Radar is able to take pictures of Earth surface even at night or through thick clouds. Because of that radar observations can be lead almost continuously. The basic principle of interpretation of ASAR images is the knowledge about the influence of ground cover, incidence angle, presence of water and polarization. A rough object, for example forest, backscatters the radar beam and, because of that, gives more bright pixels on satellite image. Smooth surface of water or low vegetation gives dark spots as they reflect a radar beam instead of scattering it. An urban area gives very bright spots because of the effect called “corner reflection”. Water has big dielectric constant and hence moist soil scatters the radar beam better than the dry one. VV polarization of radar beam (vertical send, vertical receive) is used to detect vertical objects (for example trees), while HH polarization (horizontal send, horizontal receive) is more likely to obtain soil roughness and SM. Brightness of pixel depends on incidence angle in a complicated way. ASAR pictures must be geographical and radiometric corrected and processed by advanced algorithms of filtering and averaging.

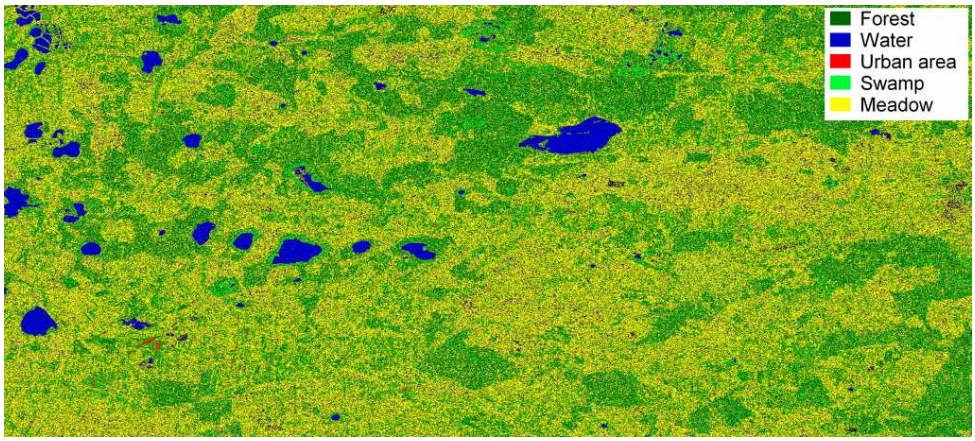

Fig. 1. Satellite image of Western Polesie after interpretation

Two ASAR pictures of Western Polesie, Poland (taken 24 May 2007 and 30 August 2007) were used to interpret some basic information about this region. It was divided into five basic classes of land cover: water, forest, meadow, urban area and swamp, as shown in Figure 1. These two images were also compared to observe changes during the vegetation season. The biggest changes were observed on cultivated fields. Special attention was paid to Piaseczno Lake and Usciwierz Lake because of their shore diversity. Piaseczno Lake shore was interpreted as a dry soil covered by high vegetation. Usciwierz Lake shore appeared in interpretation as a moist soil covered by low vegetation. These interpretations are confirmed because Piaseczno Lake has sandy shores covered by pines and Usciwierz Lake is surrounded by peat-land. Software tool used to satellite data interpretation was BEAM 4.1.1.

APPLICATION OF ELECTRICAL CAPACITANCE TOMOGRAPHY (ECT) TO MEASUREMENT OF SAND CONCENTRATION CHANGES DURING SILO FLOW

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Abstract. The paper presents results of solid concentration changes in bulk solids during granular flow in a cylindrical silo with an electrical capacitance tomography sensor located around the silo. During flow strong dynamic effects connected with booming sound occurred. Local 1D and cross-sectional 2D evolutions of solid concentrations in cohesionless sand during silo discharge were shown. The first ones were estimated directly from the raw measurement data and the latter were obtained from the reconstructed data by solving an inverse problem with a Linear Back Projection algorithm. The experiments in model silo were carried out with a different initial density of cohesionless sand and wall roughness.
Key words: silo, ECT, dynamic effects, tomography, concentration

INTRODUCTION

Operational safety of silo constructions is connected with the knowledge of the distribution of the bulk solid pressure on the silo walls during emptying. It is important when discharging tall steel and aluminium silos wherein strong dynamic effects take often place as a result of a dynamic interaction between flowing solid and silo structure (Tejchman 1992, Wensrich 2002). An estimation of pressures on silo walls is complicated due the presence of strain localization in the form of wall and internal shear zones. Moreover, internal shear zone cause a flow non-symmetry. The thickness of shear zones depends mainly of the initial bulk solid density, wall roughness, pressure level and emptying velocity. To describe theoretically the behaviour of the bulk solid during flow in silos, it is of major importance to know the distribution of its density.

In the paper, the results of solid concentration changes during silo flow obtained by the ECT method (Pląskowski et al. 1995) are demonstrated. The tests were performed with a model silo containing cohesionless dry sand. The influence of the initial sand density and silo wall roughness on the concentration changes during silo emptying was investigated.

EXPERIMENTAL SET-UP AND ECT METHOD

Tests were performed with a cylindrical perspex model silo (diameter 0.2 m, height 2.0 m, wall thickness 0.005 m) containing cohesionless, dry sand with a

mean grain diameter of 0.8 mm. The silo was fixed at the bottom by a steel rigid frame structure. Sand was initially loose or dense. Tests were performed for gravitational outflow (diameter of the symmetric outlet was 0.07 m). The experiments were carried out with smooth and very rough silo walls. During test with smooth walls, strong dynamic effects (called silo music) due to a dynamic interaction between solid and silo structure occurred in the upper part of the silo from the beginning of the silo discharge during mass flow. They disappeared in the lower part of the silo when funnel flow took place (Niedostatkiewicz and Tejchman 2003).

The ECT method is based on the registration of inter-electrode capacitances allowing us to determine the distribution of the electrical-permittivity inside the sensor (Chaniecki at all 2006). The measurements of solid concentration changes were registered at the heights of h=0.3, 0.85, 1.0, 1.5 m above the silo bottom. The ECT system was equipped with two sensors consisting of 12 electrodes each surrounding the silo. The solid concentration changes were expressed by a relationship between the solid area in the selected cross-section to the area of the entire silo cross-section in the form of 1D plots (based on the raw data) and 2D images (based on the reconstructed data). The plots were presented for two different profiles: cross-sectional and along the wall perimeter. On the 2D images, the continuous changes of the solid concentration in the cross-section at the selected height above the silo bottom were shown during the entire flow.

