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QUALITY ASSESSMENT OF GRINDING OPERATION

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Abstract: *In milling industry the purpose of wheat processing is to obtain the main products (flour) and secondary products (bran, germ) of well-defined quality. The grist control, made at the end of milling process, is done to remove some deviations from quality conditions. This paper presents two of the most usual methods of grist control resulted from the crushing process, like mechanical classification using the sieve analysis and the laser diffraction method.*
Keywords: *degree of crushing, sieving, laser diffraction.*

1. INTRODUCTION

In order to assess the quality of the grinding operation is very important to take into account geometric characteristics of the product resulting from the process of grinding.

The product obtained by the crushing operation is a mixture of particles having the characteristics defined by the size and shape of the particles. The final dimensions of the particles are characterized by a degree of fineness.[6]

The degree of grinding is dependent on the process applied by the grinding operation, the initial size of the particles in the feed stream (the initial size of the structural elements of the material) and the mechanical characteristics of the material subjected to grinding operation (resistance to crushing).

Degree of fineness *i* is defined as the ratio of the initial D average particle size and final d average particle size:

$$i = \frac{D}{d} \tag{1}$$

The grinding operation can be achieved, depending on the desired degree of fineness in one step or in multiple steps, the power consumption increases in proportion to the degree of fineness.

If are required high levels of grinding degree, the grinding operation is carried out in several steps. If the grinding operation is performed in n steps, the total grinding degree is determined as a product of the fineness degree of each stage of grinding, and is calculated using:

$$i = i_1 \cdot i_2 \cdot \ldots \cdot i_n = \prod_{k=1}^{n} i_k \tag{2}$$

Depending on the degree of crushing, grinding is classified as follows:

- Crushing coarse 0 <i <1;
- Crushed 1 <i <10;
- Crushing 10 <i <100;
- Fine grinding 100 <i <1000;
- Ultrafine grinding i> 1000.

After the grinding operation results a big number of different sized particles with a high total surface area. To determine the fineness degree of grinding grist resulting from different methods can be used direct or indirect methods: the method of sieving, sedimentation method, turbidimetric method, laser diffraction method, analyze the optical path.[6]

2. MATERIALS AND METHODS

The simplest method of determining the newly particle surface created by mechanical classification, is the sieve analysis. This method is used in heterogeneous mixtures of polydisperse type solid - solid, with a particle size in excess of 50 ... 70 μm. For accurate determination of the particle surface, it is necessary to divide the product by screening in several classes. The more particles are divided into several classes with both their size is accurate, and the surface can be determined exactly.

Are used the Tyler series sieves (ASAE standard of State), in which the holes of two successive sieve are in $\sqrt{2}$ report, so the holes of each upper sieve are duplicates their area. The Tyler base sieve (Fig. 2) is the sieve with the size of 0.074 mm (200 mesh / inch, 1 inch = 25.4 mm).

The device used for the sieve analysis is the device Makarov (Fig. 1) provided with a predetermined number of planar sieves. [10, 7]

Figure 1: The device used for the sieve analysis, type Makarov [10, 7]

Figure 2: Tyler sieves [10]

By sieving the material are obtained several classes of products, the differences are depending on the mesh size sieve. The sieve with the largest holes is positioned first; the next sieves are positioned in the following descending order of mesh sieve. The last area, called blind sieve is a surface without holes, and on it are collected the sifting from the last sieve. During sifting the material remaining on the sieve is called refuse, and the material passing through the mesh is called sieving.

