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A. S. Dorogokupets, M. Sc. (Engineering), deputy chief mechanic (RUE “Belmedpreparaty”);
V. S. Frantskevich, PhD (Engineering), assistant professor (BSTU)

INFLUENCE OF TECHNOLOGICAL PARAMETERS OF THE DYNAMIC SEPARATOR OF A BOWL ROLLER MILL ON ENERGY COSTS

In the process of operation of technological equipment, which uses a gaseous medium as a transporting agent, a decisive influence on the specific energy consumption has a drag machine. For the analysis of drag equipment modeled grinding unit in conjunction with a dynamic classifier and analytical studies are conducted in the software package ANSYSCFX with the construction of the graph-analytical relationships.

Introduction. In pharmaceutical industry one of the stages of yielding a finished product is a grinding process of the material: the preparation of tablet mass, crushing substances, semi-products, and others.

As a rule, industrial mills are used in combination with classifying devices (classifiers and separators) [1, 2]. This is necessary due to the fact that after grinding the finished product contains the particles not always satisfying the requirements of an effective flow of subsequent processes. So, often in pharmaceutical industry they resort to regrinding and conduct the process to achieve the desired granulometric composition of the product. This may result in over-grinding, that is unacceptable, and increasing specific energy consumption.

In the Republic of Belarus bowl mills have recently been introduced in various technologies. They are characterized by low specific power consumption and high performance and are used for dry grinding with the formation of a closed cycle. Bowl mills are widely used in the manufacture of cement, lime, gypsum, dolomite, and others. The analysis of their work shows that the use of such equipment in the pharmaceutical industry are also economically feasible.

Considering the promising use in the industry of the Republic of Belarus, including that of the pharmaceutical industry, this type of equipment, the grinding unit with a bowl roller mill and air classifier has been chosen as the object of the research. The dynamic classifier with a rotor in the form of a truncated conical basket has been used as the latter.

The aim of this study is to analyze the impact of technological parameters of the dynamic separator of a bowl roller mill on energy costs.

Main part. To analyze the influence of technological parameters of the classifier on the energy efficiency of the grinding machine the computer simulation in the software package ANSYSCFX has been used. To realize the possibilities of the program the grinding machine with real geometric dimensions (Fig. 1). [3] was modeled in CAD SolidWorks application.

The inner diameter of the mill body – 350 mm, the height of the mill – 550 mm, the number of rolls – 2, the average diameter of the rolls – 160 mm, the diameter of the grinding plates – 300 mm, the inner diameter of the body of the dynamic separator – 400 mm, the height – 305 mm, the average diameter of the rotor – 315 mm, the height of the rotor – 270 mm.

The grinding machine consists of a control unit *1* (Fig. 1) to control and regulate the process of grinding and classification, a support/bearing *2* on which *a* control panel with frequency converters is fixed, a bowl roller mill *3, 4* a dynamic classifier (Fig. 2). To capture the finished product a baghouse is used *5.*

The dynamic classifier is a cylindrical body *1* (Fig. 2) within which a conical basket *5* with inclined blades is located with increase in diameter in height of the classifier that enables to block evenly and constructively the output of the classifier section.

The rotor is rotated by means of an electric motor *3*. The crushed product passed classification is taken out by the gas flow from the grinding unit.

The grinding machine operates as follows (Fig. 3): the previously prepared feedstock is fed into the hopper of a screw feeder and then a feeder directs it onto the cone of the grinding plate, where the feedstock is uniformly distributed on it under the influence of centrifugal forces caused by the rotation of the plate. The material then falls under the grinding rolls and is destroyed due to crushing and partial abrasion. The transporting agent in the grinding unit can be the air (sometimes in a mixture with inert gas) or flue gases in the case of the drying material.

The crushed and fallen material is carried away by the air swirling flow as it moves vertically along the grinding unit, then it enters the separation space of the dynamic classifier, where depending on the desired fineness of the product, at a certain speed a rotor basket is rotating.The separated fraction of the desired granulometric composition of the material through the branch pipe enters the collector of finished products. The collector is the baghouse itself. The coarse fraction comes back to the grinding plate for regrinding.