TEST RESULTS

The test results are shown for a model silo with smooth walls at the height of h=1.0 m above the silo bottom (where mass flow changed into funnel flow), Fig.1. Initially loose sand globally experienced mainly contractancy and initially dense sand dilatancy. At the height of 0.3 m above the bottom, initially loose sand underwent in its cross-section first contractancy (the average solid concentration increased maximum by 8% with respect to the initial value) and then dilatancy due to funnel flow (the average solid concentration decreased maximum by about 3%), and along the silo perimeter only contractancy (the average solid concentration increased maximum by 10%). At the height of 1.0 m and 1.5 m above the bottom, initially loose sand experienced only contractancy; the average solid concentration increased by about 12%-15% in its cross-section and 3%-10% along the silo perimeter. Initially dense sand at the height of 0.3 m underwent first significant dilatancy (the average solid concentration decreased 20% in its cross-section and 10% along the silo perimeter). Afterwards, it was subject to alternating contractancy and dilatancy (the solid concentration globally increased). At the height of 1.0 m it behaved similarly, however the

corresponding concentration changes were smaller. In turn, above 1.5 m, sand first contracted and later dilated in its cross-section, and only dilated at the walls. Flow was always non-symmetric with pronounced pulsations of the solid concentration in the upper part of the silo independently of the initial density due to dynamic effects.

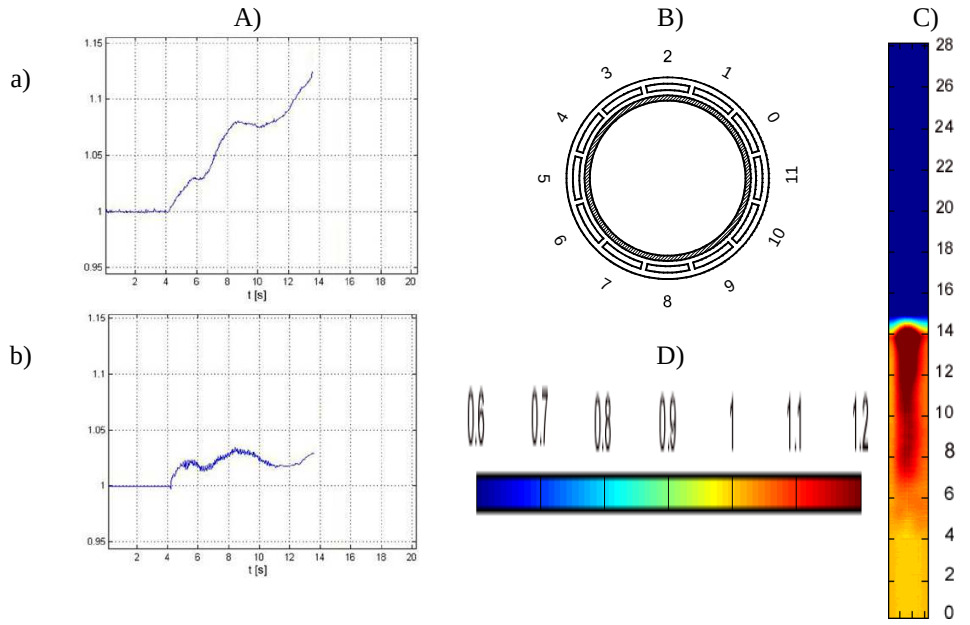

Fig.1. Concentration of initially loose sand during silo emptying at height h=1.0 m above the silo bottom (smooth walls): A) average between electrodes profiles: a) cross-sectional, b) next to the wall, B) location of outside electrodes, C) 2D visualization of concentration change of sand during silo emptying t=0-28 s, D) colored scale of concentration changes.

CONCLUSIONS

In this paper, an improved tomography system for imaging permittivity distributions based on ECT sensor has been applied to image solid concentration changes during confined granular flow in a cylindrical model silo.

The ECT method enabled us to quantitatively measure the solid concentration changes of a bulk solid at two locations at the same time during granular flow in a model silo. The results were demonstrated as continuous 1D curves showing the evolution of the solid concentration between arbitrary electrodes or 2D reconstructed cross-section images. The differences of the sand concentration between the raw data and the reconstructed data existed mainly in loose sand in cross-sectional profiles. The results based on the raw measurement data seem

more accurately in the wall regions, as compared to 2D images which include reconstruction mistakes. The results of sand concentration changes obtained with the improved tomography were by 5-15% smaller. The used tomography system allowed us to measure smaller concentration changes as compared to those with a previously applied ECT tomograph. The sand behavior during silo flow was strongly influenced by its initial density and wall roughness. Initially loose sand globally experienced mainly contractancy and initially dense sand only dilatancy. Flow of initially dense solid was more non-uniform and non-symmetric. The concentration changes and their oscillations were also larger in initially dense solids. The solid concentration varied during the entire flow.

Close to the wall, initially loose sand contracted at the wall at smooth walls and dilated at very rough walls. In turn, initially dense sand experienced dilatancy independently of the wall roughness.

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EFFECT OF OUTLET VELOCITY OF BULK SOLIDS ON LOADS IN SILOS

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Abstract. The paper presents the effect of the outlet velocity on loads in a cylindrical model silo. Tests were performed with dry cohesionless sand during controlled outflow. The outlet velocity was varying. The resultant vertical bottom force was measured.
Keywords: granular flow, loads, silo, control outlet velocity, sand

INTRODUCTION

Granular materials which play an important role in many branches of our industries, such as mining, agriculture and construction are large conglomerations of discrete macroscopic grains in contact and surrounding voids whose interaction determines the material behaviour (Jager et al. 1996). Granular materials are primarily dissipative and non-thermal systems. Their micromechanical behaviour is inherently discontinuous, heterogeneous and non-linear. In granular flows, there exist three well-defined asymptotic regimes: rapid flows where internal stresses are mainly due to collisions between grains where the material behaves like a dissipative gas, quasi-static flows where stresses are principally due to friction between particles where material behaves like a solid and transitional moderate flows where the material behaves like a liquid. The dominating mechanism in the solid-like regime is frictional, while the fluid-like behaviour is primarily viscous. The behaviour of granular materials exhibiting fluid-like or dynamic behaviour is of importance in numerous engineering problems, e.g. bulk solid handling, debris flow, bed transport and fluidization. To describe the behaviour during rapid and moderate flow, different models are used, as: kinetic-theory (Jenkins and Savage 1983), discrete element method DEM (Ahn 2007) and continuum models (Rombach 1991, Mohan et al. 2002, Tejchman and Klisinski 2002). To describe the behaviour in the quasi-static regime, continuum models are mainly used. The viscous behaviour differs from that of Newtonian fluids in several aspects, e.g. the dependence of viscosity on the volume fraction of granular materials.

There is an extensive experimental data base on the flow properties of non-cohesive granular materials (Bagnold 1954, Hanes and Inman 1985, Löffelmann 1989). The experiments show that the dependence of the shear and normal stress on the shear rate is mainly linear at low shear rate and quadratic at high shear rate.

However, according to Hungr and Morgenstern (1984), the stress ratio is not affected by variation of the shear strain rate.

The intention of the paper is to demonstrate the effect of inertial forces expressed by the outlet velocity on loads during granular flow in a cylindrical model silo wherein outflow was controlled. The experiments were performed for different initial densities of cohesionless dry sand. In experiments, the resultant vertical force on the silo bottom was measured during filling and emptying.

