GRINDING PROCESS OF THE WHEAT KERNEL WITH A NEW DESIGNED MICROMILL

Cristina DANCIU[1], Ioan DANCIU[1]

[1]The Faculty of Agricultural Sciences, Food Industry and Environmental Protection
Lucian Blaga University , 5-7 Ion Ratiu str, Sibiu, ROMANIA
cristina.danciu@ulbsibiu.ro

Abstract: *Wheat is one of the most important cereal crops in the world with various end-uses: food (bread, cakes, cookies and pasta), animal feed, raw material for beer and whisky, biodegradable plastic (from wheat starch). In all these technologies, grinding has great importance and is very energy consuming.*

The motivation to measure energy requirements for size reduction at specified roller mill settings, led to the development of instrumented roller mills of various designs. For this research, was used a new designed micromill which can perform in the grinding process of the wheat and of the middling too, in the same conditions as in the milling industry. The adjustment of the roller characteristics can be done for each type of milling product (grain, semolina, bran). The grains are in the same time under the compression and the shearing efforts. The energy consumption is represented by one single value for one pair of rollers. This single value is significant for the comparative appreciation regarding the energy consumption in the milling proces, for different wheat cultivars or different batches, but also for different characteristics of the rollers.

The micromill is designed to determine the grinding resistance of the cereals.The method has the same accuracy as the classical one and it has the advantage to be quicker and less demanding as work volume. The new designed equipment can be used in laboratory for the benefice of students as well in the milling industry.

Keywords: *conditioning, grinding resistance, energy consumption.*

Introduction

Milling wheat into flour for human consumption is a still growing up industry, represented by highly efficient processes at low economic margins. Nowadays, the major issue is how to process a variable feedstock to produce a high quality product with low energy.

The grinding process is the most important step in the milling system. In the grinding operation, energy is needed to break apart the bran and endosperm and to reduce the endosperm to flour. This uses about 50 % of the power connected with the milling system and results in heat generation and moisture loss in the ground material [1].

Wheat milling is an energy-intensive industry because it is a wet process that produces dry products.

Significant amounts of energy are required to power the large motors for grinding process. Opportunities exist within wheat milling plants to improve energy efficiency while maintaining or enhancing productivity. The grinding energy depends both on the properties of the grinding material and on the used machines and their work parameters. The motivation to measure energy requirements for size reduction at specified roller mill settings led to the development of instrumented roller mills of various designs (Gehle, 1965; Kilborn et al., 1982; Fang, 1995**;** Pujol et al., 2000), [2], [3], [4], [5]. Scanlon and Dexter emphasized on the mill adjustments [6] which affect energy consumption during the grinding process. The motivation to measure energy requirments at specified roller mill settings led to the development of a micromill which can perform in the grinding process of the wheat and of the middling too, in the same conditions as in the milling industry. The adjustment of the roller characteristics can be done for each type of milling product (grain, semolina, bran). The grains are in the same time under the compression and the shearing efforts. The energy consumption is represented by one single value for one pair of rollers. This single value is significant for the comparative appreciation regarding the energy consumption in the milling process, for different wheat cultivars or different batches, but also for different characteristics of the rollers.

Materials and Methods

Wheat samples

Table 1.

Quality indices of the wheat varieties

Variety / Indicator	Dropia	Pegasus
Hectolitric weight [kg/hl]	71.2	77.2
Vitreousness [%]	31	79
Wet gluten content [%]	23.2	26.4
Moisture content [%]	13.3	13.2
Falling number [s]	202	277
Protein content [%]	12.7	13.2

The investigations were carried out on Romanian winter wheat varieties (*Triticum aestivum, ssp. vulgare*) Dropia and Pegasus, harvested in 2009. The preparation of the samples colected carried out according to the chess- board pattern method, after cleaning with an Sadkiewicz Instruments Scourer.The physicochemical characteristics of the wheat were evaluated as follows: the moisture content using the SR ISO 712 : 2005; the wet gluten content, protein content using the NIR technique (Inframatic, model 8600, Perten Instruments AB); vitreous kernel using the STAS 6283-2/1984 (farinotom apparatus).

The quality indices of the studied wheat varieties are depicted in Table 1.

Before milling, 30 grams of each dry wheat sample was tempered overnight to reach 16 % (optimum) moisture content, wet basis; this toughens the bran and germ and softens the endosperm, making the separation of endosperm from germ and bran easier. Then, the moist wheat was allowed to temper for different rest time period depending on variety. For the same rest time were prepared two paralel samples.

