Use of a knifeless grinding plant for waste paper recycling

Roman A. Marchenko*, *Elena* A. Slizikova, and *Valentina* I. Shurkina

Reshetnev Siberian State University of Science and Technology, 31, Krasnoyarskii rabochii ave., Krasnoyarsk, 660037, Russian Federation

Abstract. The article considers the problem of recycling waste paper and the main reasons for the deterioration of paper-forming and physical and mechanical indicators of finished products during recycling of recycled fiber. A study was carried out on the effect of increasing the number of recycling cycles of waste paper of the MS-8V brand on such indicators as fractional composition, breaking length and resistance of paper to punching when using a jet-barrier type knifeless grinding unit.

1 Introduction

Despite the modern development of society the creation of the Internet, electronic media, a person still consumes a large amount of paper, and the volume of processing and consumption of waste paper in the production of paper and cardboard products in most developed countries is constantly increasing [1]. Therefore, the use of waste paper as a secondary fiber contributes not only to saving wood, but also reduces the cost of paper products and the burden on the environment.

The main goal of waste paper recycling is to obtain high-quality fibrous mass, which can be used in the composition of paper and cardboard, replacing the primary fibrous semi-finished products as much as possible [2].

However, the quality indicators of recycled fibers are always lower than those of virgin fibers. First of all, this is due to the fact that during the processing of fibrous raw materials, the fibers shorten during grinding, and drying is accompanied by a decrease in the ability of the fibers to swell due to irreversible keratinization [2].

The purpose of this work is to increase the number of processing cycles of waste paper (WP) when using a knifeless installation of the "jet-barrier" type, as well as to study the effect of the cyclic use of MS-8V waste paper on such indicators as: fractional composition, breaking length and bursting resistance.

2 Materials and methods

There are various waste paper mills currently in use, but the most common are blade mills such as disc mills and cone mills. However, in such machines, the fibers are subjected to

* Corresponding author: r.a.marchenko@mail.ru

strong chopping and crushing, which ultimately leads to a decrease in the strength characteristics of the finished product and greatly complicates the use of waste paper in the production [3].

The process of grinding and dissolution entails the destruction of the fibrous structure. Due to the repetition of these processes and the keratinization of the fibers that have undergone drying, they turn out to be weakly fibrillated and significantly shredded compared to the primary semi-finished products, and the resulting paper is less strong and more friable.

It is known, the waste paper mass, when processed by the knife method, is able to withstand about 4-5 cycles before it becomes unsuitable for further use [4].

To increase the number of processing cycles we propose to use a knifeless "jet-barrier" installation (a general view is shown in Figure 1), developed at the Siberian State University of Science and Technology named after Academician M.F. Reshetnev at the Department of Machinery and Apparatus for Industrial Technologies (MAPT) [5]. Since in the works of Yu. D. Alashkevich and R. A. Marchenko [6] it was found that knifeless refining has a more gentle, gentle effect on the recycled fiber, which is especially important for a fibrous suspension from waste paper, which has already undergone a refining stage once. Therefore, it can be assumed that the paper-forming properties of the fibrous mass will deteriorate less intensively when recycling using this installation.

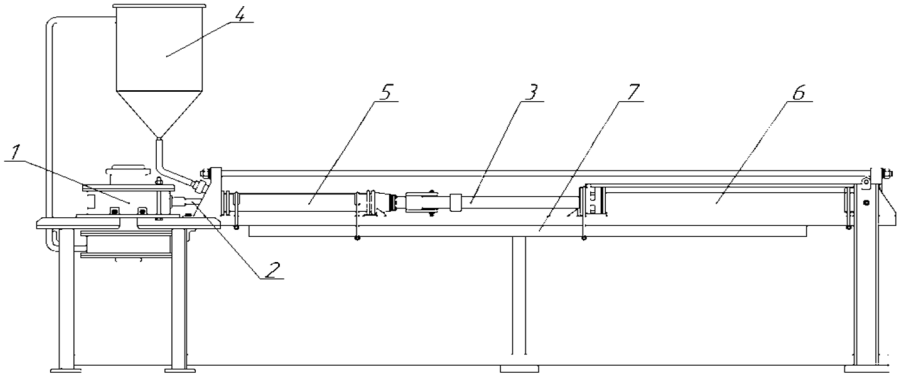


Fig. 1. Scheme of the "jet-barrier" installation: 1 - knifeless grinding unit; 2 - nozzle; 3 - stock; 4 - capacity; 5 - working cylinder; 6 - drive cylinder; 7 - frame.

The "jet-barrier" installation works as follows: the mass with a concentration of 1–3% is in the circulation tank. During the reverse stroke of the rod, the mass is recruited into the working cylinder. Then the rod begins to move and the mass under high pressure is fed through the nozzle to the barrier. When hitting the hard surface of the blades, grinding occurs. By repeatedly skipping the mass, any desired degree of grinding can be obtained in the same way as in knife grinders.

3 Results

In the course of this study, in the laboratory of the department WP with a concentration of 2% was dried on a high-speed drying hill. Before each cycle, the dried waste paper mass was soaked in water, and then dissolved in a disintegrator. Then grinding was carried out on a knife-free installation of the "jet-barrier" type. At this stage of research, MS-8V waste paper has already passed 9 cycles.

