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THE FACTORS THAT INFLUENCE THE ENERGY REQUIREMENTS OF THE GRINDING PROCESS OF WHEAT GRAIN

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Abstract: The paper presents a bibliographic study concerning the influence of factors such as the mechanical properties of wheat grains, the moisture content and the rebranding ratio on the grinding energy requirements.

Key words: wheat, grain, mechanical properties, grinding, energy consumption, hammer mills, energy requirements.

1. INTRODUCTION

Grinding is one of the most energy consuming processes used in cereal industry. The energy consumption in the grinding process depend on the geometrical and kinematical parameters of the grinding machine and the physical properties of the ground material [2].

From the physical properties of the kernel, the greatest influence on energy requirements is exerted by the mechanical properties [8], especially hardness of kernel [3]. Wetting or during the grains can also modify the mechanical properties [6].

The mechanical properties of grain result from the endosperm properties and the bran layers properties. After debranning of wheat grains the energy required in the grinding process decrease [4]. Peyron et al. [12] investigated the relationship between bran mechanical properties and milling behavior of durum wheat. They showed that breakage force and breakage tensile strain were affected by bran density. Moreover, Dobraszczyk et al. [1] showed the correlation between wheat vitrousness and the energy consumed in the grinding process.

Laskowski and Lysiak [8] showed the relationship between the characteristics of the compression curve and the grinding energy requirements.

The mechanical properties of the kernel are very strongly heritable in wheat. In other word, a variety of wheat grown in different locations will retain their order of hardness. Kilborn et al. [7], discovered that the total specific milling energy take values between 46 $\mathbf{kg \cdot kj^{-1}}$ for soft varieties and 124 $\mathbf{kg \cdot kj^{-1}}$ for durum wheat.

The moisture (water content) of the wheat grains affect the mechanical properties of wheat. Dry kernels are easy to grind and need less energy for their comminution [8]. Increase of the moisture will increase the plasticity of the kernel especially the plasticity of bran [11]

and we have seen above that the bran mechanical properties affect a lot the grinding process.

The objective of this study is to show the factors that have the more important influence on the grinding process and on the grinding energy requirements.

2. METHODS

Many reserchers have investigate the influence of the particular factors on the grinding process.

a. Dziki [3] try to determine the influence of wheat grain mechanical properties, obtained on the basis of compression test, on wheat grinding energy requirements. He used a universal testing machine to compresse the wheat grains. On the basis of the obtained compression curves (fig. 1) he determined the following parameters: F_1 - breakage force, F_2 - the force at the end of compression, Δh_1 - the deformation at the breakage point, Δh_2 - the deformation at the end of compression.

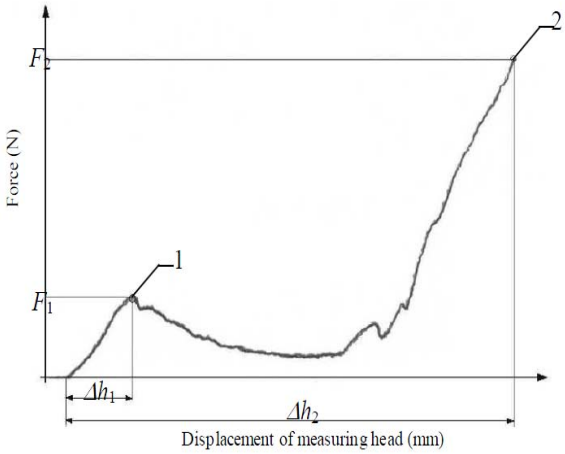

Fig. 1. Exemple of wheat grain compression curve: 1 – breakage point; 2 – the end of the compression (grain moisture 15%).

The changes of power consumption during the grinding were recorded using laboratory equipment.

The specific grinding energy (E_1r) was calculated with the equation:

$$E_r = \frac{E_c - E_s}{m} \qquad (1)$$

where:

m – the mass of ground sample, kg;

E_c - the total grinding energy comsumption, J;

E_s - the idle running energy consumption, J.

The grinding index K was calculated on the basis of the size reduction theory described by Sokolowski [13]:

$$K = \frac{E_r}{\frac{1}{\sqrt{d}} - \frac{1}{\sqrt{D}}} \qquad (2)$$

where:

d – the average particle size before grinding, m.

He found positive correlations between the grinding index K and the breakage force. The strongest correlations that he observed were between k and force and the work that characterize the end of the compression.