Experimental micromill

For this research, was used a new designed micromill which can perform in the grinding process of the wheat and of the middling too, for the appreciation of the grain resistance (specific surface energy consumption) in the milling process, in the same conditions as in the milling industry. The adjustment of the roller characteristics can be done for each type of milling product (grain, semolina, bran). The grains are in the same time under the compression and the shearing efforts. The energy consumption is represented by one single value for one pair of rollers. This single value is significant for the comparative appreciation regarding the energy consumption in the milling proces, for different wheat cultivars or different batches, but also for different characteristics of the rollers: the size of the gap, roll disposition sharp-to-sharp, sharp-to-dull, dull-to-sharp or dull-to-dull, the corrugations number/cm, the differential speed ratio, profile and inclination. The appreciation of the energy consumption (kJ/kg) is made by measurements of the resistant moment of the kernel, between the rollers, in the breaking process. The micromill is equipped with corrugated break rollers measuring 50 mm in length and 90 mm in diameter, using with a fast roll speed of 500 rpm, 5 corrugations/cm, 0,6 mm roll gap, with a sharp-to-sharp roll disposition and differential speed (1:2,5). To ensure the proper balance and the efficiency of the breaking operation, samples were sieved for 5 min on a test sifter from Retsch Gmbh, using six assortment of wire mesh sieves of 1,25 mm, 630 µm, 400 µm, 315 µm, 250 µm and 160 µm, along with a bottom pan.

The experimental first–break roller micromill equipped with a computerized data acquisition system is connected to a tensometric cell to measure the resistant moment of the particles grounded between the rollers.

The measurements of the resistant moment of the kernel, between the rollers, in the first breaking step lead to the appreciation of the energy consumption (kJ/kg).

The grinding work of the first breaking rolls is checked by sifting the ground stock on the Retsch test sifter.

Results and Discussion

The rest time value obtained from each paralel samples is represented in Figure 1 (for Dropia) and Figure 2 (for Pegasus). The optimum rest time value for the conditioning of Dropia variety is 5 hours. For this value it was obtained the lowest average resistant moment in the grinding process of this soft wheat variety, which it means also the lowest energy consumption. The lowest average resistant moment was obtained also for the Pegasus variety (hard wheat) for 9 hours rest time in the conditioning process.

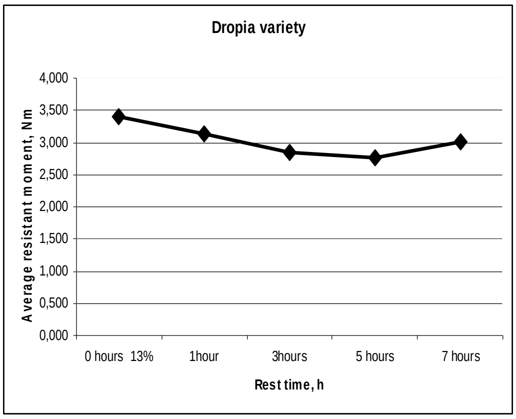

Figure 1. The rest time in the conditioning process of Dropia variety

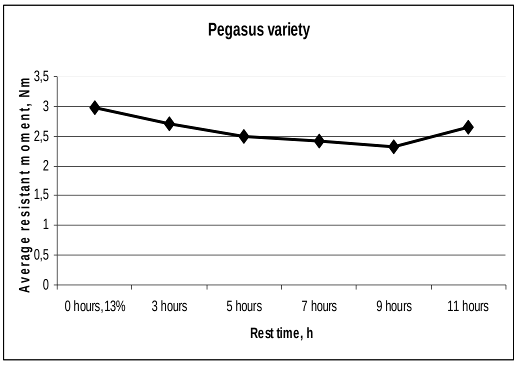

Figure 2. The rest time in the conditioning process of Pegasus variety

The resistant moment of the particles grounded between the rollers has been obtained for each period of rest time for the moistened wheat. The results are confirming that for the lowest resistant moment value, the optimum rest time is 5 hours for Dropia variety and 9 hours for Pegasus wheat variety.