Tabelul 1: The surface of particles obtained by milling wheat[4]

Average particle size d, cm	Weighed quantity m_i, g		The surface of all particles, mm^2	
	Rollers mill	Hammer mill	Rollers mill	Hammer mill
0,072	0,5	1,0	27,78	55,56
0,060	11,5	11,2	966,67	746,68
0,047	6,8	5,0	578,72	425,54
0,035	15,7	10,0	1794,28	1142,86
0,025	22,8	20,2	3648,00	3232,00
0,020	6,4	7,2	1280,00	1440,00
0,017	0,7	1,6	1647,06	3764,71
0,014	6,8	8,4	1942,85	2400,00
0,012	3,8	4,5	1266,67	1500,00
0,010	2,75	6,34	1100,00	2536,00
0,008	1,10	5,40	550,00	2700,00
0,006	6,71	6,49	4773,00	4326,67
0,004	4,10	4,33	4180,00	4330,00
0,002	4,95	5,10	9900,00	10200,00
0,0012	2,31	3,24	7700,00	10800,00
Total	100,0	100,0	41055,37	49600,02

To determine the particle surface need to take into account the following characteristics:
- the quantity of product in each size class;
- the average size of the particles in each size class;
- density of particles in each class.

Table 1 presents some surface particles obtained by crushing wheat. [4] The number of particles in each class may be determined by the relation:

$$n_1 = \frac{m_i}{d_i^{\,3} \cdot \circ \cdot g}, \tag{3}$$

where n_1 is the number of particles which are in the class; m_i - the amount of product class in g; d_i - an average particle size of the product, m; ρ - density of the particle in kg/m^3.

Another method of determining the newly particle surface created is the laser diffraction measurement method. The determination is carried out by using a laser diffraction spectrometer. The divergent radiation of the laser is converted in parallel radiation, as a result of laser location in the focus of a convergent lens. The flat wave laser is influenced by the particles which diameter will be determined.

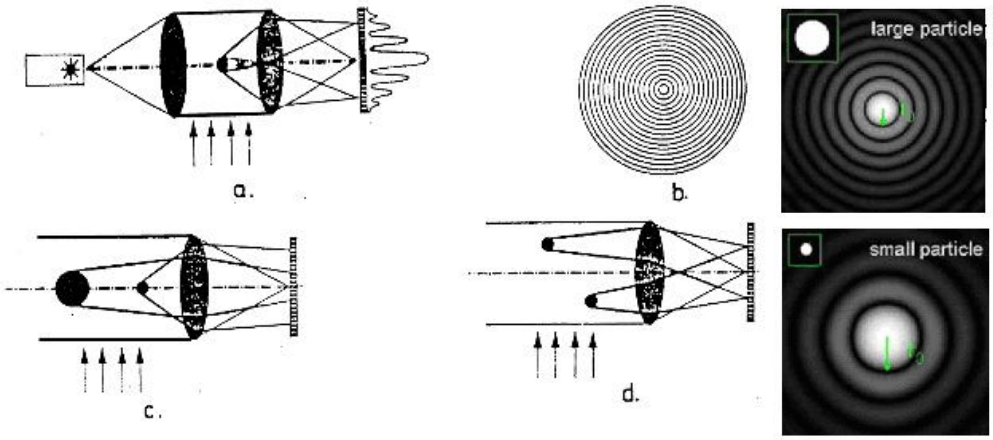

Figure 3: The principle of diffraction particle size measurement [10]

Behind each particle, the radius suffers a diffraction (fig. 3 a), the diffraction angle is inversely proportional to particle size, the particles with smaller size have the light diffraction angle smaller (fig. 3, c) and therefore the diameters of the diffraction rings will be larger (fig. 3, b). The particle size is determined by measuring the diameter of the central ring diffraction. The diameters of the diffraction rings are measured by a transducer made from a photoelectric elements points, ordered by several concentric circles. Diffraction rings of the same size particles are accumulate; increasing the intensity of the diffraction ring, the position of the particle in the field is not influence the position of diffraction rings.[5,6]

3. CONCLUSION

In order to assess the quality of the grinding operation is very important to take into account geometric characteristics of the product resulting from the process of grinding.

To determine the particle surface need to take into account the following characteristics: the quantity of product in each size class; the average size of the particles in each size class; density of particles in each class.

The simplest method of determining the newly particle surface created by mechanical classification, is the sieve analysis. This method is used in heterogeneous mixtures of polydisperse type solid - solid, with a particle size in excess of 50 ... 70 μm.

Another method of determining the newly particle surface created is the laser diffraction measurement method, the determination is carried out by using a laser diffraction spectrometer.

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