Energy Saving Opportunities Related to the Size Reduction for the First Break, in the Wheat Milling, with a New Designed Micromill

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Abstract: - Energy efficiency is an important component of a company’s environmental strategy. The new mills are designed to reduce labor and machinery to lower capital, lower consuming energy and manufacturing costs. 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. This paper shows energy saving opportunities provided by a new designed micromill.

Key-Words: - Wheat, Energy, Breaking, Resistant moment, Roll disposition, Size Reduction.

1 Introduction
As food manufacturers face an increasingly competitive global business environment, they seek out opportunities to reduce production costs without negatively affecting product yield or quality. Uncertain energy prices in today’s marketplace negatively affect predictable earnings, which are a concern, particularly for the publicly traded companies in the wheat milling industry. Successful, cost-effective investment into energy efficiency technologies and practices meets the challenge of maintaining the output of a high quality product despite reduced production costs. Cross-cutting equipment present well-documented opportunities for improvement. Equally important, the production process can be fine-tuned to produce additional savings. During wheat flour production only about 1% of grinding energy is transformed into receiving a new surface [1] (Mohsenin N.N., 1986). The main cause of such large energy loss are plastic and elastic strains [2], [3] (Fang and Campbell, 2002a, 2002b). It is also essential to fully characterize the milling fractions produced when assessing the grindability of wheat in a roller mill. The most common particle size analyses involve sieving analysis [4] (Hareland, 1994). The grinding energy and how it relates to size reduction has been a subject of considerable interest to researchers. 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), [5], [6], [7], [8].

2 Problem Formulation
The aim of the research is to identify the optimum roll disposition for obtaining the maximum efficiency of intermediate products (middling, flour), with minimum energy consumption, on the first breaking step in the wheat milling process.

2.1 Materials
Wheat samples
The investigations were carried out on Romanian winter wheat variety (Triticum aestivum, ssp. vulgare) Droapia, harvested in 2009. The preparation of the samples collected 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 variety are depicted in Table 1. Before milling, 30 grams of each dry wheat sample was conditioned overnight to reach 15,5 % (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 at least 8 hours to give an even distribution of moisture.
<table>
<thead>
<tr>
<th>Variety Indicator</th>
<th>Dropia</th>
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<tbody>
<tr>
<td>Hectolitric weight [kg/hl]</td>
<td>77,6</td>
</tr>
<tr>
<td>Vitreousness [%]</td>
<td>18</td>
</tr>
<tr>
<td>Wet gluten content [%]</td>
<td>21</td>
</tr>
<tr>
<td>Moisture content [%]</td>
<td>11,3</td>
</tr>
<tr>
<td>Falling number [s]</td>
<td>260</td>
</tr>
<tr>
<td>Protein content [%]</td>
<td>10,8</td>
</tr>
</tbody>
</table>

Table 1. Quality indices of the Dropia wheat variety

Experimental micromill

In flour milling, roller mills perform bran separation as well as size reduction. First–break, or the first roller mill operation in the milling process, performs the first bran separation by opening the wheat kernels with minimum bran breakage. Bran coming out in the form of flakes ensures ease of separation from the endosperm in succeeding stages. Mechanical energy is required to impart compressive and shear forces that break wheat kernels and reduce the size of endosperm particles.

For this research, was used a new designed micromill which can perform in the grinding process of the wheat and of the middlings 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 process, for different wheat varieties or different batches, but also for different characteristics of the rollers. The micromill is equipped with rolls measuring 60 mm in length and 90 mm in diameter, 0,8 mm roll gap for the first breaking step, 7 corrugations/cm, roll disposition dull-to-dull (D/D), sharp-to-sharp (S/S), sharp-to-dull (S/D), dull-to-sharp (D/S), 2,5:1 differential speed ratio, 6% inclination and 30/60° (α/β) profile. 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.

2.2 Methods

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.

3 Problem Solution

After the first breaking step in the wheat grinding, were obtained the curves (Fig. 1) representing the resistant moment of the wheat kernel in the breaking process for different roll disposition (S/S, D/D, S/D, D/S).

![Fig. 1 The resistant moment (specific surface energy consumption) for Dropia variety, with 0.8 mm roll gap and different roll disposition.](image)

The energy consumption is represented by the surface aria, below the resistant moment curves. The highest energy consume is obtained with the
D/S roll disposition, followed by D/D, S/S and S/D roll disposition. The same results were obtained calculating the average resistant moment (Fig. 2) and cumulative (sum) resistant moment (Fig. 3), for all 4 roll dispositions.

![Fig. 2 The average resistant moment, for different roll disposition](image)

The highest value of energy consuming for D/S roll disposition is explained by the compression efforts specific to this disposition. The compression efforts in the grinding process is highest than the shearing efforts.

![Fig. 3 Cumulative (sum) resistant moment, for different roll disposition](image)

The grinding efficiency is related to the first break intermediate fractions quantity. The aim of the first breaking step is to obtain a large amount of middlings. This is possible using the S/S roll disposition (Fig. 4).

![Fig. 4 The efficiency of intermediate fractions from the first break](image)

Also important for the size reduction is the grinding degree. The highest value of the grinding degree on the first breaking step is obtained for the S/S roll disposition.

![Fig. 5 The size reduction indices (grinding degree, i), for different roll disposition](image)

**4 Conclusion**

The results of the research recommend the S/S roll disposition as the most advantageous disposition for the maximum energetic efficiency, the highest yield in middlings and the highest grinding degree in the size reduction on the first break.

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References: