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INFLUENCE OF HAMMER TYPE ON MILLING PARAMETERS

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Abstract: *The present paper presents the results concerning the influence of hammer type 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 utilization of the hammer 2 has as consequence the increase of the specific grinding energy for both maize and wheat, but the grinding feed decreased.*
Key words: *Wheat, maize, power, milling, grinding, specific energy, hammers.*

1. INTRODUCTION

Milling process is an energy consuming process used in feed grain processing, food industry, pharmaceutical industry etc. From the total power that is used for the production of feed grains, the biggest part of it is used in the fragmentation process. The energy consumption during milling process is influenced by 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 [2], the hardness.

If the hardness of the grain increases, so does the power that is required for their milling and as a consequence the energy required for grinding [3].

From the constructive parameters of the hammer mill, the largest influence on energy consumption in the milling process is due to:

- the rotor (length, outside diameter during operation, rotating speed);
- sieve (diameter of the holes);
- hammers (length, width, thickness, shape of the hammer, hammer-sieve distance, peripheral speed of the hammers).

The objective of the present study is to investigate the influence of hammers forms 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 as it was explained in [1].

For the grinding process of the grains was used a hammer mill MB 7,5 from S.C.

TEHNOFAVORIT S.A. Bontida with a power of 7.5 kW. The hammer mill was presented in [1]. Three sieves were used, having different diameters of the holes (4 mm for sieve 1, 6 mm for sieve 2 and 8 mm for sieve 3). 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 ±(0.0!.

This hammer mill is a part of a complex installation that is working at the University of Agriculture and Veterinary Medicine Cluj-Napoca. This installation is presented in [1].

A dedicated device (Metrawatt Co. model Mavowatt 45) was used for measuring several parameters of the grinding process. Its configuration is presented in figure 1.

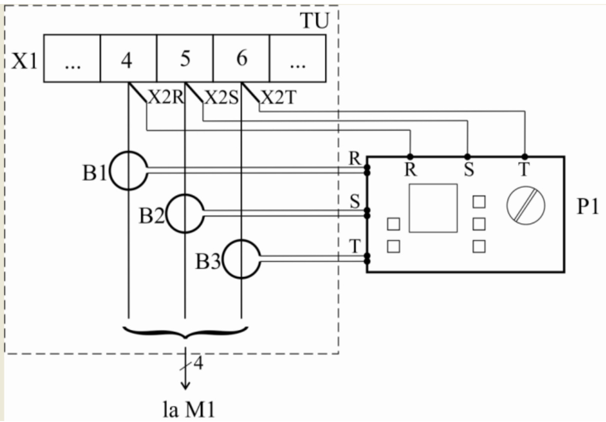

Fig. 1. Mavowatt 45 energy and power disturbance analyzer (P1 – the measuring device; TU - control panel of the machine; X1...4,5,6.. – device plugs; X2R, X2S, X2T - the location where the plugs were mounted; R, S, T – voltage inputs; B1, B2, B3 – current transducers, M1 – electric motor; 4 – electric motor power supply

The necessary details concerning the parameters as well as its operation may be found in [1].

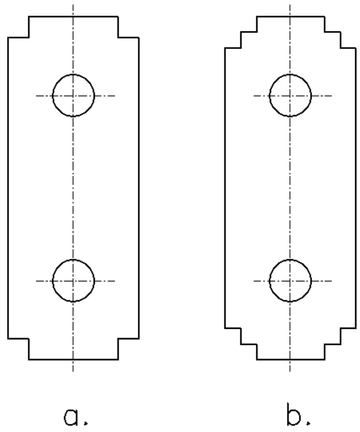

Fig. 2. Hammers types:
a – hammer 1; b – hammer 2

For grinding grain seeds, two types of hammers were used (fig. 2). Their length, width and thickness are identical. The only difference is the configuration of the extremities. The material used for their manufacture is 1C45. The area of the hammer most intensely used in the grinding process was hardened for better resistance.

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 energy consumption in the process of grinding was determined by integrating the elementary energy in the time interval (0, t) in which the grinding process was conducted.

Finally, the specific grinding energy E_s was expressed in kWh/t, as it appears in figures 3-6.

