Improving the quality parameters of a fibrous pulp in the process of knife milling

D E Zyryanov, N S Reshetova and R A Marchenko

Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarsky Rabochy Av., Krasnoyarsk, 660037, Russian Federation

E-mail: r.a.marchenko@mail.ru

Abstract. Pulp and paper products in the modern world are used in a variety of types and areas, due to which the issue of improving paper production technologies is relevant. The article presents the results of grinding fibrous semi-finished products using the knife method. A disc mill with an original knife set was used as the unit under study. For the most effective modes of grinding were selected to obtain raw materials with high quality indicators.

1. Introduction

Milling of fibrous materials is an important stage in the technological process of obtaining pulp and paper products. As a result of milling, the fiber is chopped and fibrillated, thereby increasing the paper-forming characteristics of the pulp, on which the physical and mechanical characteristics of the finished product will largely depend [1-2]. In order to increase the efficiency of the preparation of fibrous semi-finished products for casting on a paper or cardboard machine, research is required in this area [3].

At the Department of Machines and Apparatus for Industrial Technologies (MAIT) of the Siberian State University of Science and Technology named after academician M.F. Reshetnev, research is being carried out in the field of improving equipment and technology for grinding fibrous materials. One of the directions of research is the improvement of the shape (pattern) of the knives of the grinding set.

Grinding set is the main working body of a disk mill, which directly affects the fibers during their processing. The working surface of the set is characterized by the number and size of knives and grooves, and their location on the surface [4].

A feature of the patterns of the working surface of the headsets with an open outlet is that the open area should decrease from inlet to outlet, in accordance with the change in the fractional composition of the semi-finished product, when moving it from the inlet to the peripheral edge of the disc edge [4-5].

2. Methods

Grinding in a disk mill was carried out by us under the following modes: fiber mass concentration - 2 - 3%, rotor speed - 2000 rpm and inter-knife gap between rotor and stator knives - 0.1 mm. These parameters were selected as the most effective, in terms of the duration of grinding and the degree of fiber development, based on research previously conducted at the Department of MAIT. Preliminarily, the pulping of the fibrous material was carried out in a pulper. As a knife grinding set of a disk mill, a set with an involute shape of knives was used (general view is shown in figure 1) [6].
Figure 1. Diagram of an involute headset.

This set, other things being equal for grinding, provides a gentler development of the fibers, in comparison with the sets we considered earlier [7-8].

The fibrous material was coniferous and deciduous sulphate bleached cellulose - the products of OJSC “Ilim Group” in Bratsk.

3. Results
Figure 2-4 shows plot of pulp versus freeness.

Figure 2. Dependence of the fiber length on the degree of grinding.

Figure 3. Dependence of the fibrillation index on the degree of grinding.
During the refining process, the fiber undergoes chopping and fibrillation, as a result of which the fiber length decreases, and the percentage of fibrillated fibers increases. From the graphs it can be concluded that the higher the concentration of the pulp to be ground, the higher the fibrillation index, that is, the fibers acquire a higher external specific surface area. The more the fiber is fibrillated, the better it will be developed and at the stage of the ebb of the web, stronger interfiber bonds will be formed (as a result, the physical and mechanical parameters of the finished product will be higher).

Figures 5-7 show graphs of the dependence of the physical and mechanical properties of finished castings on the degree of grinding.

As can be seen from the graphs, castings made from ground softwood pulp have higher values of breaking length, bursting strength, and bending strength in comparison with castings from hardwood pulp.
Figure 7. Dependence of the resistance of paper to break on the degree of grinding.

At the same time, other things being equal, a higher concentration of the mass during grinding makes it possible to obtain a long-fiber, well-fibrillated mass, the castings from which have high strength characteristics, regardless of the type of cellulose.

So, when milling hardwood cellulose, the greatest breaking length, bursting resistance and fracture resistance are observed at a concentration of 3%.

4. Conclusion

The nature of the development of the paper-forming properties of the pulp and the physicomechanical parameters of the finished hardwood cellulose castings is similar to the behavior during the grinding of softwood cellulose, but the quality indicators are different. This is due to the properties of the original fibers (the values of the initial length and width of hardwood cellulose fibers are 1.5 times less than those of softwood). The selected grinding modes of hardwood cellulose ensure the preservation of the length of the fibers and their fibrillation with an increase in the degree of grinding. This is especially significant when using hardwood pulp in a high percentage of softwood pulp in high-grade paper composition, due to the low quality characteristics of the original hardwood pulp fibers.

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