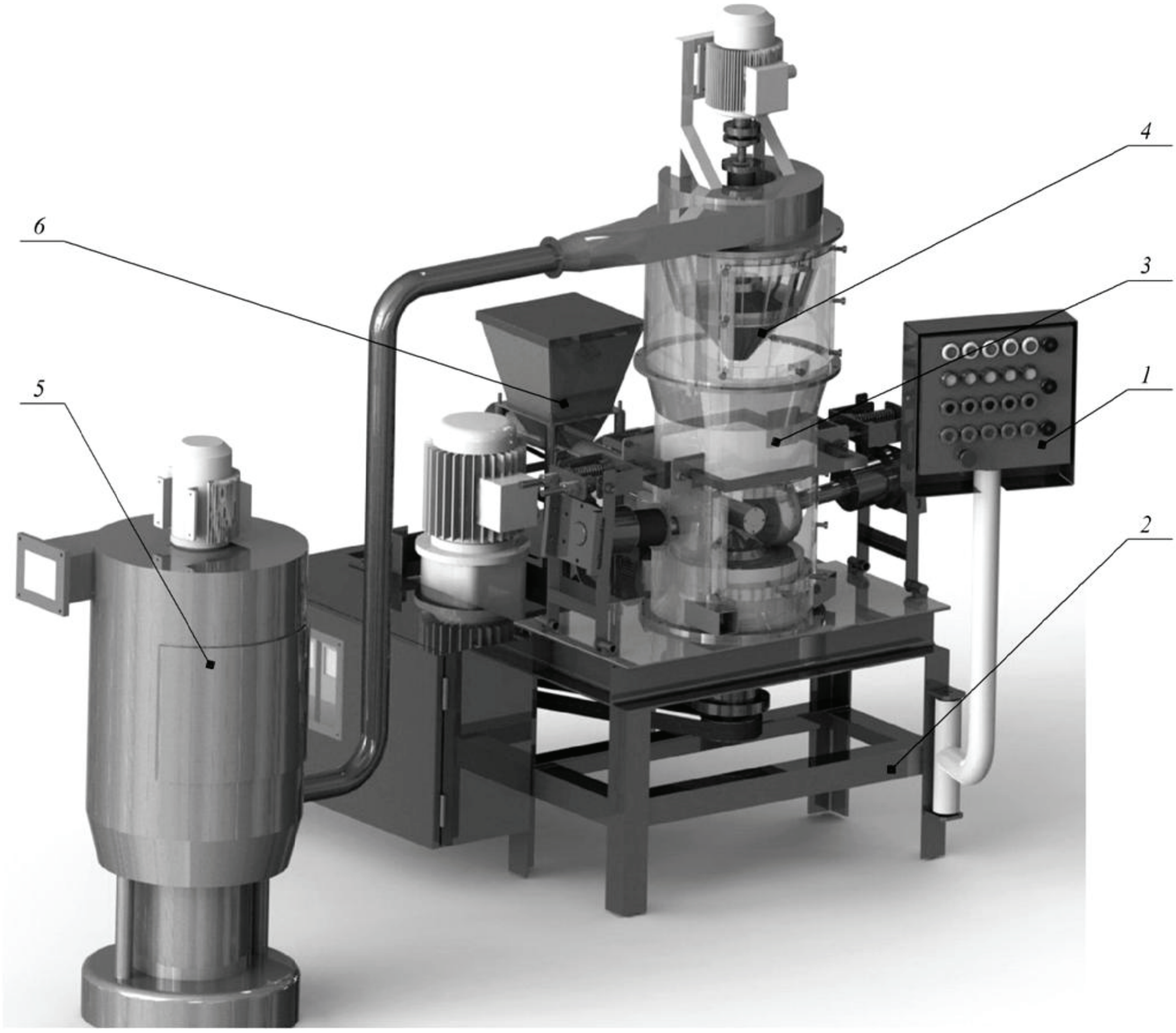


Fig. 1. The grinding unit:
1 – remote control; *2* – bearing; *3* – mill; *4* – dynamic classifier; *5* – baghouse; *6* – screw feeder