EXPERIMENTAL SET-UP

Tests were performed with a cylindrical perspex model silo (diameter 0.2 m, height 2.0 m, wall thickness 0.005 m) containing cohesionless, dry sand with a mean grain diameter of 0.8 mm. The silo was supported at the bottom by a steel rigid frame structure. Sand was initially loose (volumetric weight γ=15.0 kN/m^3, void ratio e_0=0.76) and dense (γ=16.5 kN/m^3, e_0=0.61). Tests were performed for controlled outflow where the diameter of the bottom plate was equal to the silo diameter. The velocity of the vertically moving bottom was in the range v=0.05-10 mm/s. In the first step, the experiments were carried out with smooth walls. The weight of sand in the model silo during filling was 852 N (initially loose sand) and 900 N (initially dense sand).

TEST RESULTS

The evolutions of the resultant vertical bottom force P versus bottom displacement u is shown in Fig.1 for 4 different velocities (initially loose sand). In turn, Fig.2 demonstrate the effect of the bottom velocity v on the resultant vertical bottom force P.

During outflow, the force P decreases first, then slightly increases and afterwards approaches its residual value. The force drop increases with increasing outflow velocity v. The amplitudes increase also with increasing v.

CONCLUSIONS

Our model tests demonstrate that the effect of inertial forces and viscosity on the granulat flow behaviour in silos is pronounced.

An increasing outlet velocity causes an increase of the drop of the resultant vertical bottom force and an increase of the resultant wall friction force.

The amplitudes of the resultant forces in a silo increase with increasing outlet velocity.

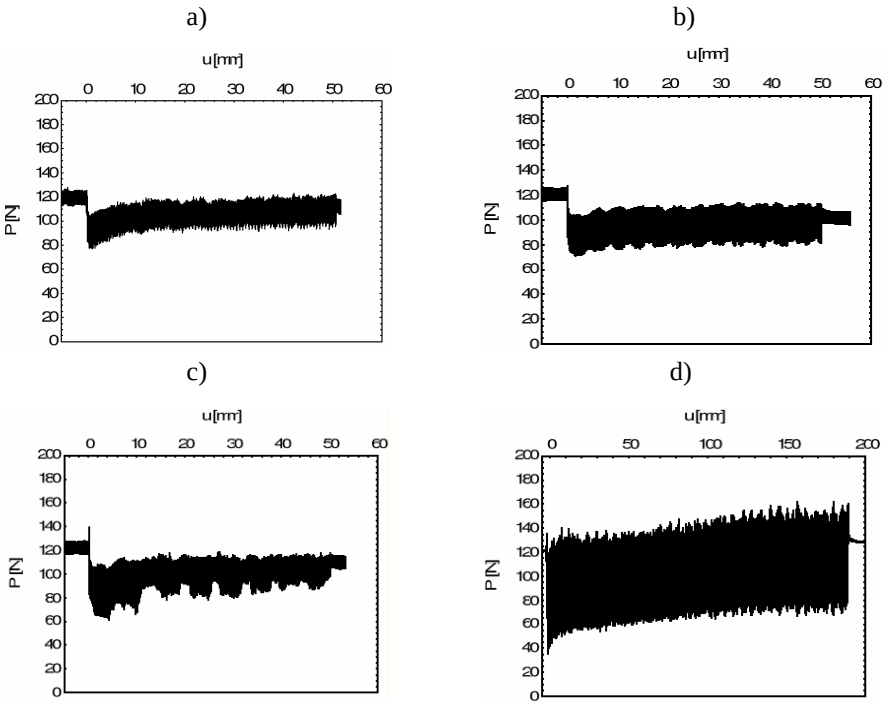

Fig.1. Evolution of the resultant vertical bottom force *P* during controlled outflow for different outlet velocities: a) *v*=0.08 mm/s, b) *v*=0.5 mm/s, c) *v*=0.8 mm/s, d) *v*=10.0 mm/s

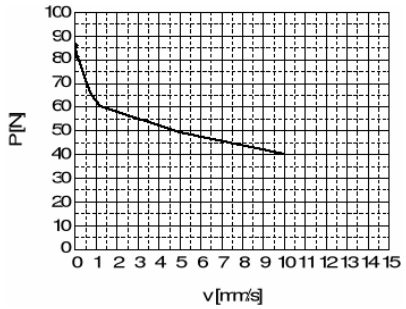

Fig.2. Effect of the bottom velocity *v* on the minimum resultant vertical force *P* (initially loose sand)

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CRITICAL VALUES OF SOIL PARAMETERS INFLUENCING N_2O EMISSION FROM SANDY LOAM SOILS DURING GROWING SEASON

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Nitrouse oxide (N_2O) is a powerful greenhouse gas. Most of N_2O is produced in soils as a result of biological processes of nitrification and denitrification. Emission of N_2O from soils is strongly affected by N-fertiliser and manure application, as well as such soil properties as temperature, water-filled pore space (WFPS), amount of soil available nitrogen, and available soil organic matter.

To find out critical values of above-mentioned soil properties for N_2O emission from sandy loam soils of North-Western Russia a field experiment was carried out in St. Petersburg region (59°34'N, 30° 08'E) during growing seasons in 2003 - 2007.

The soil of the region was a loamy sand Spodosol. Different crops were grown on the plots during the whole experiment – barley, cabbage, carrot, grass-clover mixture, potato, and oat-legume mixture. Bare soil was also included into the experiment. Different rates of nitrogen (N) with mineral fertilisers, green and farmyard manures were applied into the soils in different years. Plots where no N was applied were used for control. In 2005-2007 different plots of the experimental soil contained different amount of soil organic carbon (SOC) due to earlier application of high rates of FYM in the soil of some of them.

The closed chamber technique was used to measure direct N_2O fluxes from the soil with chamber area being 0.03 m^2 (Buchkina et al., 2006). Gas samples were collected two-three times a week throughout the growing seasons (May – September). Four replicate chambers were used on the barley, oat-legume mixture, grass-clover mixture, and bare plots while eight chambers (four in furrows and four on ridges) were used on the cabbage, carrot, and potato plots. Gas samples were collected into airtight glass vials and transported to the laboratory where amount of N_2O was measured with a GC fitted with an ECD.

SOC content, soil total N content, amount of soil available nitrogen, soil bulk density, soil water content were measured with conventional methods. Soil WFPS was calculated using data on soil water content, bulk density and specific density. All the necessary meteorological data were received from the Menkovo meteorological station of the Agrophysical Research Institute situated near the experimental fields.

Effect of SOC content on N_2O fluxes was most pronounced in wet growing seasons and only if extra mineral nitrogen was applied into the soil. For example, during a wet growing season of 2005 the soil containing 21 g C kg^{-1} soil of SOC emitted twice as much of N_2O as the soil containing 17 g C kg^{-1} soil of SOC. While the same two soils in a dry growing season of 2006 produced the same and very low amount of N_2O in spite of the fact that high rate of N-mineral fertiliser was applied into the two soils both in 2005 and 2006 (Buchkina et al., 2008 Rizhiya et al., 2008).

