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THE INFLUENCE OF MOISTURE CONTENT OF WHEAT SINGLE KERNEL ON THE ENERGY CONSUMPTION BY SHEARING PROCESS

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Abstract: *The paper presents the results of investigations on the energy consumption of individual wheat kernels, based on shearing process. The experimental research was carried out on individual wheat grains at 10%, 12%, 14%, 16%, 18% and 20% moisture content, pursuing the energy consumption during the wheat grain shearing process. Depending on the results obtained from the experimental research may be determined the working parameters of the milling machine. The measurements showed significant differences regarding the energy consumption between the grain moisture contents.*

Key words: *shearing method, energy consumption, individual wheat kernels, force, deformation.*

1. Introduction

Wheat is currently the most important crop in the world. It is unique because of the special properties of its flour, which forms a cohesive mass – gluten or dough – which is useful in baking. The properties of wheat flour reside primarily in the types and quantities of gluten proteins it contains [12].

The behaviour of solid materials put under the grinding operation is very different from a case to another, according to the great number of parameters which contribute to its performing.

Physical properties of foodstuffs may be determined by the same test methods used for engineering solids, i.e. tension, compression, torsion, shear, creep and relaxation experiments etc., on unprecracked and on cracked samples [1].

Shear cutting is a typical mass production technology for sheet metal parts [4] but is used in food industry too especially in grinding process. Knowledge of the stress state in the sheet is of high interest for users of this technology, because it provides information about the load of tools, but is also closely connected to the attributes of the finished product, such as the cut surface quality [3].

The grinding process is one of the most expensive operations. To streamline the process and thus to reduce costs, many studies have been developed in order to

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determine the influence of grinding factors or for the optimization of grinding machines. In grinding process, the specific energy consumption (J/kg) represents the energy required, in order to achieve a certain degree of fineness of the unit mass of the grinding product [10].

The mechanical properties of grains have been investigated by a number of researchers [13] but the researches have been carried out mainly on wheat seeds. There are many methods for the determination of wheat mechanical properties, and these methods are very often determined as wheat hardness [2], [13]. Some authors define hardness as the mechanical property of the individual wheat kernel [2], [8] or fragments of endosperm [2], or the resistance to deformation or crushing [2], [12], whilst others define hardness as the property of a mass of kernels [12]. The mechanical properties of individual parts of the kernel (germ, bran layer, endosperm) are also different and these properties also strongly depend on the water content [4], [5], [8]. We can find in the literature many methods of measure the wheat hardness and they are different from those used for the evaluation of the hardness of constructional materials such as metals.

2. Materials and Method

Investigations were carried out on one type of wheat Apache s and one type of maize Olt Fao 430, collected in the year 2015. Apache wheat is a superior wheat used in bakery industry and has the next mean values of the samples: moisture content 12.5%, hectoliter mass 73.4 kg/hl, total ash 1.75%. Experimental research of shear resistance of wheat grains was achieved with the device shown in Figure 1. For the purposes of the application was used a mobile arm connected to test equipment and a fixed arm, with the Ø12 diameter, in which was introduced the wheat grain.

The experimental research were carried out on individual wheat kernels, at 12%, 14%, 16%, 18% and 20% moisture content, pursuing energy consumption, the loading force and the kernel deformation [6], [7], during the wheat grain shearing process. The individual wheat kernels are sheared with a constant speed of 50 mm min^{-1} until the entire grain is beaked.

Fig.1. *The device used for shear solicitation tests in experimental research*

For each experimental research was selected 15 wheat kernels and for data analysis and interpretation of experimental research were used the average of the 15 determinations.

Measurements of grain resistance characteristics were carried out on a universal testing machine ZWICK /ROELL 005. The measurement accuracy was ±0.001 N in force of 0.001 mm deformation. Changes in the loading force in relation to kernel deformation and the energy consumption were recorded with the testing machine software “Test Expert”[6], [7].

All of the test kernels were checked for stress cracks and before loading, the thickness and length of each kernel was determined with a digital caliper. The individual kernels were put in to the middle of the cylinder. In mechanical properties test, each kernel, was loaded until rupture occurred and the resultant load-deformation behavior and the work were recorded.

In order to bring the wheat grains to the needed moisture content, a WK 11 600 climatic chambers was used. The grains were put into the climatic chamber and kept there for 5 or 6 days. For determined the final moisture content of the wheat grains, a special Granomat humidometer for cereal grains was used which was calibrated according to ASAE Standard.

Wheat hardness has the greatest influence on the milling process and this parameter should be determined before milling. Kernel texture influences power consumption during milling. Hard wheat cultivars require more power to grind the kernels than do soft wheat cultivars [2]. The moisture content has a different influence on endosperm and bran layer properties. A study showed that, when a wheat grain was subjected to uniaxial compression, it behaved as an elastic-plastic-viscous body exhibiting creep, stress relaxation and elastic after effects [9], [14].