4. RESULTS

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

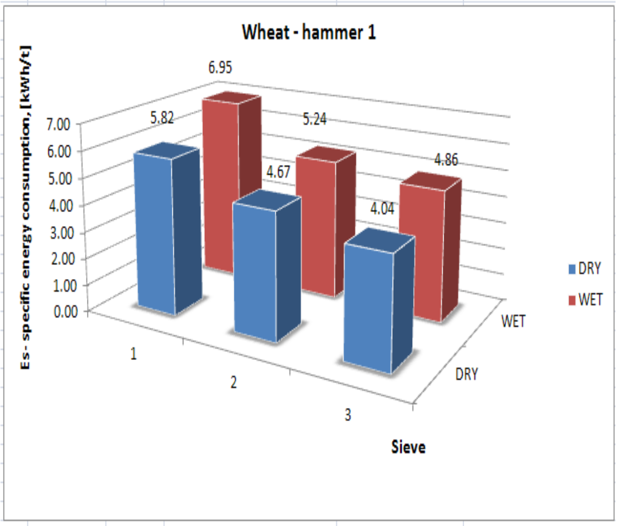

Fig. 3. Specific grinding energy variation in case of grinding wheat grains (with hammer 1).

For milling wheat, the values of the specific grinding energy increase with increasing the moisture content of the grains regardless the type of the hammers. In the case of hammer 1, the values of the specific grinding energy for wet wheat grains range from 6.95 to 4.86 kWh/t besides 5.82 to 4.04 kWh/t for dry wheat (fig. 3). When the hammer type 2 was used, the values of the specific grinding energy for wet wheat grains vary from 8.71 to 4.42 kWh/t besides from 7.23 to 4.87 kWh/t in the case of dry wheat grains (fig. 4).

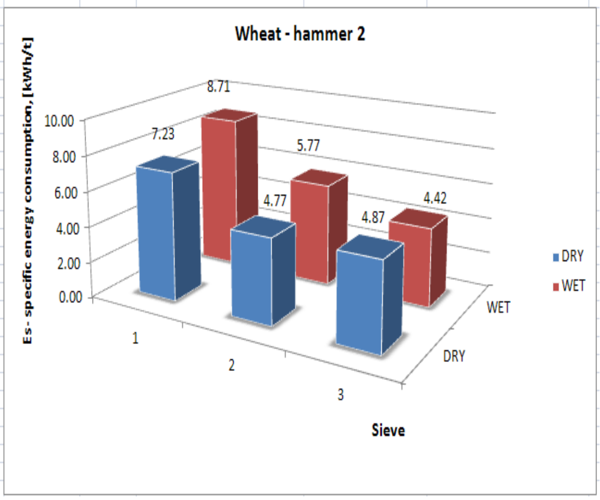

Fig. 4. Specific grinding energy variation in case of grinding wheat grains (with hammer 2).

For grinding maize grains, an opposite effect was observed: the specific energy for grinding dry grains is higher than in the case of wet grains, regardless of the hammers type. In the case of hammer 1, the values of the specific grinding energy for wet maize grains range from 7.22 to 4.42 kWh/t besides 7.23 to 4.87 kWh/t for dry wheat (fig. 5).

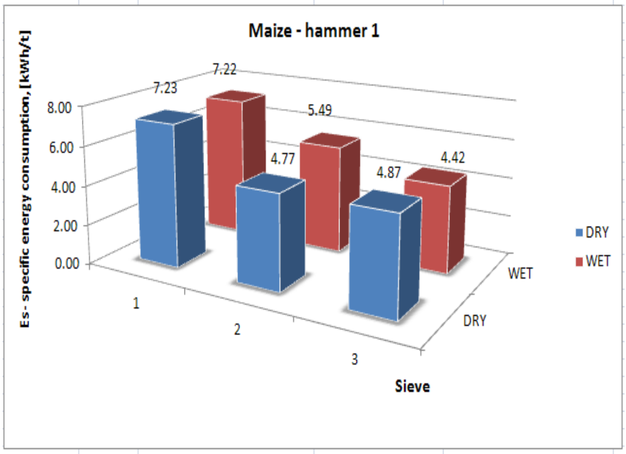

Fig. 5. Specific grinding energy variation in case of grinding maize grains (with hammer 1).

When the hammer type 2 was used, the values of the specific grinding energy for wet maize grains vary from 5.28 to 4.13 kWh/t besides from 6.03 to 5.06 kWh/t in the case of dry maize grains (fig. 6).

By using two different types of hammers for milling wheat it was observed that the specific grinding energy has higher values when using hammer 2. This tendency is the same regardless the grains moisture.

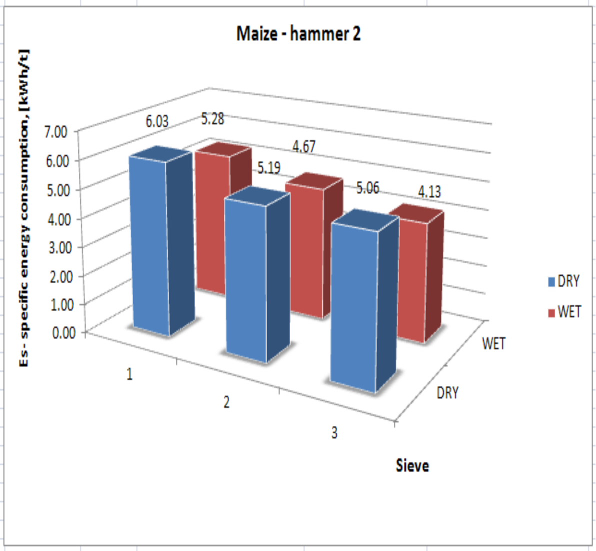

Fig. 6. Specific grinding energy variation in case of grinding maize grains (with hammer 2).