Results received in the field experiments for 5 years shown that daily N_2O emission from the soil was strongly affected by the amount of soil available nitrogen. N_2O fluxes were never higher than 5 g N_2O-N ha^{-1} day^{-1} if amount available nitrogen in the soil was less than 10 mg kg^{-1} soil. Application of mineral fertilisers in most of the cases had stronger positive effect on N_2O emission from the soil than application of green manures. The main reason for that presumably was that mineral fertilisers were releasing available nitrogen into the soil immediately after they were applied into the soil while green manures were releasing N into the soil much slower. In our experiment N_2O fluxes never increased dramatically immediately after green manure application in the soil even if amount of N applied was about the same as with mineral fertilisers. Effect of fertiliser/manure application on N_2O emissions depended very much on such soil properties as water content and soil WFPS. If the soil was dry with about 20 to 30% of WFPS, N_2O fluxes were never very high, even after application of high rates of N with mineral fertilisers.

Soil temperature and WFPS were affecting N_2O flux only if the soil contained more than 10 mg kg^{-1} soil of available nitrogen. In this case high daily N_2O fluxes from the soil were found only if soil temperature was higher than 10^oC and WFPS was higher than 60%. For those plots where soil contained low amount of available nitrogen changes in soil temperature and soil WFPS did not affect N_2O fluxes too much during growing seasons of 2003 - 2007.

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MOISTURE CONTENT MEASUREMENT BY AN UNUSUAL METHOD

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The solar energy is optimal for the low speed drying of the agricultural products, which is essential for the proper quality conversation in a lot of cases. The rate of the drying can be checked generally by methods which need human interaction (e.g. weight measurement or fast moisture content measurement). In this paper a fast, automatic method is introduced where the moisture content is determined in optical way, by the analysis of a web camera picture of the product during the drying. The method is to be applied for blackthorn drying.
Keywords: solar energy, drying, moisture content, computer aided image analysis

INTRODUCTION

The use of the solar energy is getting a greater importance in the agriculture. At the same time the quality control and quality preservation becomes also more and more important items for processing of agricultural products. A traditional and very widely used product preservation is the drying. However, the attractiveness of drying methods can be improved by using advanced control and optimization techniques for reducing the energy consumption. These methods can only be applied if sufficient information is collected on the interaction between the drying conditions and the change of product properties.

This paper deals with the experiences concerning to solar energy assisted blackthorn drying, controlled by computer aided image analysis process.

MATERIAL AND METHOD

The solar dryer planned for such purposes has three main parts: a dryer (drying cabin) with different trashes for the different products; a PV module with an electrical fan for artificial air circulation and, an air solar collector is attachable to the dryer for preheating the inlet air.

The moisture content of the blackthorn to be dried was measured by traditional way. The image analysis was carried out by using a PC camera. The recorded pictures were analyzed by computer program coded in C++.

The routines of the program can calculate the area, the contour of the products perpendicular to the direction of the image taking, and for the approximately volume of the blackthorn was calculated. These calculations were done with different image analyzing methods, as follows: colour → gray scale conversion, histogram, segmentation, outline, area and volume calculation and contour search.

RESULTS

- The changes of the area, the outline and the average diameter of the blackthorn and the moisture content are graphed in the Fig. 1.

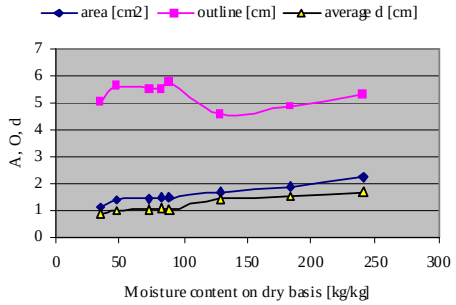

Fig. 1. Outline, area and volume of blackthorn

- The change in the perpendicular area (Fig. 2) of the blackthorn is figured against the moisture content.

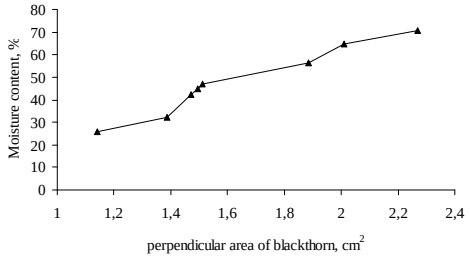

Fig. 2. The perpendicular area of blackthorn vs. moisture content

CONCLUSIONS

It can be concluded that the changes in the perpendicular area and in the average radius follows the changes in the moisture content by a quasi linear function.

It can be stated that the change of the outline does not follow the change of the moisture content because of the changes in the smoothness.

During the analysis a mutually univocal connection was established between the moisture content of the product and the perpendicular area as well as the moisture content and the smoothness of the blackthorn. Based on such relations an optical moisture content measurement can be applied successfully.

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MULCHING AND SOIL COMPACTION EFFECTS ON SOYBEAN YIELD AND NODULATION

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Plant growth and yield largely depend on soil properties. Mulching improves numerous soil physical properties (moisture, water infiltration and percolation, temperature, helps prevent crusting), chemical (increase of some nutrients and organic matter content) and biological. With respect to soybean a very important function of mulch is creating favorable conditions for the soil bacteria that contribute to increase nodulation of soybean root system and thus symbiotic nitrogen fixation.

New developments in agricultural equipment allows for more economical crop production by reducing labor costs and increasing farm size but simultaneously it leads to formation excessive soil compaction in root zone. This results in changes of soil physical parameters: pore size distribution, aeration, water content, strength and temperature that directly affect root growth and function. Common root response on excessive mechanical impedance as shallow rooting depth and change in root distribution in soil profile results in smaller water and nutrient uptake from deeper layers and consequently in reduction of yield. While moderate soil compaction contribute to increase of nutrient uptake through increase contact between soil particles and root system especially during dry seasons, excessive compaction in dry soil restricts root penetration. In wet conditions soil compaction limits plant growth because of poor aeration and oxygen stress in root zone.

Soybean is an important source of high quality but inexpensive protein and oil in seeds. From the agricultural and economical point of view soybean is valuable plant because of symbiosis with nitrogen fixing bacteria *Bradyrhizobium japonicum*. However soybean is sensitive to drought and soil compaction. The most sensitive periods to water deficit occur at bloom and pod growth stages and at the same time they most affect soybean yield.

Influence of both mulching and soil compaction on plant growth and soil properties is dependent on weather conditions during growing season.

Our objective was to determine the effect of soil compaction and mulching on soybean yield and nodulation.

Study was carried out in 2007 at the experimental field of the Lublin Agricultural University in Felin , Poland. The soil was silty loam (Orthic Luvisol) developed from loess. The experimental area was 192 m^2 divided into 3 sections consisted of 6 micro-plots (7 m^2). Three degrees of soil compaction obtained in each field part through tractor passes were compared: low, medium and heavy. This resulted in a wide range of soil bulk density (1.2 to 1.65 Mg m^{-3}). Soil was compacted 2 weeks before sowing. Soybean "Aldana" seeds were inoculated with *B. japonicum* and were sown with interrow spacing of 0.3 m. Wheat straw was uniformly spread on the half of each micro-plot at an amount of 0.5 kg m^{-2} after sowing. Plants were collected at harvest and plant height, number of pod and seed on plant were determined. Soil samples for nodule measurements were taken from the rows and interrows. A probe with a sampling tube 10 cm long and 7 cm in diameter was used for sampling. The samples were taken to a 40 cm depth in 10 cm intervals. Nodules were separate from the roots, then washed and nodules number and fresh and dry mass after drying in 65 ^{O}C for 48 h was defined.