3. Results and Discussions

To highlight the influence of wheat grain moisture content on energy invested in the process of shear grinding single kernel of wheat, experimental research data processing was done in the case of application of the load speed of 50 mm/min.

It have been compared the values obtained from the six values of moisture content, aiming the force evolution of shear resistance, the deformation and the grain energy consumption recorded during shredding process.

The shape of each variation curve of force highlights the behaviour of wheat grains at the request of quasi-static sheared for various conditions of force application.

From analysis the shape variation curves of shear resistance forces are highlighted as follows:

- in the first phase of implementation of the application there is a proportionality between the force applied by the shearing device and the elastic deformation of the kernel representing the elastic deformation of the grain;
- after passing the elastic zone is manifested plastic deformation phenomenon of grain material, a phenomenon that is highlighted by a progressive decrease in slope of the variation, up to the maximum;
- at the time of shearing in grain mass, the sheer force is at a maximum and is kept at this value and decreases progressively until the complete detachment of the grains [4].

By analyzing the results obtained by experimental research using a shear device and an operation of the calculation in Figure 2 are shown the curves variation of shear force resistance, depending on the wheat grains deformation for six values of moisture content.

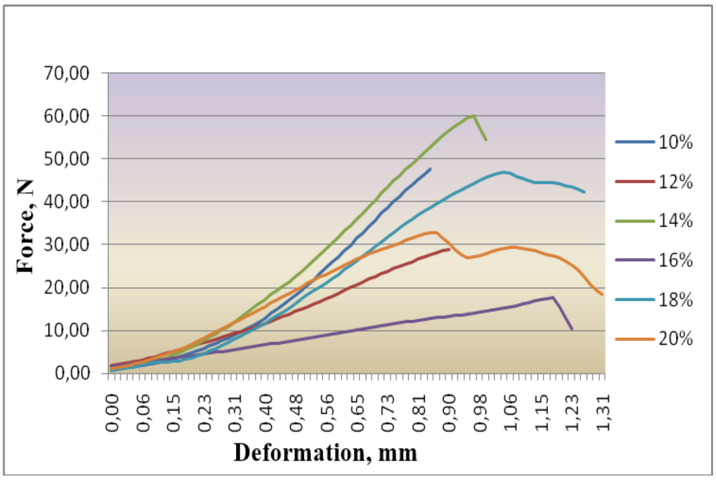

Fig. 2. *The influence of wheat grain moisture content on the shear grinding process*

Analysing the graphs it can be seen that at all the moisture content values used, the elasticity zone appears all the time in the grain. The deformation of the grains is in the range of 0.81 mm to a 10% moisture content and 1.31 mm at 20% moisture content. The maximum value of shear force appears in the case of the 14% moisture, 60 N, while the maximum deformation obtained is for 20% moisture content, 1.31 mm.Therefore it can be said that from the point of view of grain strains, shearing process is similar with the process of compression, and in terms of the value of the shear forces, the process is similar to the process of cutting.

In terms of value, energy consumption during the shearing process (Figure 3) is similar to energy usage during the grinding process by cutting.

The maximum value of 35.58 Nmm energy consumption is recorded at 20% moisture content of wheat grain, which is approximately three times greater than that corresponding to 10% moisture.

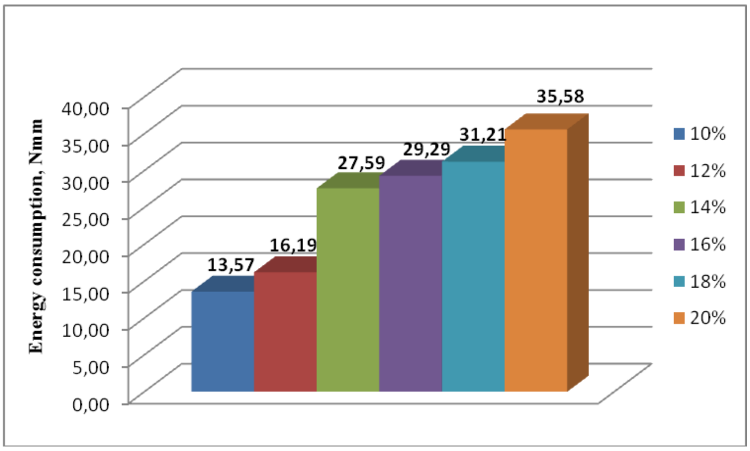

Fig. 3. *The evolution of energy consumption by shear grinding process on individual wheat grain at different values of moisture content*

4. Conclusions

Shear cutting is a typical mass production technology for sheet metal parts but is used in food industry too especially in grinding process.

The deformation of the grains is in the range of 0.81 mm to a 10% moisture content and 1.31 mm at 20% moisture content. The maximum value of shear force appears in the case of the 14% moisture, 60 N, while the maximum deformation obtained is for 20% moisture content, 1.31 mm.

The energy consumption increase with the increase of moisture content.

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