The values of the specific grinding energy for dry wheat grains ranged from 5.82 to 4.04 kWh/t for hammer 1 and from 7.23 to 4.87 kWh/t for hammer 2 – fig. 3, 4). When milling wet wheat grains, the values of the specific grinding energy ranged from 6.95 to 4.86 kWh/t for hammer 1 and from 8.71 to 4.42 kWh/t for hammer 2 – fig. 3, 4).

When grinding maize grains, one can observe that the specific energy for grinding with hammer 1 is higher than in the case of grinding with hammer 2, regardless of the moisture content. The values of the specific grinding energy for dry maize grains ranged from 7.23 to 4.87 kWh/t for hammer 1 and from 6.03 to 5.06 kWh/t for hammer 2 – fig. 5, 6). When milling wet maize grains, the values of the specific grinding energy ranged from 7.22 to 4.42 kWh/t for hammer 1 and from 5.28 to 4.13 kWh/t for hammer 2 – fig. 5, 6).

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. 7, 8).

A similar trend was observed for wheat grains grinding with greater humidity. In the case of using for grinding process the hammer 1, the values of the feed rate vary between 471.72 kg/h (when using the sieve number 1 with the dimension of the holes of 4 mm) and 651.43 kg/h (in the situation of using sieve number 3 with the dimension of the holes of 8 mm).

When hammer 2 was used in the grinding process, the values of the feed rate took values between 382.12 kg/h (for sieve 1 in the configuration of the hammer mill) and 705.15 kg/h (for sieve 3 – 8 mm diameter of the holes).

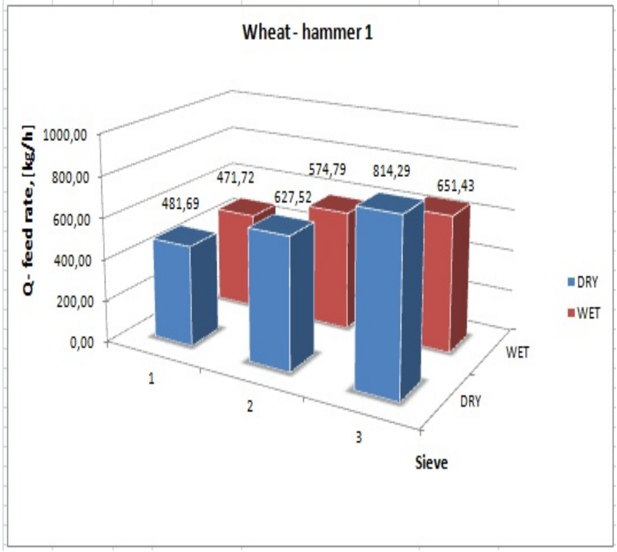

Fig. 7. Feed rate variation in case of grinding wheat grains (with hammer 1).

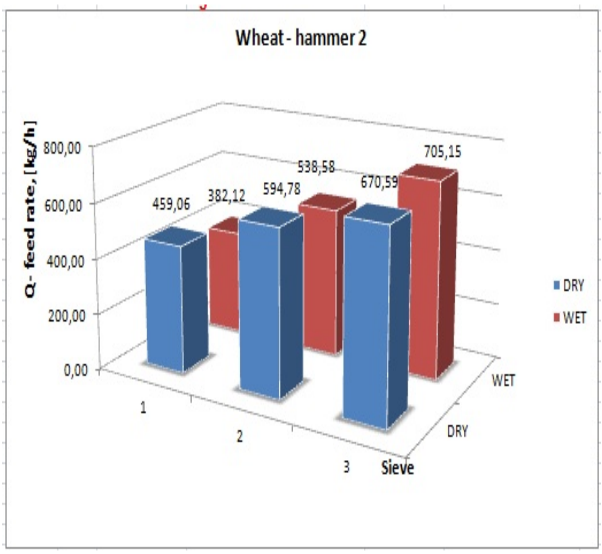

Fig. 8. Feed rate variation in case of grinding wheat grains (with hammer 2).

