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INFLUENCE OF GRAINS MOISTURE CONTENT ON MILLING PARAMETERS

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Abstract: *The present paper presents the results concerning the influence of grains moisture content on grinding feed rate and specific grinding energy. The investigations were carried out on two types of grains: maize and wheat. For both grains types two levels of moisture content were used (11.1% and 17.6 % for maize, 13.4% and 18.8% for wheat respectively).The results showed that as the grains moisture content increased, the specific grinding energy increased for both maize and wheat, but the grinding feed decreased.*
Key words: *Wheat, maize, power, milling, grinding, specific energy.*

1. INTRODUCTION

Grinding process is one of the most energy consuming processes used in feed grain processing. From the total power for the production of feed grains, the biggest part of it is used in the fragmentation process. The main factors that affect the energy consumption during grinding are the machine parameters and the physical properties of the grain. Laskowski [4] found that from all the physical properties of the grain, the greatest influence is due to the mechanical properties, but the main influence has, as Dziki showed [1], the hardness.

Real problems occur when trying to mill soft grains in a mill that was designed with the special purpose of milling hard grains. If the hardness of the grain increases, so does the power that is required for their milling [2].

The moisture of the grains affects their mechanical properties. If the grains are dry, less energy is needed for their fragmentation [5]. The plasticity of the grains increases with the moisture level [6]. However, moisturizing of the grains before milling is frequently used because it facilitates the breakage of the endosperm [3]. Romanski and Niemiec [7] investigated the wheat grinding energy by using a hammer mill. In their study, they found that the highest specific grinding energy was achieved for a moisture content of 15-16%. For moisture levels that are below or above this value, the specific grinding energy decreases.

The objective of the present study is to investigate the influence of the moisture content of grains on the milling parameters.

2. MATERIALS

The investigation was carried out on one type of maize grains and one type of wheat grains. For each grain type two different moisture samples were used. In order to have grain samples of different moisture levels, half of the total quantity from each grain types were watered and then stored for 48h. The moisture of wheat grains was increased from 13.4% to 18.8%. For maize grains the moisture of dry sample was 11.1% and for the wet one 17.6%.

3. APPARATUS AND METHOD

The moisture level of the grains was measured with a moisture meter Riela (fig.1).

Fig. 1. Moisture meter Riela

For the grinding process of the grains, a hammer mill MB 7,5 from S.C. TEHNOFAVORIT S.A. Bontida with a power of 7.5 kW was used (fig. 2). Three sieves were used, having different diameters of the holes (4, 6 and 8 mm). Also two types of hammers have been used in the grinding process. The velocity of the rotor was measured with a digital tachometer (Lutron DT-2234B) with the accuracy of $\pm(0.05$

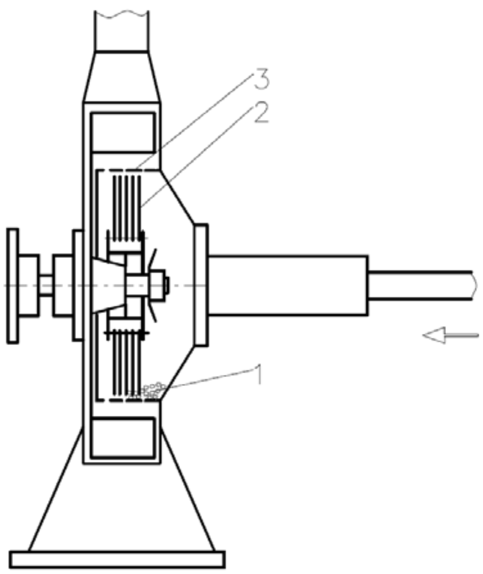

Fig. 2. Hammer mill MB 7.5
1 – milled grains; 2 – rotor; 3 - sieve

This hammer mill is the main assembly of the compound feed production installation that was used in this study (fig. 3). This installation is working at the University of Agriculture and Veterinary Medicine Cluj-Napoca.