Soil water content was measured with TDR probes at depth 0-5, 10-15, 25-30 and 50-55 cm. Soil temperature was measured with thermocouples at depths 2, 5, 10, 20, 30, 50, 70 and 100 cm on selected micro-plots, equally represented by all compaction and mulch treatments. The penetration resistance (MPa) of the soil was measured to a depth of 80 cm three times during soybean growing season.

The results of our study indicate that mulch can improve soybean yield and nodulation to various extent depending on soil compaction level. Combination of both factors at optimal level can increase the amount of biologically fixed nitrogen. This results in reduction of nitrogen fertilization and restriction of environmental contamination caused by leaching and nitrous oxide emission.

APPLICATION OF LOW-TEMPERATURE NITROGEN ADSORPTION AND MERCURY POROSIMETRY FOR STARCH ANALYSIS

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INTRODUCTION

Porosity and surface area are important characteristic of solid materials that determine their properties eg. thermal conductivity, thermal diffusivity, mass diffusion coefficient, as well as mechanical and textural properties. Starch is the major energy reserve in higher plants and the main carbohydrate in human diet. It is laid down in the form of granules of different size and shape which are dense (1500 kg m^3) and insoluble in cold water. Starch researchers referred the presence of pores on the surface of granules and suggested that they significantly influence chemical reactivity of starch and may be the site of initial enzyme attack.

Structure and properties of starch are usually changed before application with the help of various modifications eg enzymatic hydrolysis. In the food industry starch is a very valuable functional ingredient which is added to sauces, confectionery, comminuted meat and fish products and a variety of low-fat products. It increases their viscosity and stability, and improves fat- and water-binding properties. Starch granules are also utilized for non-food applications such as: plastic fillers, facial powders or carbonless copy paper. Recently, interest has become focused on starch as an adsorbent for volatile compounds and a fat substitute. For these applications microporous starches can be used. They are obtained from native starches hydrolyzed by α-amylases at temperatures lower than gelatinization temperature. Among methods used to examine starch materials and their porosity the most common are: scanning electron microscopy (SEM), transmission electron microscopy (TEM), atomic force microscopy (AFM), mercury porosimetry and methods based on physical adsorption from gaseous phase or liquid phase (eg low-temperature nitrogen adsorption). A parameter which is mainly used for determination of starch porosity is specific surface area which is defined as the actual surface of the adsorbent per unit mass and is usually expressed in m^2g^{-1}. It includes the external as well as the internal surface of the starch granules.

The aim of this work was to characterize porosity of starches of various origin in their native form and after α-amylolysis using low-temperature nitrogen adsorption and mercury porosimetry.

MATERIALS AND METHODS

Corn, wheat, rice (Sigma–Aldrich Inc., MO, USA) and potato (WPZZ Luboń SA, Polska) starches, were hydrolyzed with the use of partially purified α-amylase from *Bacillus subtilis* at 50°C for 15, 30 and 60 minutes. The specific surface area, mesospore volume and average pore diameter were estimated using an apparatus ASAP 2405 (Micromeritics Inc., USA). Samples of native and hydrolyzed granules were dried for 24 hours in vacuum at 100°C, automatically desorbed and flushed with pure helium. Measurements involved determining the isotherms of adsorption of high-purity nitrogen at temperature of 77.3 K. The monolayer capacity was calculated on basis of BET adsorption isotherm (Brunauer *et al*. 1938) from five measurement points in the relative pressure range p/p_0 0.006-0.2. Pore characteristic was determined according to BJH method (Barret *et al*.1951).

Application of mercury intrusion porosimetry allowed to estimate porosity, average diameter and cumulative area of pores present in the starch material, as well as cumulative area of intergranular pores. The measurements were carried out using Autopore IV 9500 (Micrometric, USA). Samples (1g) were dried at 105°C, placed in a dilatometer, outgassed under high vacuum and filled with mercury under the pressure varied from 0.0036 to 413 MPa.

RESULTS

It was found that native starch is a macropored material with a small participation of mesopores. In case of native starches, the highest value of S_{BET} was obtained for rice starch (1.27 m^2g^{-1}) and the lowest – for potato starch (0.14 m^2g^{-1}). After 60 min. of enzyme action, surface area of all starches doubled in comparison to native ones. The average diameter and cumulative volume of mesopores also increased. Results of porosity determinations by mercury porosimetry showed that the values of this parameter for examined starches only slightly changed after the process. The average diameter of pores present between the granules decreased which indicated that size of starch granules also decreased as a result of α-amylolysis. The results obtained by the both methods proved that starch granules contain surface pores and α-amylase action affect their number and size.

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STUDY OF HEAVY METAL CONTAMINATION IN LAKE NEAR "SZABOLCSVERESMART"

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Several heavy metals are essential for living organisms; however others are toxic even in small concentrations. They may influence the soil-water-plants-animals-human food chain, because they affect the enzymatic and physiological processes. At the beginning, the living beings react upon the increased load of heavy metals by metabolism and function disorders, later by evolutionary and reproductive disorders. The experimental and theoretical studies of the accumulation and transport processes have great importance. Therefore those examinations are very important for studying the concentration of the heavy metals in soils and water in the nature. A lake near Tisza, Hungary (Szabolcsveresmart**)** was examined from this point of view. Several heavy metal (Pb, Cd, Fe, Zn, Mn, Cu) content in sediment and water of the lake were measured by Flame Atomic Absorption Spectrometry (FAAS).
Keywords: environmental pollution, heavy metal, FAAS

INTRODUCTION

Nowadays, one of the most important problem in environmetal protection is the heavy metal contamination (Bálint et al. 2007). The concetration of heavy metals in sediments of the lake "Veresmart", soils and water samples near Szabolcsveresmart are investigated. While this lake works as reservoir of river "Tisza", and the considerable part of his water quantity derives from the river, the heavy metal which can be found in the river may settle and accumulate. Since the river is in agricultural usage, it is important to establish the possible heavy metal contaminants, because they can be incorporated into the food chain.

MATERIALS AND METHODS

The sampling and the examinations were done according to specifiations "MSZ 21470-1:1998 and MSZ 1484-3:1998". Firstly, the sampling net was planned (see on Fig.1.). The soil, sediment and water samples were collected by suitable spit. The samples were digested by microvawe digestion system (Milestone 1200 mega). The element analyses were realized by Unicam 939 FAAS (Flame Atomic Absorption Spectormeter).

The measured heavy metals were: Pb, Fe, Mn, Zn, Cu, Cd. The pH of the soil and sediments samples and their dry matter content were measured respectively.