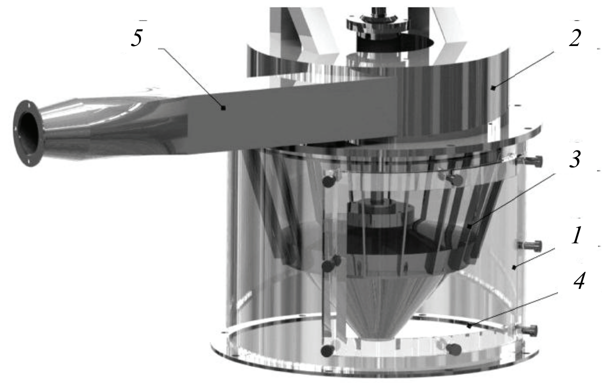


Fig. 2. Dynamic classifier:
1 – body of the classifier; *2* – cover;
3 – basket of the classifier; *4* – viewing window;
5 – material branch pipe

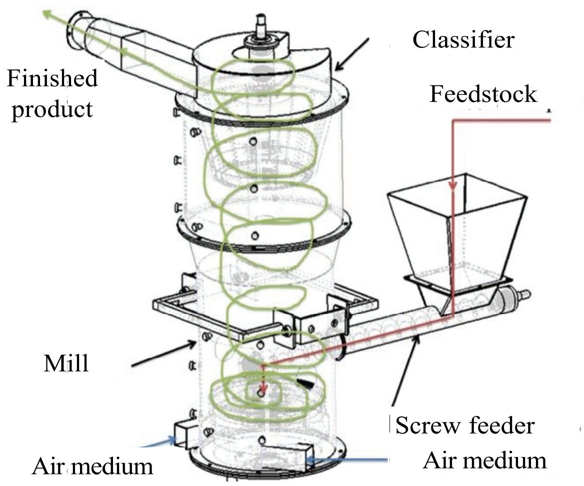


Fig. 3. Scheme of the grinding machine

As previously indicated, to analyze the influence of technological parameters on the efficiency of the grinding unit due to the complexity of the process under study, the computer modeling software package ANSYSCFX was used.

The rotational speed of the plates – 100 min^{-1}, mass flow of gas at the output – 0.2 kg/s (i. e. the arrangement system providing finding the fan after the grinding unit) were given as the input parameters for the calculation.

The variable parameters to determine the influence of technological parameters on the energy consumption of the grinding unit were the speed and direction of the rotor of the separation device. The direction of rotation was set facing the main gas stream in the opposite direction. Its rotational speed varied stepwise and was equal to 300, 500 and 750 rev/min, which corresponded to the linear velocity at the average diameter of the rotor 10, 16 and 25 m/s.

The calculation results are presented as graphic dependences of the velocity distribution in the cross section of the separator basket passing by the averaging diameter of the rotor basket (Fig. 3).

Taking into account the fact that the structure of the air flow in the cross section of the grinding machine is not symmetrical relative to the central axis, i.e. the air flow rate is not uniform and changes chaotically, due to grinding elements and material of the branch pipe being inside the machine, the velocity analysis was performed in four directions (Fig. 4).

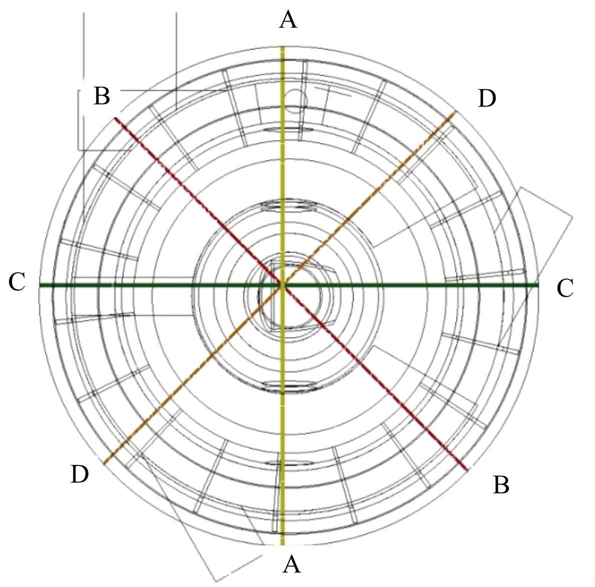


Fig. 4. Scheme airflow analysis

The analysis of the graphic dependences shows that the uniform rate distribution is achieved when passing the rotation of the gas stream and basket of the separator, particularly at 10 and 16 m/s (Fig. 5, dependences 1 and 2). Wherein at a peripheral area of the blades the maximum speed (12 m/s), which provides the penetration of the larger particles through the rotor blades. When the rotation speed is 25 m/s in the rotor, the “fan” effect increases and the zone of high speeds is shifted to the inner edges of the blades. In this case, the separated particles will have a smaller size.