One of the indicators considered was the fractional composition of the fibrous mass.

Fractionation is the separation of fibers with different lengths and flexibility. The main task of this process is to separate the long-fiber fraction of fibers from short fibers and fines formed as a result of repeated cycles of processing and refining of waste paper [7].

The short-fiber WP fraction consists of short fibers, fragments of keratinized fibers less than 0.2 mm long, which are characterized by a high degree of grinding and low paper-forming properties, and the long-fiber WP fraction consists of coarse long fibers, which has a low degree of grinding and potentially high mechanical strength [8] .

Currently, fractionation is used as a method of mass quality control. It is known that by changing the fractional composition of semi-finished products, it is possible to control the strength properties of finished products. With its help, we can see a complete picture of the properties of the fibrous mass, evaluate the effect of a fine fraction on the strength characteristics of the finished product.

Based on the experiments carried out, the following results were obtained.

Table 1 presents data on the content of the long, medium and short fractions in newspaper WP.

Table 1. Fractional composition of MS-8V waste paper.

Fraction, %	**Cycle number**				
	1	**3**	**5**	**7**	**9**
Long-staple	71.6	51.8	51.2	48.2	45.2
Medium fiber	11.2	11.2	8.8	8.8	8.4
short fiber	4.4	4	3.8	4.4	3.6
Carryover, %	12.8	33	36.2	38.6	42.8

Table 1 shows that with an increase in the number of cycles during WP fractionation, the carryover of fiber into the drain increases. We also see that the percentage of long and medium fibers in the mass is reduced. This is due to the processes of dissolution and grinding, which are accompanied by the destruction of the fibrous structure, which leads to an increase in the number of both small fibers, scraps, and external damage [9].

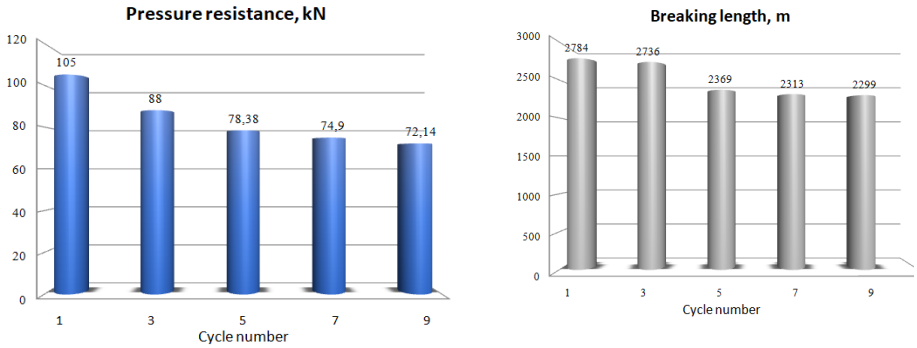
However, after 9 processing cycles, the content of the fine fraction in the mass does not reach a critical level and does not have a significant negative effect.

To assess the physical and mechanical characteristics of the finished product, castings were made from the ground WP on a sheet casting machine. The strength of paper castings was evaluated by the following indicators: breaking length and bursting resistance.

The breaking length is a conditional indicator that expresses the length of a strip of paper at which it undergoes rupture under the influence of its own gravity, being suspended at one end [10].

Paper bursting resistance is the ability of paper to withstand the maximum pressure increasing at a constant rate, acting through a rubber diaphragm on the surface of one side of the test specimen, clamped along the ring until destruction [11]. This indicator is one of the essential indicators characterizing the mechanical strength of paper, and is most important for papers that are subjected to frequent bending force during use, for example, newsprint, wrapping paper, etc. This indicator depends on the length of the fibers from which the paper is formed, their strength, flexibility, and bond strengths between fibers [12].

Figure 2 shows the physical and mechanical parameters of the waste paper mass from the newspaper.



a) b)

Fig. 2. Physical and mechanical parameters: a) – breaking length; b) - Burst resistance.

It can be seen from graph 2a, with cyclic processing of waste paper, the breaking length indicators fall. The same results can be seen when testing the bursting resistance of the specimens in graph 2b.

This is explained both by some deterioration in the fractional composition and by more intense damage during the dissolution of the surface of the fibers that became keratinized during the drying process, which leads to a weakening of the formed interfiber bonds and a decrease in the mechanical adhesion of the fibers [2].

4 Conclusion

Thus, with an increase in the number of recycling cycles of MS-8V waste paper, a gradual decrease in all WP indicators occurs.

The decrease in the mechanical strength of the waste paper mass is due to the presence of a short-fiber fraction and fiber fragments. And the keratinization of fibers during drying of paper and cardboard leads to a decrease in their ability to form hydrogen bonds, which is the main reason for the deterioration of the paper-forming properties of WP [8].

However, even after nine processing cycles were carried out on a knifeless “jet-barrier” installation, various WP indicators are still at a level sufficient to continue research with a subsequent increase in cycles. Those. according to GOST 8273-75 [13], such recycled fiber, which has already passed 9 processing cycles, can be used in the production of wrapping paper. And with the subsequent deterioration of the quality indicators of the finished product, it is possible to use it for the production of tissue paper.

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