In order to measure the grinding parameters of the process, an Energy and Power Disturbance Analyzer (Metrawatt Co. model Mavowatt 45) was used (fig. 4).

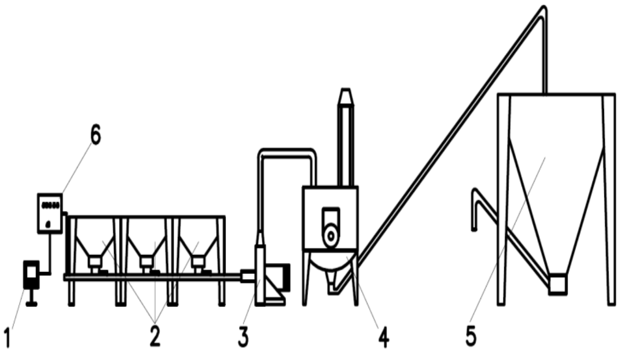

Fig. 3. Compound feed production installation (1 – computer, 2 – feed hoppers, 3 – hammer mill, 4 – feed mixer, 5 - collector hopper, 6 – control panel

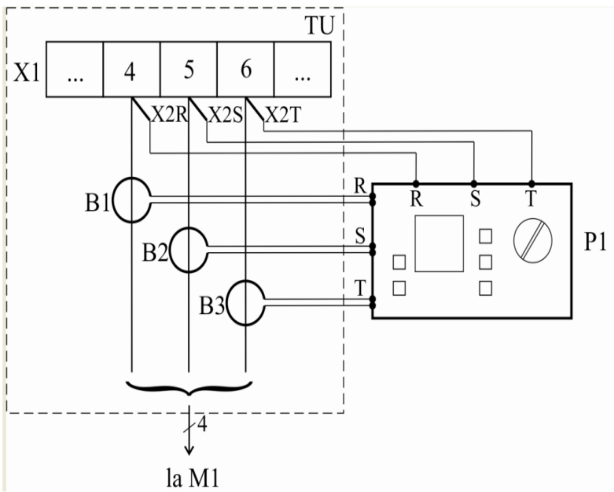

Fig. 4. Mavowatt 45 energy and power disturbance analyzer (P1 – the measuring device; TU - control panel of the machine; X1...4,5,6.. – device plugs; X2R, X2S, X2T - the location where the plugs were mounted; R, S, T – voltage inputs; B1, B2, B3 – current transducers, M1 – electric motor; 4 – electric motor power supply

This device has been designed for the measurement of electrical quantities in Direct Current (DC) systems, as well as single and 3-phase Alternating Current (AC) systems with balanced or unbalanced loads with frequencies of up to 400 Hz. Applications range from acquisition, display and recording of mains quantities through the recognition and analysis of fluctuations and other interferences within the power supply (options FFT, PDA and FSA), right on up to analysis and recording of energy consumption. The MAVOWATT 45 can also be used for a wide variety of industrial applications for the determination of characteristic quantities for electrical load components or generators either under static conditions or during dynamic operation.

The hammers used in the grinding process are shown in figure 5. The only difference between them is related to their shape. Hammer type 2 has more cutting edges because its extremity is made in several steps. The thickness of both hammers is 6 mm.

The material for both hammers is 1C45 and they are hardened in the area where collisions occur with the grain seeds.

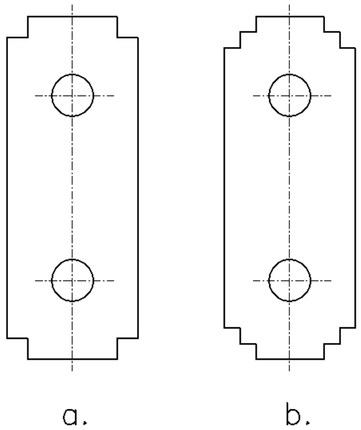

Fig. 5. Hammers types:
a – hammer 1; b – hammer 2

Each sample of material that was milled had 19 kg. Six different types of configuration has been obtained for the hammer mill (there were available two types of hammers and 3 types of sieves). For each of this configurations, samples of maize and wheat were milled distinguishing between wet samples and dry ones. 72 samples of material were milled during the experimental process.