At the counter rotation the air flow over the cross section is distributed very unevenly. The rotation speed of 10 m/s provides such a radial component which allows the particles to penetrate into the central section of the rotor, however in the zone near the axis of symmetry the gas flow rate is sharply reduced down to zero values.

As a result, there is a possibility of accumulation of particles in the axial zone of the rotor and their accidental release, due to the impact of the blades without clear separation.

This prevents the passage of particulate material between the blades. High vortices appear only directly on the rear side of the blades when they are surrounded by the gas flow.

Technological equipment, in which the air or other gas environment is used as material flow is characterized by aerodynamic resistance. One can judge the specific energy consumption for the process of classifying the value of this resistance, which ultimately determines the economic viability of those or other production processes.

Therefore, using the software package ANSYSCFX it was possible to analyze the aerodynamic resistance of the dynamic air classifier at various speeds of rotation of the rotor basket. At once, it was noted that when the basket is rotated in a direction opposite to the rotation of flow there is a rapid increase of the hydraulic resistance. Thus, when the linear speed of the rotor is 25m/s, the aerodynamic resistance is about 2750.0 Pa, which is 35% greater than in the same direction of rotation, with an increase in rotor speed of the basket this difference increases significantly.

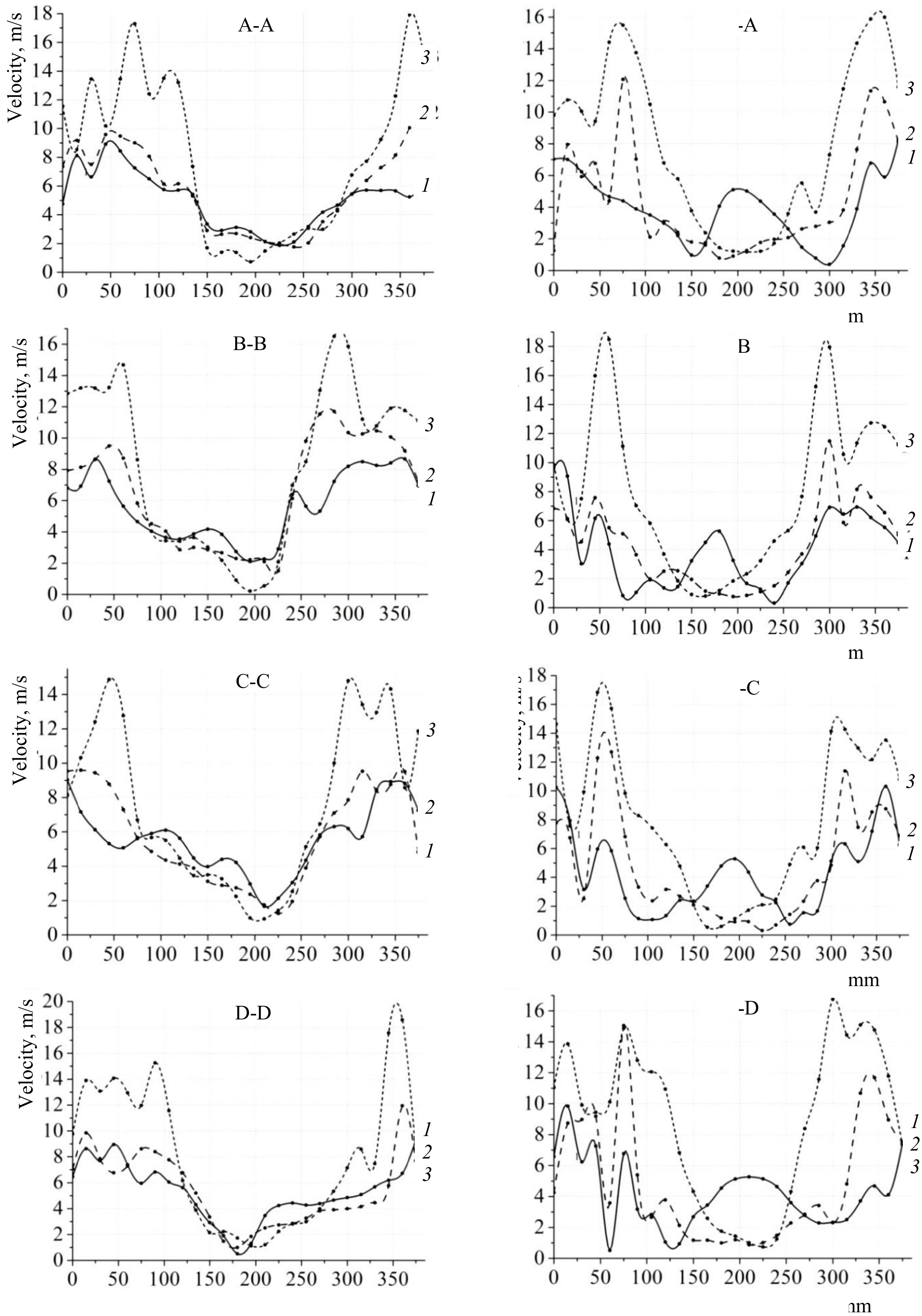
At the same direction of rotation of the rotor the aerodynamic resistance of the classifier with increasing speed increases slightly, and after reaching the linear velocity of about 15 m/s starts to slowly decrease, due to the appearance of a “fan” effect at high speeds of rotation of the rotor.