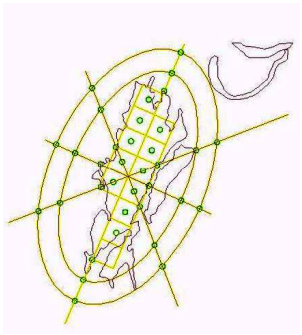

Fig. 1. Sampling net at Lake near Szabolcsveresmart

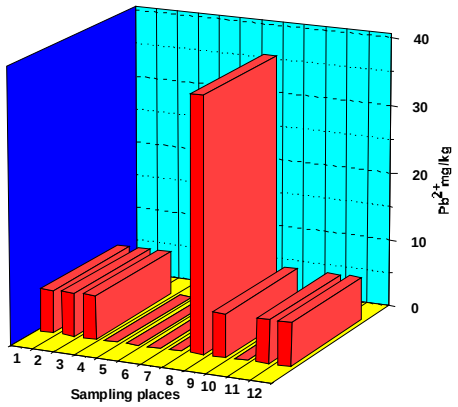

Fig. 2. Concentration of lead in soil and sediments int he lake (24.04. 2007.)

RESULTS

Preliminary examinations were made on spring in 2007. The results were compared to the actual investigations. In this paper the Fig. 2. shows the lead concentration of examined samples. The preliminary examinations showed, that considerable Pb exceeding the limit value concentration was not observable.

CONCLUSIONS

According to our results, a big amount of heavy metal accumulation was not found. But Fig. 2. shows that there are significant differences between heavy metal concentrations in soils and sediments. That's way the newest examinations find fully the distribution of heavy metal contamination in the lake.

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SIGNIFICANCE OF EXTRUSION PROCESS FOR QUALITY PROPERTIES OF RAPESEED CAKE

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In recent years, both in Poland and in Europe, rapeseed cakes are more and more frequently utilized in feeding farm animals, mostly as a source of energy and proteins. Rapeseed cakes commonly used as protein source in livestock feeding are limited by antinutritive substances. One way of improving its nutritive value is extrusion processing of the cake mixed with other ingredients. Some toxic substances may be decomposed during the process [4, 5]. As the awareness of food quality and the concern about food safety have increased, the food and feed industries were forced to place more emphasis on the consistency of product quality. Food and feed processing has become of considerable importance in resent years. Therefore extrusion technologies have important role in food industry as an efficient improvement of manufacturing processing of food and feed quality. Extrusion processing equipment has become the standard in many food industries throughout the world [6].

Extrusion is a process in which food or feed ingredients are forced to flow, under one or several conditions of mixing, heating and shearing, through a die that forms or puff-dries the ingredients. Extrudates can be visualized as devices that can transform a variety of raw ingredients into intermediate and finished product. During extrusion the use temperature can be as high as 180-190^{o}C, but residence time is usually only 20-40 seconds. For this reason, the extrusion process can be called a high temperature short time (HTST). Extrusion improves quality of extrudates because cooking is done in a very short time and less destruction of heat sensitive ingredients occurs in comparison to other processes [3].

The material used in the study was rapeseed cake from the Oil Industry. Extrudates of rapeseed oil cake and wheat meal (50:50) and of rapeseed oil cake alone were produced at the Faculty of Process Engineering, University of Agriculture in Lublin. A twin-screw extruder was used, type 2S–9/5, made by Metalchem. Extrusion was performed at worm speed of 100 rpm (worms with ø = 4 mm) and with the process temperature set to 130-160°C. The duration of extrusion was 40 s and 80 s. The basic chemical composition and profile of fatty acid in raw fat were determined in extruded rapeseed cake and native rapeseed cake. The research method included the determination of the basic chemical composition of the material (proteins, fats, ash) using the AOAC methods [1]. Crude fibre content was determined by means of the detergent method acc. to Georgin and Van Sjest [2], using the Ankom^{220} Fiber

Analyzer, assaying the fibre fractions (NDF, ADF, ADL). Fatty acid determinations (FA) were made with the technique of gas chromatography, using the Varian CP-3800 apparatus, under the following conditions: capillary column - CPWAX52CB; DF - 0,25 μM; FID detector; carrier gas – carrier helium; flow rate – 1.4ml/min; temperature of column - 120; temperature of injector and detector – 260^0C.

The study has shown that the content of total proteins and raw ash in dry mass was fairly stable in the extrudates product and comparable with native rapeseed cake. There was a reduction in the content of free fats and raw fibre in dry mass of the extrudates product. This may indicate that approximately 30% of raw fat may have been bound in insoluble protein-lipid complexes in the extrudates. The reduction in the content of raw fibre, on other hand, may be indirectly attributed to decomposition of insoluble hemicelluloses-lignin fraction, which could result that a part of the fraction of soluble celluloses was determined in nitrogen-free extract compounds. The process of extrusion had also an effect on decrease in changes in the content of acids from the group of saturated fatty acids – palmitic acid and stearic acid.

Investigation has shown that extrusion process exerted a very significant influence on quality of rapeseed cake. The lowest time of extrusion process (40s) had better influence on quality of rapeseed cake. The application of rapeseed cake for fodder will also permit for limitation of imports of much more expensive soybean, both to Poland and to other EU countries. The growing importance of rapeseed-based fodders and fodder concentrates gives Poland an opportunity to increase in utilization of the extrudates in Food and Feed Industries.

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INFLUENCE OF APPLICATION OF CHEMICAL AGENTS (GROWTH AND RIPENING REGULATORS) ON THE YIELDING OF RAPESEED

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Investigating the mechanical property changes of cliques and stalks as well as the chemical ones of rape seeds during their development (in terms of technological processing optimization) allow minimizing the quantitative and qualitative losses of seeds at the latest stage of rape maturation and during harvest. Cliques cracking and seeds shedding during the final phase of rape maturation and harvest cause considerable losses, making rape cultivation less profitable. Studies conducted for many years proved that the problem is of great importance and its elimination or even limitation will result in millions of tons of additional amounts of valuable plant material.

The variety of rape high economic value and simultaneously desirable reaction on the certain agricultural conditions affect a substantial part of the plant production technology, and it is also an important factor influencing the yield and quality of crop. The proper selection of the rape variety to be grown in large farms is one of the most important factors impacting the planning and work organization while nurturing and harvesting and also on the quality of crop.

All known varieties of the winter oilseed rape prove to be well adapted to very intensive cultivation. It means that they have a very high productivity potential but also higher demand for proper agricultural practice. The possibility of high yield depends on a proper agricultural practice in which an important factor is the right application of insecticides and fungicides. In addition, the use of regulators of growth and ripening of plants decreases the losses of harvest.

Investigations were conducted at the Experimental Station for Variety Testing in Głębokie on 3 varieties of winter oilseed rape, for two years, from 2004 to 2006. The experiment was performed at 4 replications. The plot area for each variety (11 x 1.5 m) at the time of vegetation period was treated by chemicals. To improve the characteristics of pods before the cracking process, the following pesticides were used :Spodnam 555 SC - 0,6 l/ha, Reglone 200 SL – 2,5 l/ha) and Roundup 360 SL – 1 l/ha were applied. Also, the fertilizers such as Photrel 6 kg/ha, Bortrac 1,5 l/ha and Plonvit R 2 l/ha were applied.