The total grinding energy (E) was calculated according to the ecuation:

$$E = \int_0^t P dt \quad [J] \tag{1}$$

where:

P – the power consumption during grinding process (W);

t – the time of grinding (s).

Finally, the specific grinding energy E_s was calculated in kWh/t, as it appears in figures 6-9.

4. RESULTS

The specific grinding energy is one of the most important parameters characterizing the grinding process.

For dry wheat the values of the specific grinding energy decrease with increasing the dimensions of the sieve holes regardless the type of the hammers. The value of the specific grinding energy were bigger for hammer 2 (7.23 to 4.87 kWh/t besides 5.82 to 4.04 kWh/t than for hammer 1 – fig. 6).

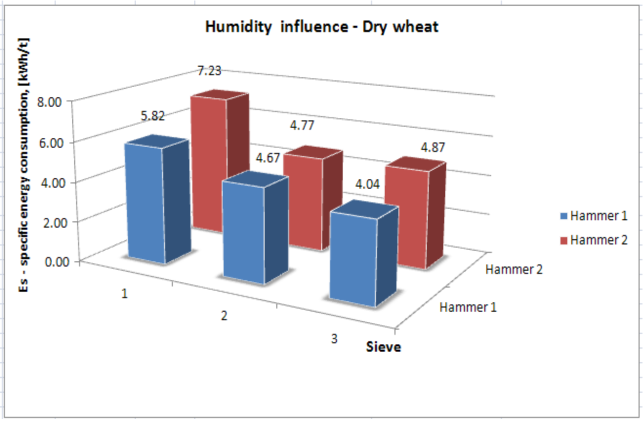

Fig. 6. Specific grinding energy variation in case of grinding dry wheat grains

In the case of wet wheat grains, the specific grinding energy had bigger values than the values for the dry milling wheat particles (from 8.71 to 4.42 kWh/t for hammer 2 and from 6.95 to 4.86 for hammer 1 – fig. 7).

A similar trend was observed for maize. The only exception was recorded for wet maize milled using hammer 2. For this, the specific energy grinding energy was lower than comparable values for wet maize milled using hammer 1 (from 5.28 to 4.13 kWh/t besides 7.22 to 4.42 kWh/t – fig. 9). The recorded values were lower also for those recorded for dry maize (from 5.28 to 4.13 kWh/t besides 6.03 to 5.06 kWh/t – fig. 8, 9).