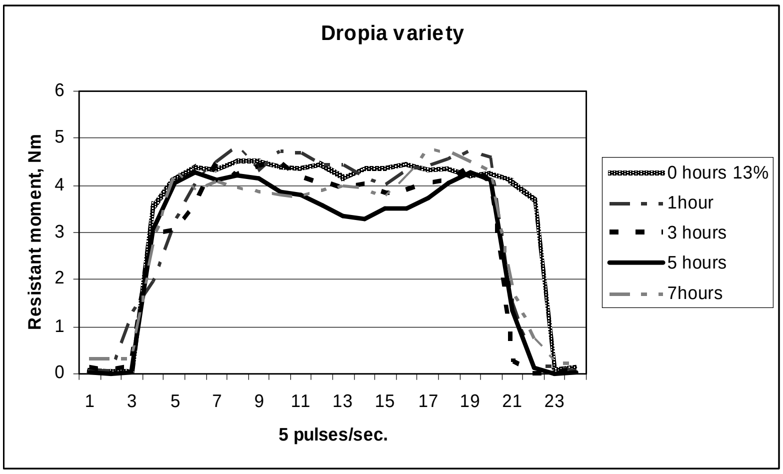

Figure 3. The average resistant moment, for different rest time values of Dropia variety

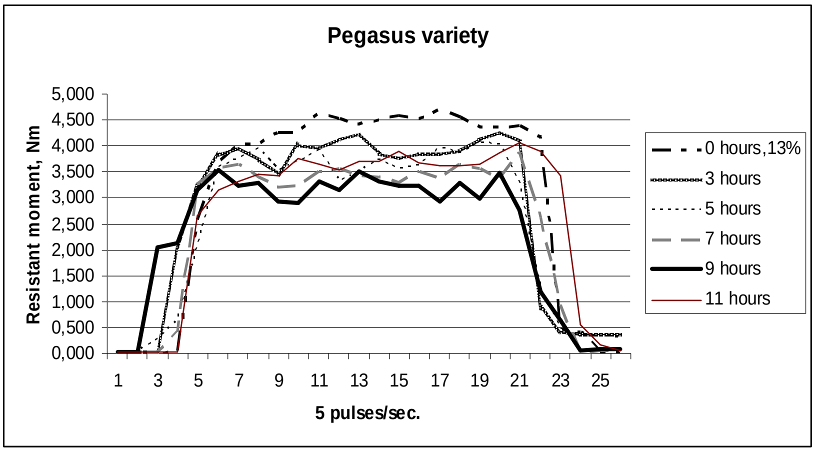

Figure 4. The average resistant moment, for different rest time values of Pegasus variety

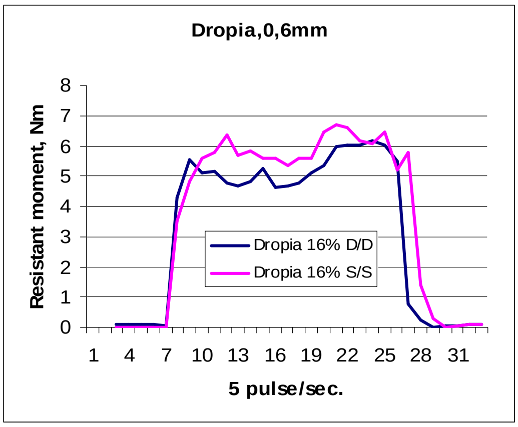

Figure 5. The resistant moment (specific surface energy consumption) for Dropia variety with 0,6 mm roll gap and D/D or S/S roll disposition.

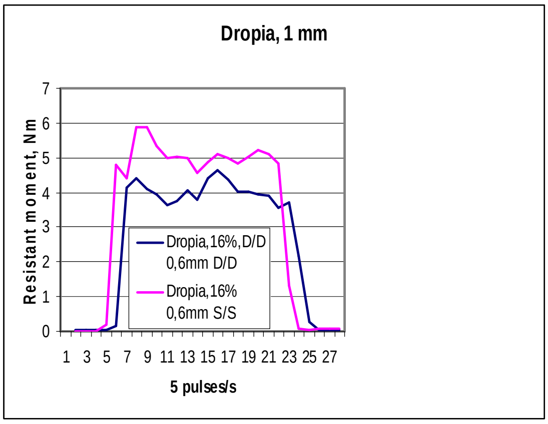

Figure 6. The resistant moment (specific surface energy consumption) for Dropia variety with 1 mm roll gap and D/D or S/S roll disposition

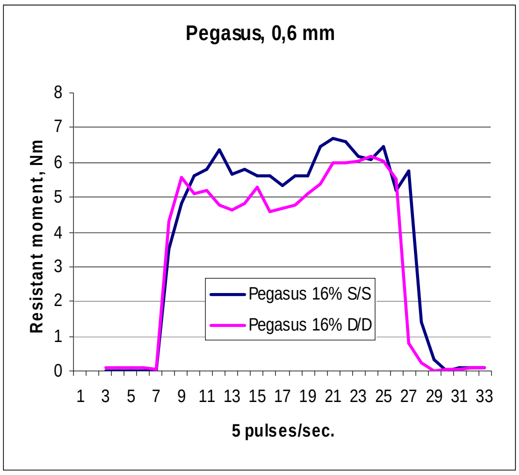

Figure 7. The resistant moment (specific surface energy consumption) for Pegasus variety with 0,6 mm roll gap and D/D or S/S roll disposition.