Grain mechanical parameters obtained after compression test show significant correlation with wheat grinding requirements and could be a useful tool for describing the grinding process.

b. Laskowski and Dziki [4] wanted to determine the influence of wheat debranning ratio and moisture content on the grinding energy requirements.

They determined the specific grinding energy (E_1r) using equation (1).

On the basis of the particle size distribution, they calculated the average particle size [2].

The grinding index K was calculated on the basis of the size reduction theory described by Sokolowski [13].

The debranning ratio was calculated according to the equation:

$$d_r = \frac{\Delta m_b}{\Delta m_t} \cdot 100\ \% \qquad (3)$$

where:

Δm_b – the difference between the kernel ash content before and after debranning, %;

Δm_t - the difference between the kernel ash content before debranning and endosperm ash content, %.

The results of the study showed that the debranning caused the decrease of E_r up to

46%. As the grain moisture increased from 12 to 16% the E_r increase from 15 to 21 %.

The debranning caused the increase of grinding index K from 13 to 39%. The increase of kernel moisture caused the increase of K from 16 to 19%.

c. Dziki [5] investigated the influence of kernel moisture on the energy consumption. He used two Polish cultivars for his study. Half of the kernels from each variety were crushed before grinding and half remained intact. He made a comparative study between the milling of the crushed wheat grains and the whole one.

He discovered that both moisture content and the crushing of the wheat grains affect the energy consumption during grinding. The increase of moisture content determined the increase of the energy requirements. The specific grinding energy ($E_{,s}$) of the whole kernels range from 72.3 to 146.7 $kg \cdot kj^{-1}$ for durum wheat and from 67.0 to 114.4 $kg \cdot kj^{-1}$ for soft wheat. Crushing caused a decrease of E_s. The total specific grinding energy ($E_{,t}$) of crushed kernels range from 47.6 to 100.5 $kg \cdot kj^{-1}$ for durum wheat and from 44.6 to 85.3 $kg \cdot kj^{-1}$ for soft wheat. The total specific grinding energy ($E_{,t}$) is the sum of the specific grinding energy ($E_{,s}$) and the specific crushing energy ($E_{,cs}$) (Fig. 2).

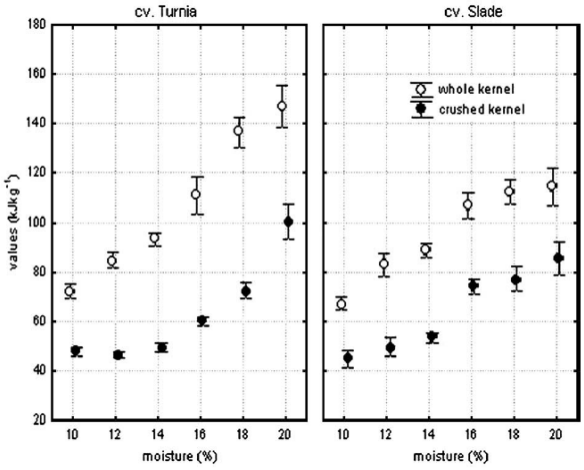

Fig. 2. Specific grinding energy of whole wheat kernels and total grinding energy of crushed wheat kernels

The conclusion of the study showed that the increase of kernel moisture has as result the increase of grinding energy consumption. Also the crushing of kernels before grinding has as effect the decrease of energy requirements. Further more he observed that the index (K) for the crushed kernels is smaller that for grinding the whole grains.

3. CONCLUSION

1. There are positive correlations between the grinding index K and the breakage force. The strongest correlations that could been found were between k and force and the work that characterize the end of the compression.

2. The debranning caused the decrease of E_r up to 46%. As the grain moisture increased from 12 to 16% the E_r increase from 15 to 21 %.

The debranning caused the increase of grinding index K from 13 to 39%. The increase of kernel moisture caused the increase of K from 16 to 19%.

3. The increase of kernel moisture has as result the increase of grinding energy consumption. Also the crushing of kernels before grinding has as effect the decrease of energy requirements. Also the index (K) for the crushed kernels is smaller that for grinding the whole grains.

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Factorii care influenţează cererile de energie pentru procesul de măcinare a boabelor de grâu

Rezumat: *În această lucrare este prezentat un studiu privind influenţa unor factori precum proprietăţile mecanice ale seminţelor de grâu, umiditatea şi gradul de decorticare asupra consumului de energie în pocesul de măcinare.*

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