



THE ANALYZE OF THE CEREAL GRAINS MECHANICAL PROPERTIES

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Abstract: Cereal grains presents characteristics which determines their use as raw materials in the production of food goods that need to be taken into account in the milling industry processing operations. For grinding and appreciation of the finished products value, counts in a large extent the mechanical characteristics to which are subject the materials. This paper presents the most important mechanical properties of grain seeds which must take into account in the milling industry processing operations.

Keywords: shape and grain size, specific surface area, crushing resistance, hardness.

1. INTRODUCTION

Cereal production and processing their technologies have been subjected over the development of human civilization, to continuous improvements and adaptations to food needs of the population, serving to improve living standards. Cereals of all time were one of the main sources of human food, which made their processing history to be confused with the history of humanity and its material culture.

Processing and expansion of grain cultivation and human interest for their selection to increase yield and adaptation processing performance requirements were determined by the important role they have played in food production.[5]

Knowing the mechanical properties of cereal grains, intended to enter into manufacturing process is very important, because based on these properties are selected the processing technologies, techniques and procedures for crushing and as well the operating mode and active organs to that process. The most important mechanical properties are: shape and particle size, grain elasticity, the hardness of the particle, the particle crushing strength, etc.. Below are presented some of these properties.

The seeds shape and size

The shape and size of the grains greatly influence the grinding process, according to these criteria are chosen the functional characteristics of grinding machines.

The particles may have different shapes: spherical, rounded, conical, oval, elliptical, etc.. (Fig. 1), for which in 3D system the exact size of the seed grain can't be expressed in only one dimension, but is characterized by three dimensions: length L, width b and a thickness c. This is an impediment to particle size analysis.

The particle size in the case of spherical particles, refers to its diameter, for cubical particles refers to the side of the cube, and in the case of irregularly shaped particles refers to the equivalent diameter.

The equivalent diameter is defined as the diameter of a hypothetical sphere which in relation with the real particles presents the same values of one equivalence values criteria (the number of particles, the outer surface, designed or specified volume, weight or the same behavior ex. speed of sedimentation, flotation and so on).

It is preferred to adopt an equivalent spherical body because the projected area is constant for any position of the body. [5,810]

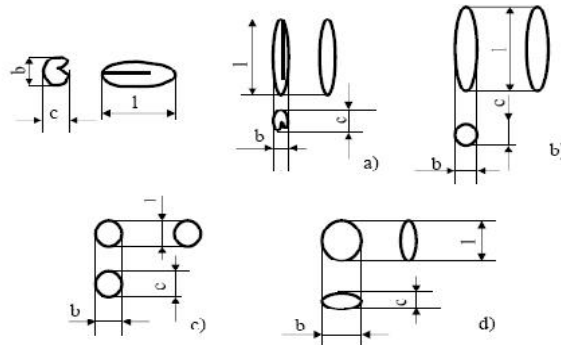


Figure 1: The main dimensions of the particles [5,8,10]

✚ Surface area

The specific surface area of the particle is used as a way for assessing the degree of grinding in the processes of milling industry and in most cases are relate to external surface of the particles. It is noted this because the particle of porous materials shows an interstitial area (pore surface).

The specific surface area is defined as the ratio of external surface of the particle and the volume of the particle, and is determined by the relationship:

For volume V of the initial particle , the external surface of the result particulates is determined by the relationship:

$$S = \frac{6V}{d} \quad (1)$$

where d is the median diameter of the particles results, in m.[8]

✚ Grinding resistance of cereal grains

During the grinding process, the products are subjected to mechanical grinding action, crushing and so on, which have the effect of changes in shape and volume.

The form deformation of cereal grains may have low values, avoiding their deterioration (harvest crops) or may be large enough to cause changes in the volume of grain (cutting, crushing and so on).

Grinding resistance of solids particles represents their property to resist to mechanical deformations caused by external efforts.

Crushing forces for compression application are much higher than for the application of shear. Generalized characteristic curve crushing process by crushing the grain of wheat is shown in figure 2.

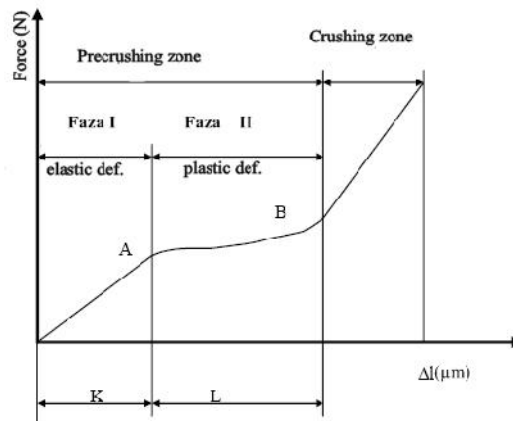


Figure 2: Generalized curve characteristic for crushing process by compression [9]

The curve is characterized by three zones:

- zone I – elastic deformation zone, characterized by proportionality between crushing force F and K grain deformations;
- zone II - plastic deformation zone, characterized by large increases in strain L of grain (Plastic) for small increases in force;
- zone III - crushing zone, characterized by crushing the grains which takes place after reaching a certain value of the crushing force.

✚ Hardness

Hardness represents the materials properties in order to express their resistance to deformation; it is an indication for the characterization of the solid material to grinding strength and resistance to wear of the materials used in the construction of the grinding machine.

Currently, the hardness of the materials is expressed as the Mohs hardness scale, which is estimated to their relative hardness when compared with other materials whose hardness is taken as a reference (eg, diamond, which is designated relative hardness of 10).

Hardness is determined by the imprint dimensions left in material by the top of a diamond pyramid or hard steel.[5]

2. MATERIALS AND METHODS

The experimental research attempts, on the one hand, to check the veracity of the hypothesis and theories which are the basis of the theoretical studies concerning the researched processes, and, on the other hand, it allows investigating a range of phenomena of which practical applicability cannot be obtained by means of theoretical study, due to their complexity or to the lack of sufficient knowledge of the laws which determine the researched phenomenon.

The experimental research has been performed using the Zwick/Roell 5kN testing equipment. During the experimental research has been analyzed the mechanical properties of wheat kernels, monitoring, in the same time, the resistance of the individual wheat kernel during the compression process.

The experimental research has been performed at humidity values of 10% and 16%. The compression speed during all the experimental research is 50 mm/min.

In order to bring the wheat grains to the needed humidity, a WK 11 600 climatic chambers was used. The grains were put into the climatic chamber and kept there for 5 or 6 days. In order to determine the final humidity of the grains, a special Granomat humid meter for cereal grains was used.

For each experiment, 15 corn grains belonging to the same wheat variety and dimensional group were used. Along each performed experiment the compression force value variation has been measured depending on the device movement from the beginning of the experiment and up to the entire compression of the wheat grain.

In order to measure the force value, the device used for compression was put into the fixing system of the force tens metric transducer of the material testing Zwick/Roell 5 kN equipment, which allows to measure the force value with a 0.01% resolution. The measuring of the device movement along the compression process was performed using the incremental position transducer of the equipment, which was indexed for each equipment separately, for the moment when the device touched the tested grain surface.

The electrical signals of the two transducers were registered in the computer database.

3. RESULTS AND DISCUSSION

To highlight the influence of wheat grain moisture on the crushing process was carried out experimental research obtained by compressing a single kernel of wheat.

The result of the experimental research is shown in the diagram below.

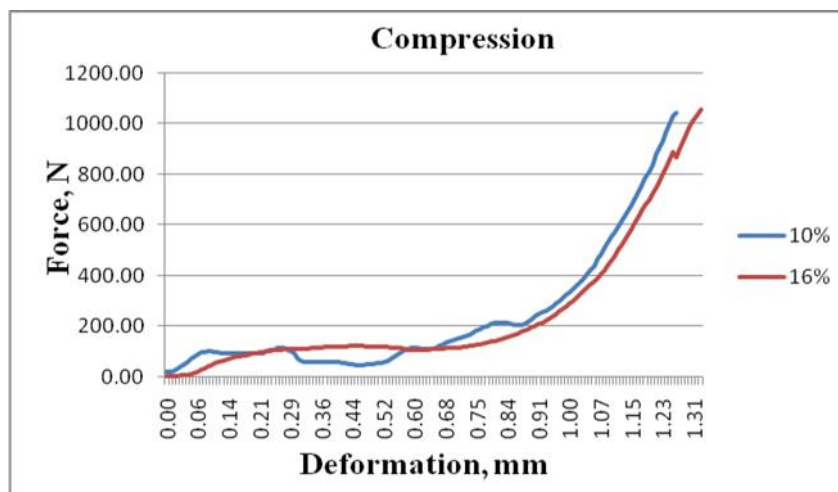


Figure 1: The influence of the wheat grains humidity on the compression resistance.

Analyzing the graph in Figure 1, it can be seen that, at lower grain moisture content, the duration of the grinding process is reduced. It can also deduce that, the higher the grain humidity value is, the flatter the slope

line of the variation curve will be, and so, the grain elasticity is higher, the maximum deformation occurring at the grain moisture of 16%, being 1.31 mm.

The maximum compression force resulting from the grinding process by compression is registered at the humidity of 16%, and it has the value of 1054,05 N.

The mechanical properties of the wheat grains used in the experimental research are shown in the table 1.

Table 1: The properties of the wheat grains

Cereal type	Humidity [%]	Density [kg/hl]	Elastic modulus [MPa]
Wheat	10	44.4	63.10
	16	73.2	21.46

3. CONCLUSION

The analysis of the experimental research has shown the following facts:

Knowing the mechanical properties of cereal grains, intended to enter into manufacturing process is very important, because based on these properties are selected the processing technologies, techniques and procedures for crushing and as well the operating mode and active organs to that process.

The particle size in the case of spherical particles, refers to its diameter, for cubical particles refers to the side of the cube, and in the case of irregularly shaped particles refers to the equivalent diameter

The specific surface area of the particle is used as a way for assessing the degree of grinding in the processes of milling industry and in most cases are relate to external surface of the particles. It is noted this because the particle of porous materials shows an interstitial area (pore surface).

During the grinding process, the products are subjected to mechanical shearing action, crushing and so on, which have the effect of changes in shape and volume.

Hardness is determined by the imprint dimensions left in material by the top of a diamond pyramid or hard steel.

The lower the wheat grains humidity value is, the shorter the grinding duration time will be.

The higher the grain humidity value is, the flatter the slope line of the variation curve will be.

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