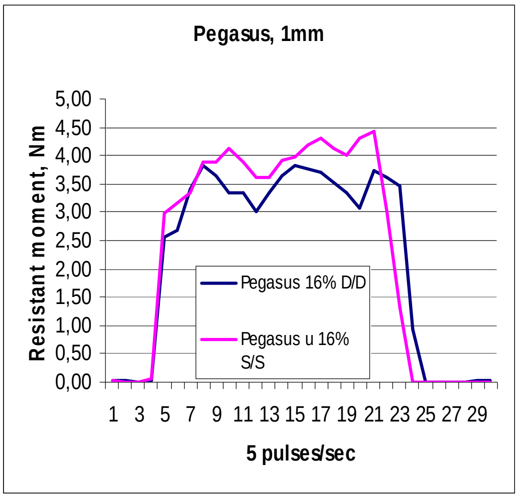

Figure 8. The resistant moment (specific surface energy consumption) for Pegasus variety with 1 mm roll gap and D/D or S/S roll disposition.

After the first breaking step in the wheat grinding, were obtained the curves (Fig. 5,6,7,8) representing the resistant moment of the wheat kernel in the breaking process.
The energy consumption is represented by the surface aria, below the resistant moment curves.
For both Dropia and Pegasus wheat varieties, the lowest energy consumption is achieved with mill adjustment regarding the dull-to-dull (D/D) disposition, rather then sharp-to-sharp (S/S) disposition.
Also, the same lowest energy consumption in the first break is obtained for a maximum size of the roll gap (1 mm for the first break). The energy amount is higher when the size of the roll gap is decreasing.

Conclusion

The assessment of the optimum parameters in the conditionning process can be made by the micromill designed to determine the grinding resistance of the cereals.
The method has the same accuracy as the classical one and has the advantage to be quicker and less demanding as work volume.It is an alternative way to describe the optimum for the conditioning process and can be used in laboratory for the benefice of students as well in the milling industry.
The best results for the first break, from the point of view of technological efficiency and the energy consumption were obtained for the sharp-to-sharp disposition and a roll gap related to the grinding length of the rollers.
The new designed micromill can be used for the assessment of the energy consumption for the first break, in the laboratory conditions, for the benefice of the students.

The micromill designed for determination of the grinding resistance of the cereals, can be used in an industrial mill plant, because it has the advantage of obtaining the cumulative compression and shearing efforts like in the industrial process.

The resistant moment can be obtained also for the middling grinding process, step which can lead to the economic optimization of the cereal processing.
The micromill is ideal for testing improved wheat cultivars developed in breeding programs.

Acknowledgments

This research was supported by The National Programme Research Council and UEFISCSU, contract no. 411/2007-2010.

References

1. POSNER, ELIESER S., HIBBS, ARTHUR N., *Wheat flour milling*, American Association of Cereal Chemists, St. Paul, Minnesota, 1997, pp. 125.
2. GEHLe, H. 1965. *The MIAG "Vario" Rollstand: Design and purpose*. Amer. Assoc. of Operative Millers' Tech. Bull. (May): 2861–2862.
3. KILBORN, R. H., H. C. BLACK, J. E. DEXTER, AND D. G. MARTIN. 1982. *Energy consumption during flour milling: Description of two measuring systems and influence of wheat hardness on energy requirements.* Cereal Chemistry. 59(4): 284–288.
4. FANG, Q. 1995. *Effects of physical properties of wheat and operational parameters of roller mills on size reduction.* MS thesis, Kansas State Univ., Manhattan, Kansas.
5. PUJOL, R., C. LETANG, I. LEMPEREUR, M. CHAURAND, F. MABILLE, AND J. ABECASSIS. 2000. *Decription of a micromill with instrumentation for measuring grinding characteristics of wheat grain.* Cereal Chemistry 77(4): 421–427.
6. SCANLON, M. G., AND DEXTER, J. E. 1986. *Effect of smooth roll grinding conditions on reduction of hard red spring wheat farina.* Cereal Chem.63:431-441