

WHEAT RESISTANCE ANALYSIS ON THE SUBJECT OF ENERGY CONSUMPTION IN THE GRINDING PROCESS

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Abstract: *The paper presents the results of investigations on the energy consumption of individual winter wheat kernels, obtained based on uniaxial compression test. The experimental research was carried out on individual wheat grains at 10%, 12%, 14%, 16% and 18% moisture content, pursuing the energy consumption during the wheat grain compression. For each moisture content were selected 30 wheat grains and for the data analysis and interpretation of experimental research were used the average of the 30 determinations. The measurements showed significant differences regarding the energy consumption between the three moisture contents.*

Key words: *energy consumption, individual kernels, energy consumption, compression.*

1. Introduction

Over time, cereals represented a great importance to humankind, and it covered the world's largest planted area of all crops. The need for crushing, in food industry, results from the fact that the cereals grains are rarely used in their original shape and size. The energy consumption for carrying out the grinding process depends on the physical and mechanical properties of the grain, of the stress type applied to the crushing process and the grinding degree.

Wheat is the world's most popular crop grown on large areas and under a series of wide range conditions. It provides more nutrition for humans than any other cereal. Wheat is the oldest crop grown in over 120 countries with many different technologies and traditions. Wheat production has

increased ~ 100% within recent decades. Its maximum increase is seen in food crops. [7]

Wheat can also be used in various ways for human food, but usually, it is grounded and/or fractionated for further processing. [1]

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 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. [6]

The energy consumption for the grinding process is useful only partially; the rest of it, it is lost through the production of elastic and plastic deformations, by rubbing the material

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pieces between them and the active organs of the machine; or into internal mechanical transformations of the equipment.

The grinding process should be done in such a manner, so that the raw material does not suffer unwanted changes, such as: contamination or overheating.

In order to achieve low energy consumption during the grinding process, it must be taken into account the establishment of a strictly particle size of the grinding process, and to use an appropriate choice of functional and technological scheme of the machine, which depends on the physical and mechanical properties of the cereals.

In time many grinding theories have been proposed and to these correspond many relations in order to determine the energy required for the grinding process; but these theories don't have a satisfactory scientific validation, and this because it is not possible to simply express the complexity of the physical phenomena of priming and the breakage development.

2. Materials and method

The experimental research was carried out on individual winter wheat grains, at 10%, 12%, 14%, 16% and 18% moisture content, pursuing energy consumption, the loading force and the kernel deformation, during the wheat grain compression.

For each moisture content were selected 30 wheat grains and for data analysis and interpretation of experimental research were used the average of the 30 determinations. Individual wheat kernels are constraint with a constant speed of 50 mm min^{-1} , between two parallel flat plates. (Fig.1)[2]

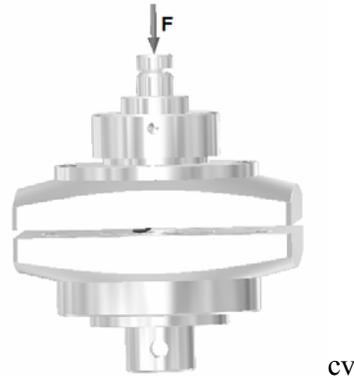


Fig.1. *Uniaxial compression of wheat grain between two parallel plates* [2]

Measurements of grain resistance characteristics were carried out on a universal testing machine ZWICK /ROELL 005. The measurement accuracy was $\pm 0.001 \text{ N}$ 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".

The stress-strain characterization of grain crushing can be expressed in a series of rheological phases which correspond to the resisting force of the crushing shell and to the endosperm of the grain. (Fig. 2) [5]

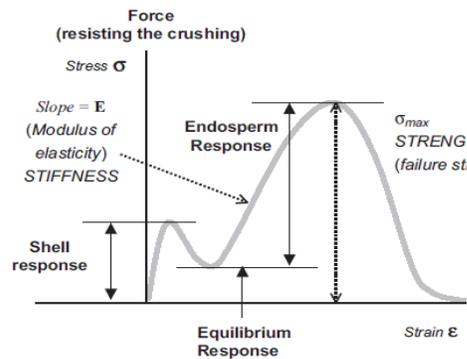


Fig.2. *The generic of the crush structure response profile* [5]

3. Results and discussions

To highlight the influence of the content of wheat grain moisture of the energy invested in the grinding process, there were carried out processing data of experimental research, that were obtained from individual wheat grains crushed with a constant speed of 50 mm min⁻¹, between two parallel flat plates.