The obtained results specify that the delay of harvest of rape has a substantial influence on the yield of seeds. The application of Caramba (especially in the

variant of B and C) had a substantial influence on the yield growth (about 5-6 q/ha) at collections in an optimum term, and even stronger in the detained term

The applied regulators of ripening (Reglone and Roundup) had a negative influence on the yield growth, causing its decrease of about 2-3 q/ha

The applied chemicals modified MTS only in an insignificant way (statistically unimportant) Substantial differences were found only between control and combination where Roundup was applied – but only in the second term of harvest. The meaningful decrease of MTS was also found in the combination where Reglone was applied. However, it was statistically insignificant.

The most useful conditions influencing MTS appeared in 2004. MTS, in 2004, was significantly higher in comparison with 2005 as well as 2006 (when seed ripness was the worst).

DIFFERENTIAL SCANNING CALORIMETRY OF POLYSACCHARIDES

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Differential scanning calorimetry (DSC) seems to be a suitable method for polysaccharide identification. Various types of these biopolymers as well as their derivatives can be distinguished by DSC according to the mechanism of their decomposition. Specific structural properties (monosaccharide distribution, molecular size, branching, geometry of glycosidic bonds, anomeric configuration etc.) and presence of characteristic functional groups (carboxyls, organic and inorganic esters, amino groups etc.) cause various events on DSC curves of polysaccharides that could be useful for their discrimination. The DSC measurement were performed on DSC 131 (Setaram France) in temperature range 20 – 700 °C with the heating rate 10 °C·min^{-1}

Keywords: polysaccharides, differential scanning calorimetry.

INTRODUCTION

Differential scanning calorimetry (DSC) belongs to the group of thermo analytical methods. DSC measures the heat effects, caused by chemical or physical changes, as a function of temperature or time while the substance is heated at a uniform rate.

DSC seems to be a suitable method for polysaccharide identification. Various types of these biopolymers as well as their derivatives can be distinguished by DSC according to the mechanism of their decomposition. DSC measurement of polysaccharides in an inert atmosphere leads to the observation of both endothermic and exothermic events. DSC curves usually have several peaks, the first of which is caused by the evaporation of water. From the first peak we can assume the hygroscopic capacity of the material. It is possible to integrate the area and get the amount of enthalpy of the process. The other peaks are related to the decomposition of polysaccharides. Endothermic peaks may result from the subsequent fragmentation of polysaccharide chains with the formation of char and volatile products, whereas exothermic peaks may correspond to cross-linking reactions that occur during the thermal degradation and the following thermal degradation of a new cross-linked material. The DSC curves are influenced by the polysaccharide structure: the branching, type and position of glycosidic bonds, molecular weight, functional groups attached to the chain, etc. All peaks are possible to integrate and to determine T_{onset}. T_{onset} is the point of intersection of the tangent drawn at the point of the greatest slope on the leading edge of the peak with the extrapolated baseline.

MATERIAL AND METHOD

Selected polysaccharides (cellulose, starch, amylose, amylopectin, chitin, chitosan, pectin, locust gum, guar and xanthan) and their derivatives (methylcellulose, carboxymethylcellulose) were analyzed. These polysaccharides are important in the food-processing industry. All samples were analyzed in a nitrogen atmosphere, temperature range 25 – 700 °C with the heating rate 10 °C·min^{-1} on DSC 131 (Setaram France).

RESULTS AND DISCUSSION

The hydrophilic carboxylic group significantly influences the hygroscopic capacity of polysaccharide which corresponds to our results. The highest amount of moisture was present in pectin and the lowest amount in cellulose.

The main aim was to record the thermal decomposition of polysaccharides and their derivatives in an inert atmosphere. All samples, except guar and locust gum, displayed strong endothermic or exothermic characteristics. It was discovered that the presence of carboxylic group causes exothermic degradation. The carboxylic group occurs in pectin and carboxymethylcellulose. Chitosan also degrades exothermically although it doesn't contain a carboxylic group. The exothermal degradation of chitosan is caused by free aminogroups. The other polysaccharides decompose by depolymerisation. The elimination of water and the origination of monomeric and oligomeric anhydrosugars are characteristic for this type of decomposition. This type of decomposition is an endothermic process. The exception is starch, which decomposes at first endothermically and then exothermically. The amylopectin also exhibits the exothermal event after endothermal event, but not as significantly as starch. In comparing the T_{onsets} that were, the linear chains are more thermo stable than the branched ones, and the polysaccharides with endothermic degradation are more thermo stable than the ones with exothermal decomposition.

CONCLUSION

Specific structural properties and the presence of characteristic functional groups cause various characteristics on polysaccharides DSC curves that could be useful to distinguish them.

ACKNOWLEDEMENTS

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STUDY OF ELECTROCHEMICAL PROPERTIES OF SOIL ORGANIC MATTER BY POTENTIOMETRIC TITRATION METHOD – ADVANTAGES & DISADVANTAGES

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Soil organic matter (SOM) takes part in all processes coupled with acid – base properties (biogeochemical processes, pH buffering, nutrient cycling, ionic balance, mineral weathering, metal leaching, pollutant toxicity, mobility and bioavailability). However soil organic matter is very difficult material to investigation because of it chemical diversity.

Potentiometric titration technique belongs to simple methods. As result of titration, relationship between titrant volume and suspension pH is obtained. On the basis of those data, a lot of valuable parameters can be calculated. For the unquestionable advantages, great sensitivity and precision (at properly matched conditions) as also low costs of exploitation and relatively short time of analysis should be counted.

Potentiometric titration method is effective for qualitative and quantitative analysis of likewise compound types. This technique enables, in a simple manner, to characterize of surface physicochemical properties of soil organic matter. Received results can be converted to variable surface charge and buffer capacities. Variable surface charge provides with information about strength of surface functional groups and about chemical character of studied substance. In turn, buffer capacity is a measure of soil resistance to aggressive agents. Buffer properties of soils are responsible for retaining a constant value of pH in spite of adding small amounts of strong acids or bases. Retaining neutral and stable pH in aquatic environment, as well as in soils is very important, especially for many biochemical processes, which determine life of plants and animals. Buffer capacity calculated from potentiometric curves enables analysis of buffer properties of different soil components at wide range of pH. From ecological point of view, it is one of the most important parameter to describe defensive action of soils.

Potentiometric titration makes also possible to qualitative determination of surface functional groups kind. In general, functional groups of acidic character dominate on natural soil organic matter surfaces. These groups (aliphatic, aromatic carboxylic, phenolic etc.) have very different acidic strength, depending

on the kind of the group, its locality. The number, quality and acidic strength of these groups are a primary characteristics of soil organic matter.

However due to much diversified character of soil composition, different constituents of soils can create difficulties in potentiometric titration process and investigations of organic matter.

