Research of the paper-forming properties of a fibrous material with the use of a tacking with curvilinear knives

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Abstract. This article considers the influence of a tacking with curvilinear knives on the quality of sulfated bleached softwood pulp crushing, certain paper-forming characteristics of the paper pulp are determined as well.

One of the efficient ways of increasing the quality of the finished products without modernizing a production line and as a consequence without raising production costs is crushing improvement due to the use of crucially new types of tacking [1].

At the Department of Industrial Engineering Machines and Apparatuses, Siberian State Aerospace University, a tacking with curvilinear knives was developed (Figure 1) [2]. This tacking improves the quality of wood pulp treatment, as well as performance and power consumption reduction.

It is important to study the influence of this tacking shape on the crushing quality of sulfated bleached softwood pulp, as well as to determine certain paper-forming characteristics of paper pulp, such as average fiber length, moisture retention capacity, interfiber bonding strength.

While analyzing the experimental data, the most efficient parameters of crushing for a tacking with curvilinear knives were chosen: paper pulp concentration of 3%, rotor speed of 2000 rpm and clearance between rotor and stator disks of 0.1 mm.

Table 1 shows the main paper-forming characteristics of paper pulp when various designs of tacking are used.

For comparison with a curvilinear tacking, a standard eight-section knife tacking with an angle of knife crossing of 45° [3] and a force applying tacking without skew bevel were chosen [4].

Table 1 shows the main paper-forming characteristics of paper pulp when various designs of tacking are used.
Table 1. Main paper-forming characteristics of paper pulp and physical and mechanical characteristics of finished products when various design of tackings at 50 °SR are used.

| Paper-forming characteristics of paper pulp | Tacking with curvilinear knives | Force applying tacking without skew bevel | Standard eight-section knife tacking with an angle of knife crossing of 45° |
|--------------------------------------------|--------------------------------|----------------------------------------|------------------------------------------------|
| Crushing duration, min                     | 21                             | 28                                     | 35                                              |
| Average fiber length, mm                   | 1.58                           | 1.38                                   | 1.23                                            |
| Half-finished fiber product's moisture retention capacity, % | 522                           | 501                                    | 486                                             |
| Interfiber bonding strength, kPa            | 0.157                          | 0.124                                  | 0.142                                           |

For descriptive reasons the Microsoft Excel program was used to make diagrams that show dependence of changes in paper-forming characteristics when tackings of various design are used (Figure 2).

Table 1 and Figure 2 show that when a tacking with curvilinear knives is used, crushing duration is the shortest, while when a standard tacking is used, crushing duration is the longest.

Figure 2 also shows that there is a tendency of increasing a crushing rate, as well as crushing duration is increased; moreover, it should be noted that the intensity of the crushing rate is higher, when a tacking with curvilinear knives is used, in comparison with a force applying tacking or a standard knife tacking.

The fact that crushing to a certain size by a curvilinear knife tacking demands less time positively affects power consumption. Besides, the studied tacking shows an increase in the most of physical and mechanical characteristics in comparison with the figures of a tacking of another shape.

Dependence (fig.2) of average fiber length on the crushing rate °SR and the type of tacking indicates the tendency of decrease in average fiber length while the crushing rate is increasing, which corresponds to the acknowledged data from literature sources [5].
The analysis of the diagrams shows that the curves irrespective of the design of a knife tacking are of equal qualitative character and are parabolic curves. However, quantitative values are different. When a tacking with curvilinear knives is used, fibers are shortened less intensively, which proves higher fibrillation of fibers, in comparison with tacking with rectilinear knives.

Table 1 and Figure 2 show that the highest rate of water retaining capacity belongs to paper pulp that is crushed by a tacking with curvilinear knives. As it is known, an increase in water-retaining capacity is characterized by fiber surface expansion, which in its turn contributes to a better contact and connection of separate fibers in a paper sheet [4].

The highest value of interfiber bonding strength in comparison with a rectilinear knives tacking is achieved when using a tacking with curvilinear knives.

Conclusions
Upon analyzing Table 1 and Figure 2, it may be concluded that a tacking with curvilinear knives is effective in terms of paper-forming characteristics of paper pulp. The obtained data confirm the efficiency of using a tacking with curvilinear knives in comparison with tackings of other designs.

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