High concentrated mass transportation to the grinding zone

A.V. Ushakov, Y.D. Alashkevich, V.A. Kozhukhov, R.A. Marchenko

Reshetnev Siberian State University of Science and Technology 31, Krasnoyrsky Rabochy Av., Krasnoyarsk, 660037, Russian Federation
e-mail: al.ushakov2194@mail.ru

Transportation of high concentrated fibrous materials to the disk mill grinding zone may be accompanied by problems when the fibrous material clogs the knife gap and causes subsequent failure of the grinding equipment. The article considers one of the few recommendations helping to eliminate this negative effect taking into account main technological factors of the grinding process.

Key words: grinding, high concentrated mass, resisting forces, centrifugal force.

Grinding is the most important stage in production of pulp and paper products. Grinding of fibrous materials in an aqueous medium is accompanied by complex mechanical and hydrodynamic impact on the fibers. Quality of the final paper product strongly depends on the grinding process quality. There are many technological factors that have significant impact on the grinding process. Assuming that properties of the fibrous material entering the grinding apparatus are constant, the main factors influencing the grinding process include: duration of grinding, specific pressure between the grinding surfaces, design parameters of the knife tooling, peripheral speed of the grinding elements, concentration and temperature of the fibrous mass and other factors [1, 2, 3].

Grinding of low concentrated mass leads to an increase in hydraulic forces arising from rotation of the grinding element and a decrease in the gap between the knives which causes an increase in cutting action of the machine. An increase in the mass concentration during grinding leads to an increase in the gap between the grinding elements due to a decrease of the hydraulic component value. In this case processing of the fibrous material occurs not only due to the work of the knife tooling, but also due to the mutual friction of the fibers. As the result, it helps to maintain the original length of the fiber and direct the fiber treatment process towards fibrillation and hydration [3, 4].

Each milling unit has its own optimum mass concentration parameter at which grinding is the most efficient. A disk mill is the most suitable equipment to grind high concentrated fibrous materials (from 5%). At this point, milling of high concentrated fibrous materials is a promising area of research [3, 4].

Grinding of a high concentrated mass results in much better physical- and mechanical characteristics of the finished paper mass than in the case of low concentrated grinding. Despite that, the high concentrated grinding has a number of disadvantages that can damage the grinding equipment. These include clogging of the disc tooling of the rotor and stator with the fibrous material [3, 4].

The centrifugal force developed by the disc tooling rotor is the driving force of the mass. The force is aimed to overcome the resisting forces that slow down passage of the fibrous material through the grinding zone. When the centrifugal force prevails over the resisting forces, grinding takes place under normal conditions. Otherwise clogging occurs [3].

Previous studies show that, to carry out the process of high concentrated grinding successfully, it is necessary to increase the centrifugal force to overcome the resisting force or reduce resistance to the grinding zone passage reducing the centrifugal force of the feeder and leaving the centrifugal force developed by the disc tooling rotor unchanged [3].

The centrifugal force is calculated by the following formula:

$$J_ц = kmRn^2;$$

Where m- is the fibrous material mass, kg;

R - is the disc tooling radius, m;

k - is a coefficient;

n - is the number of the disc tooling rotor revolutions per minute, rpm.

It is not always possible and necessary to develop the centrifugal force of the grinding element to the level at which this equality will be fulfilled . To address unsolved issues, the MAPT department of the Siberian State University named after Reshetnev M.F. has an experimental grinding unit (Figure 1). This grinding unit is equipped with a specially designed rotary spreader that should help to solve the clogging problem of the disc tooling inter-knife gap and increase productivity.

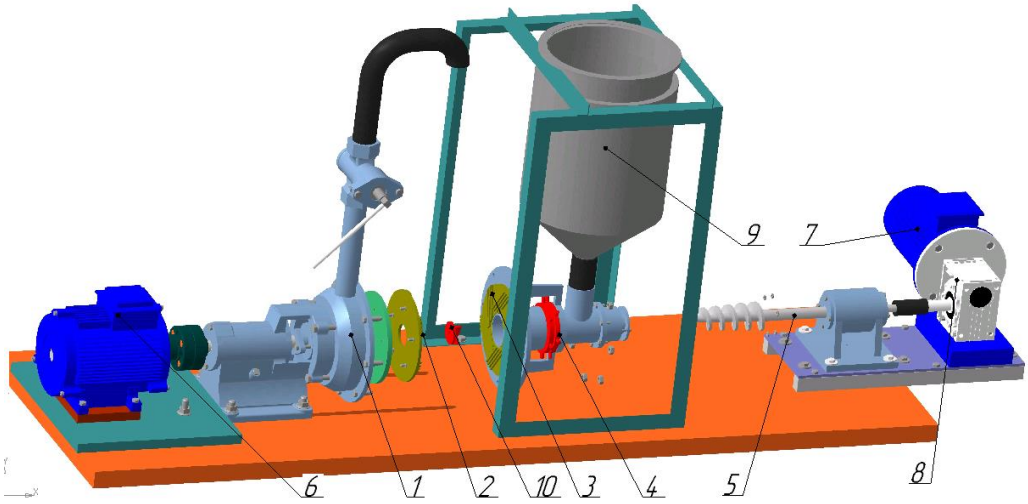

Fig. 1.Grinding unit design (1 - grinding zone; 2 - rotor; 3 stator; 4 - adjusting device; 5 - screw feeder; 6 - electric motor of the rotor; 7 - electric motor of the screw feeder drive; 8 - worm gear reducer of the screw feeder drive, 9 - fibrous mass container; 10 - rotary spreader)

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References

1. Alashkevich, Ju.D. Teorija i konstrukcija mashin i oborudovanija otrasli [Theory and design of machinery and equipment of the industry]: ucheb. posobie / Ju.D. Alashkevich, N.S. Reshetova. – Krasnojarsk: SibGTU. – 2015. – 317 p.
2. Ivanov, S.N. Tehnologija bumagi [Paper Technology]: S.N. Ivanov. – M., L.: Goslesbumizdat. – 1970. – 720 p.
3. Matveev, B.P. Issledovanie osnovnyh faktorov processa razmola sul'fatnoj nebelenoj celljulozy v diskovoj mel'nice pri vysokoj koncentracii: dis. kand. teh. Nauk [Investigation of the main factors of the process of grinding kraft unbleached pulp in a disk mill at a high concentration] : 05.21.03 / Matveev Boris Petrovich – M.: Leningradskij Tehnologicheskij Institut Celljulozno Bumazhnoj Promyshlennosti, 1974. – 158 p.
4. Korda, I. Razmol bumazhnoj massy [pulp beating stage]: ucheb. dlja vuzov / I. Korda, Z. Libnar, I. Prokop. – M.: Lesnaja promyshlennost'. – 1967. – 421 P.