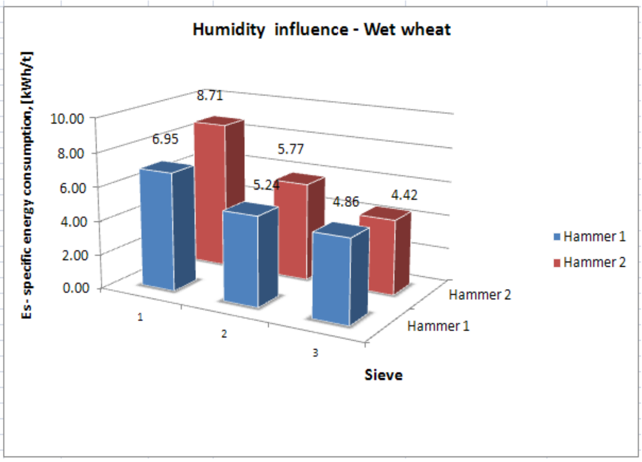

Fig. 7. Specific grinding energy variation in case of grinding wet wheat grains

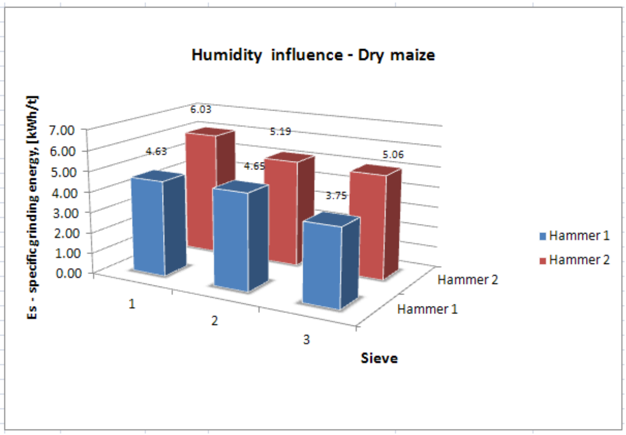

Fig. 8. Specific grinding energy variation in case of grinding dry maize grains

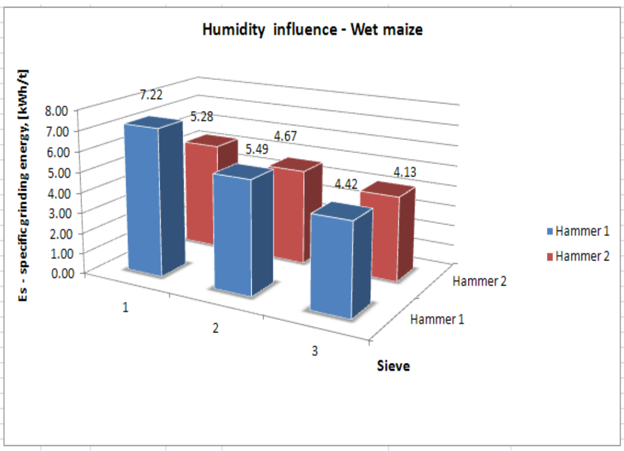

Fig. 9. Specific grinding energy variation in case of grinding wet maize grains

As a conclusion one can say that the humidity of the grains influence the specific energy consumption, more precisely, the higher is the level of moisture the greater is the specific energy consumption in the grinding process.

The feed rate of the grinding process shows us how is the productivity of our installation and how profitable the process is. The feed rate depends mainly on the sieve holes dimensions and on the degree of comminution. In our case, the initial dimension of the particles was the same in all cases (taking in consideration the cereal type), but the dimensions of the sieve holes were 4 mm for sieve 1, 6 mm for sieve 2 and 8 mm for sieve 3 (and the comminution degree is different as well).

After grinding dry wheat, it was found that the value of the feed rate naturally increases with increasing the holes dimension of the sieve. Furthermore, grinding flow values are higher when using hammer 1 (from 481.69 to 814.29 kg/h) than when using the hammer 2 (from 459.06 to 670.59 kg/h – fig. 10).

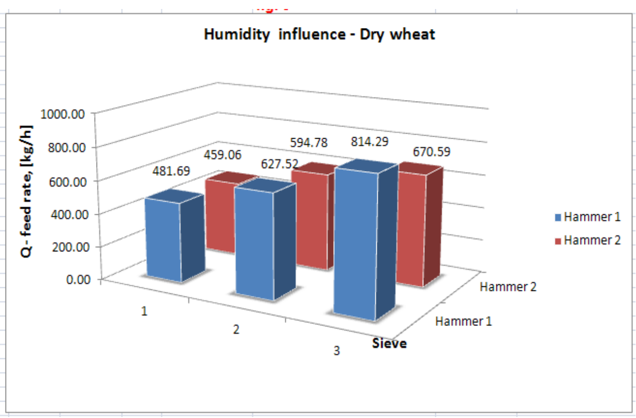

Fig. 10. Feed rate variation in case of grinding dry wheat grains

The same trend was observed for wheat grinding with greater humidity. But comparing the obtained feed rates for wet and dry grains, it was observed that the feed rates for crushing wet grains is smaller than in the case of grinding dry wheat grains (regardless hammer type – fig. 10, 11).