There were compared values obtained from six types of humidity (10%, 12%, 14%, 16%, 18% and 20%), aiming the development of crushing resistance forces, the kernel deformation and the energy consumption, registered during the grinding process.

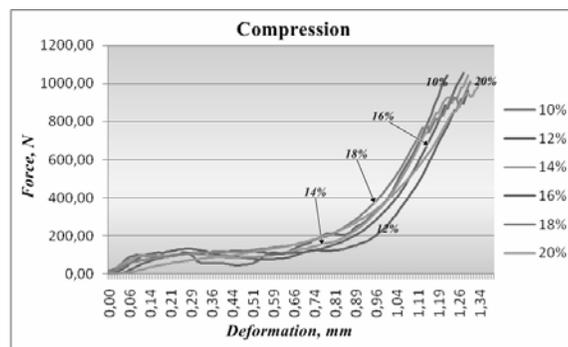


Fig.3. *Moisture influence on the crushing resistance of individual wheat grains*

By analyzing the graphic shown in Figure 3, it is found that the development of crushing forces resistance, for all six humidity types, are similar. In all the cases, the maximum crushing force is about 1000 N.

For all moisture values, the characteristic area of elastic deformation is smaller. The appropriate force of elasticity limit for 10% humidity do not exceeds 100 N, and the grains deformation is of 0.06 mm.

As humidity increases, the elastic properties are higher, at a 20% moisture content, the strains occur directly in the plastic deformation (flow). In the case of wheat grains, in the flow area, the external load is constant and the wheat grain deformation reach values from 0.74 to 0.81 mm.

Beyond the floe tier, the characteristic curves present an ascendant tier again; the

slope is approximately the same, being a little lower, a 20% moisture content.

From the point of view of wheat grains deformation, the highest value of 1.34 mm grain deformation is achieved at a humidity of 20%, due to its high elasticity. We noticed that, the lower the moisture content is, the grains elasticity decreases. This is particularly evident if we follow the evolution of the curve, up to the maximum force of about 170 N. We observed that, if the grain moisture is of 20%, the curve variation of the force has a much greater elasticity in comparison with the curve variation of the force at the humidity of 10% and of 12%.

The energy values, consumed during the grinding crushing for the content of all six humidity types, are shown in figure 4. The maximum value of energy consumption is recorded for a 20% wheat grain moisture.

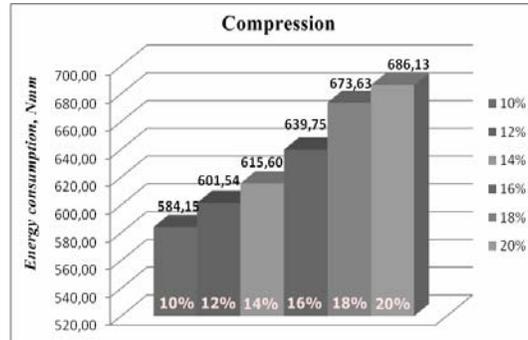


Fig. 4. Energy consumption evolution of grinding process by crushing the wheat grains at different moisture content.

Following the evolution of the values of energy consumption depending on the wheat grain moisture, we noticed that, the increasing moisture content of the wheat grains, increases during the energy consumption of the grinding crushing process.

Conclusions

1. For all six humidity types (10%, 12%, 14%, 16%, 18% and 20%) the maximum crushing force is about 1000 N.
2. The lower the moisture content is, the grain elasticity decreases.
3. If the moisture content of the wheat grains increases, the energy consumption during grinding compression also increases.

Acknowledgement

This paper is supported by the Sectorial Operational Programme Human Resources Development (SOP HRD), financed from the European Social Fund and by the Romanian Government under the project number POSDRU/159/1.5/S/134378.

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