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. 7, 8): 481.69, 627.52 and 814.29 kg/h for dry wheat besides 471.72, 574.79 and 651.43 kg/h for wet wheat for hammer 1 (the values are in ascending order of sieve holes dimension). For hammer 2 the values for dry wheat were 459.06, 594.78 and 670.59 kg/h besides 382.12, 538.58 and 705.15 kg/h for wet wheat grains. It can be seen that the only situation in which the rule is not respected is for grinding with hammer 2 and sieve 3 – 8 mm diameter of the sieve holes.

In the case of grinding maize grains, the increase of feed rate when using sieve with greater holes is obvious as for grinding wheat grains.

The grinding feed rates for dry maize grains are higher when grinding with hammer 1 (fig. 9 - from 633.33 kg/h to 900.00 kg/h) than for grinding with hammer 2 (fig.10 - 621.82 kg/h to 697.96 kg/h). The oposite situation was recorded for grinding wet wheat grains: the values of the feed rates for grinding with hammer 1 (fig. 9 - from 483.39 kg/h to 727.66 kg/h) were smaller than the values of the feed rates when using hammer 2 (fig.10 - from 651.43 kg/h to 834.15 kg/h).

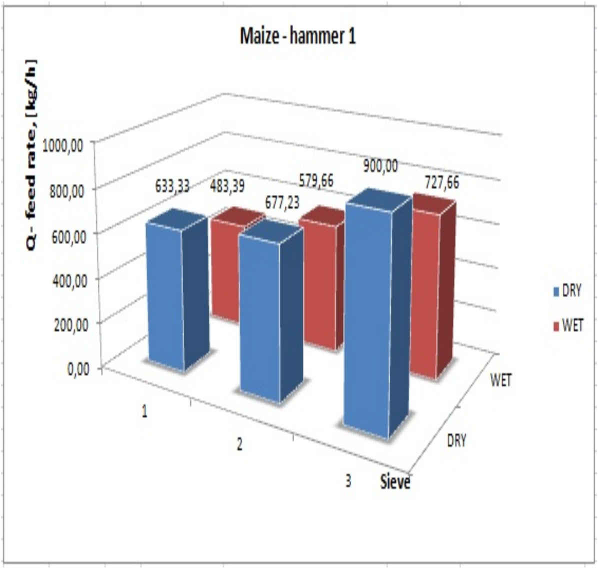

Fig. 9. Feed rate variation in case of grinding maize grains (with hammer 1).

Comparing the values of the feed rates recorded when using the same hammer mill configuration (same hammer and same sieve) the values of the feed rates are higher for dry maize grains grinding than for wet maize grains. In the case of using hammer 2 the oposite trend was observed.

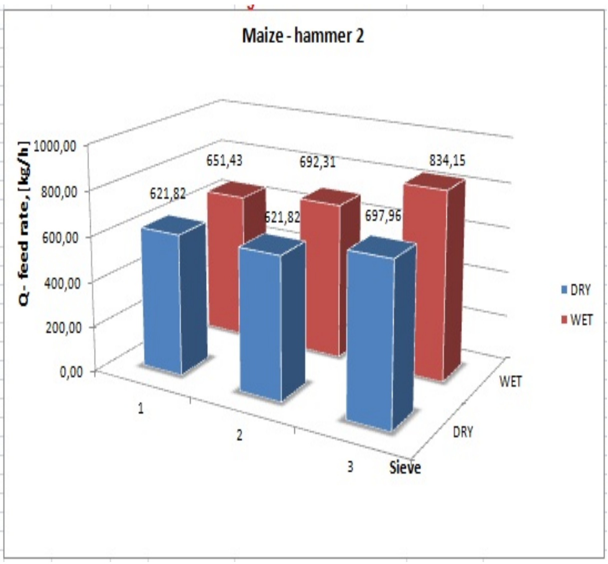

Fig. 10. Feed rate variation in case of grinding maize grains (with hammer 2).

5. CONCLUSIONS

The influence of the hammer type can be observed on both the flow rate and the specific energy consumed in the grinding process. Specific grinding energy values for milling wheat grains increases with increasing the moisture level regardless the type of hammers. In the case grinding maize grains the opposite effect was observed, namely the specific energy for grinding dry grains is higher than in the case of wet grains, regardless the hammers type.

By using two different types of hammers for milling wheat it was observed that the specific grinding energy has higher values when using hammer 2. This tendency is the same regardless the grains moisture. In the case of grinding maize grains the opposite effect was observed, namely the specific energy for grinding with hammer 1 is higher than in the case of grinding with hammer 2, regardless the moisture content.

6. ACKNOWLEDGMENT

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Influența tipului de ciocan folosit asupra parametrilor procesului de măcinare

Rezumat: *În această lucrare au fost prezentate rezultatele referitoare la influența tipului de ciocan 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 utilizarea ciocanului 2 are ca efect creşterea energiei specifice la măcinare pentru ambele tipuri de cereale, dar în schimb debitul de măcinare scade.*

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