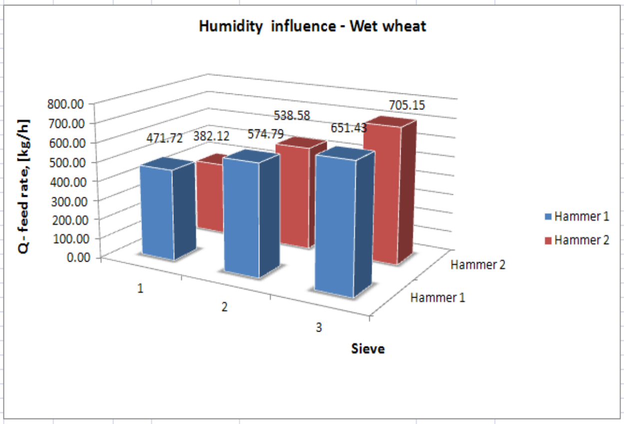

Fig. 11. Feed rate variation in case of grinding wet wheat grains

Similar trends were observed when milling maize grains (fig. 12, 13).

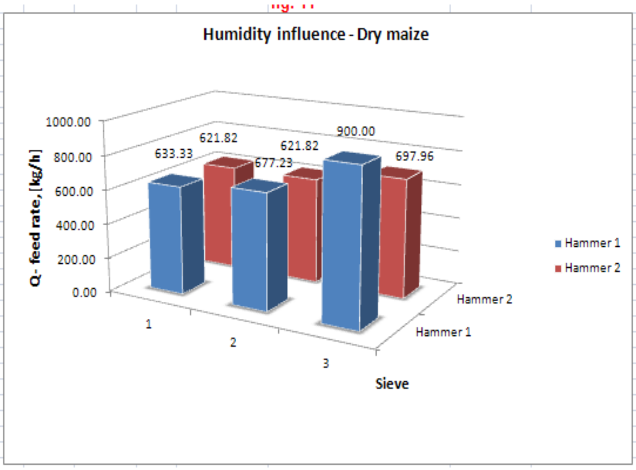

Fig. 12. Feed rate variation in case of grinding dry maize grains

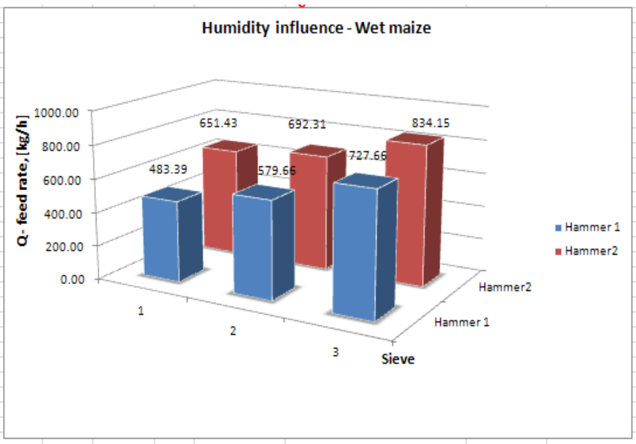

Fig. 13. Feed rate variation in case of grinding wet maize grains

5. CONCLUSIONS

The influence of the ground material moisture can be observed on both the flow rate and the specific energy consumed in grinding process. Specific grinding energy values increases with increasing the moisture level and the feed rate values for crushing decreases when the moisture of the ground material increases.

The increase of the sieve holes diameters determine the reduction of specific energy consumption and increasing feed flow.

6. ACKNOWLEDGMENT

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Influența umidității semințelor de cereale asupra parametrilor procesului de măcinare

Rezumat: *În această lucrare au fost prezentate rezultatele referitoare la influența umidității semințelor de cereale asupra debitului de măcinare al morii şi asupra consumului specific de energie. Pentru acest studiu s-au folosit două tipuri de cereale: porumb şi grâu. Pentru ambele au fost folosite două valori diferite ale umidității (11.1% şi 17.6 % pentru porumb, respectiv 13.4% şi 18.8% pentru grâu). În urma rezultatelor s-a constatat faptul că odată cu creşterea umidității particulelor de material creşte energia specifică la măcinare pentru ambele tipuri de cereale, dar în schimb debitul de măcinare scade.*

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