Power required to maintain the desired speed of the gaseous medium in a section of the grinding unit is determined by the following formula:

$$N = Q \cdot \Delta p ,$$

where Q – air flow rate, m^3/s; Δp – aerodynamic resistance of the grinding machine, Pa.

Taking into account a linear dependence of power on resistance, graphically energy costs of the rotor speed of the basket are similar to the change in the aerodynamic resistance of the classifier (see Fig. 6).



a *b*

Fig. 5. The graphs of the air flow rate distribution in the cross section of the separator basket:
a – the same direction of rotation; *b* – the opposite direction of rotation;
1 – the speed of rotation of the rotor basket 10 m/ s; *2* – 16 m/s; *3* – 25 m/s

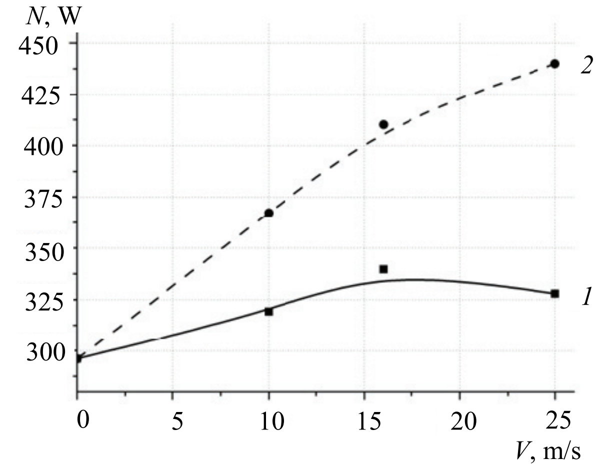


Fig. 6. The energy consumption of the grinding unit:
1 – the same direction of rotation;
2 – the opposite direction of rotation

Conclusion. As a result of analytical studies of the effect of technological parameters (rotor speed and direction of rotation of the basket) of the dynamic classifier with the rotor in the form of a basket with fender blades operating in a closed cycle with a bowl roller mill, one can make the following conclusions.

1. To reduce the energy consumption for purging a grinding unit and increase the efficiency of the dynamic classifier the direction of rotation of the rotor basket should coincide with the direction of rotation of the gas stream which enters the mill tangentially.

2. In evaluating the energy costs to overcome the aerodynamic forces of resistance it is important to take into account real aerodynamic characteristics in the separation space of the mill which are possible to study with the help of computer simulation.

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