One of the most often occurred problem is titration with the presence of strongly buffering substances. Such process requires choosing a number of measurement parameters in order to received result could be repeatable and reliable. Presence of chemically diverse substances in studied samples causes that equilibrium of solution is stabilized with different rate. It can result in interferences, which are visible on the titration curves. That problem especially appears in case of presence strongly buffering substances such as phosphates, fulvic and humic acids. Choice of suitable apparatus parameters can improve of received signal quality. For the main apparatus parameters can include:

-Way of titrant dosage
-Rate of titrant dosage
-Volume of titrant portion
-Value of potential drift threshold
-Titrant concentration

In the potentiometric titration processes, significant meaning has also proper preparation of samples. In case of titration it is above all minimization of carbon dioxide influence, which can impact on characteristics obtained from potentiometric titration curves. Working in the protective atmosphere of nitrogen, enables to avoid of carbon dioxide sorption and as a result distortion of sample signal by carbonates creating in the solution.

Well effects bring also concentrating of organic matter. Signal comes from sample should be much bigger than interferences level. In order to detailed investigations, titration should be slow to enable to stabilization of equilibrium state and also should not be too slow for reason of possibility of CO_2 sorption and carbonates creation. Compromise between above apparatus parameters enables to get satisfactory results even in the phosphate presence.

Therefore, in the potentiometric studies, method optimization is necessary in further investigation in order to eliminate of above problems.

INFLUENCE OF PARTICLE SIZE VARIABILITY ON MECHANICAL AND GEOMETRICAL PROPERTIES OF GRANULAR SYSTEM

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The geometrical properties and mechanical response of particulate media in which the coefficient of variation of particle size was varied under uniaxial compression test was studied. The series of numerical tests using discrete element method was conducted for spheres and non-spherical particles of coefficient variation of their length CV = 0, 5%, 10% and 30%.

The slight impact of variability of particle size distribution on distribution of stresses in system was found with CV lower than 5%. Similar effects were observed for particles of different shapes.

Keywords: particle size distribution, DEM, uniaxial compression test

INTRODUCTION

The heterogeneity in grain size in the specimen is considered to have a high impact on packing structure of assembly determining its mechanical behavior. It was reported that bulk density increased with increase in the coefficient of variation of particle size (McGeary 1961). O'Sullivan *et al.* (2002) have studied the influence of rod size distribution on coordination number and strength in system under biaxial compression test using discrete element method (Cundall and Strack 1979).

MATERIAL AND METHOD

The uniaxial compression test of assembly of 600 spheres 10mm in diameter and 905 oblique particles of aspect ratio of 2.12 was modelled using discrete element method. Normal distribution of particle size with coefficient of variation of 0%, 5%, 10% and 30% was applied.

Initially randomly generated particles settled down under the gravity on the bottom of rectangular chamber of width W = 11 mm, height H = 20 mm and thickness T = 33 mm or 46.7 mm, for spheres and nonspherical objects respectively. The systems of equal bulk densities were created.

The loading of assembly was modelled through top lid moving down with the constant velocity $V = 0.1\ \mathrm{m \cdot s^{-1}}$.

RESULTS AND DISCUSSION

The comparison of tangent modulus of assemblies of nonuniform grains revealed the lack of dependence of particle size distribution on stiffness of system.

The high coincidence of relationships between pressure ratio *k* and vertical stress in monodispersive and polydispersive systems at *CV* = 5% was found. The increase in coefficient of variation of particle length to 10% resulted in 15% decrese in *k* value at vertical pressure of 50 kPa. The further 30% increase in *CV* resulted in 30% decrease in pressure ratio.

The low pressure ratio in highly polydispersive systems arised from changes in distributions of stress and contact in assemblies. As the coefficient of particle size variation increased the lower horizontal stresses were transmitted in system.

The same findings for spheres and elongated particles were made.

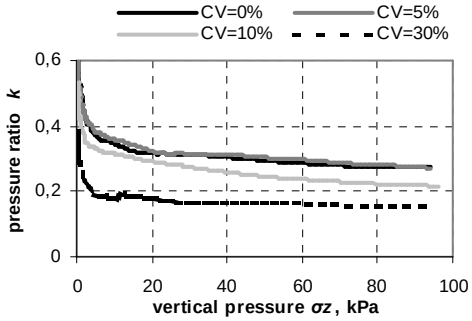

Fig. 1. The evolution of pressure ratio in monodispersive and polydispersive systems of spheres with different distribution of particle size

CONCLUSIONS

The transmission of stresses in particulate system depends highly on the grain size distribution for coefficient of particle size variation higher than 5% which results from changes in coordination number in assembly. The relationship between stiffness of system and grain size distribution was not found.

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EFFECT OF COMPACTION ON SOME HYDRAULIC PROPERTIES OF SOIL AGGREGATES

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Productivity of soil is a function of complex physical relations and parameters which should be determined for better understanding optimal conditions for plant growth and conducting of sustainable agriculture.

Soil degradation in result of compaction is a worldwide problem and difficult to avoid till farmers use heavy and wide-span multi-functional machinery to reduce time of tillage operations. Intensification of soil treatments is reflected by crop yields which are dependent on complex soil properties. Heavy equipment and tillage implements can cause damage to the soil structure which determines the ability of a soil to hold and conduct water, nutrients, and air necessary for plant root activity.

Transport and retention of water and solutes in aggregated soils largely depends on hydraulic properties of a single aggregate such as wettability, infiltration, sorptivity and hydraulic conductivity which can differ even between inner and outer part of aggregate. Structural properties of aggregates such as wettability or sorptivity affect erodibility of soil and may be indicators of soil reaction to management.

Repellency (opposite to wettability) is a common feature of many soils. Soil is recognized as water repellent if it does not wet spontaneously when the drop of water is placed on it. The repellency can lead to surface runoff, erosion, unstable and preferential flow. On the other hand in some range it may strengthen soil aggregates, its stability and prevent disruption. Repellency depends on various soil attributes like:

- soil water content- some dry soils may be completely repellent whereas with adding water the repellency vanishes
- quality and quantity of organic matter components- hydrophobic or hydrophilic groups
- clay content- usually inverse relationship
- pH of soil- increasing repellency with decreasing pH

A great impact on wettability has type of soil management. Generally pasture soils are not as wettable as plowed ones. Compaction by changes in soil structure also changes arrangement of organic matter and by that may control soil wetting.

The rearrangement of organic matter components, that may appear while compaction, may be more important than its amount or quality.

In the presented work we determined the influence of soil compaction on selected hydraulic properties like:

- water and ethanol sorptivity (S_W,S_E)
- wettability (repellency index R)
- unsaturated hydraulic conductivity (K_{uns})

In our experiment we used soil aggregates modified by three levels of compaction induced by tractor traffic: no compaction (NC), medium compaction (MC) and strong compaction (SC). We conduct measurements on aggregates of different size (10, 15 and 20 mm diameter) taken from two horizons of loamy soil. More than 200 aggregates were examined. We determined mentioned parameters from the measurement of water and/or ethanol uptake by soil aggregate from a capillary tube.

Our results indicate interesting relations between determined parameters and traffic intensity. We found that small variances in level of compaction may considerably change soil wetting properties depending on aggregate size and soil depth.

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