Estimating the Effectiveness of Hydrodynamic Treatment of Wood for Producing Wood Boards without Adhesives

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Abstract. This paper suggests the water retention value (WRV) as a criterion of estimation of wood pulp produced through treatment in the hydrodynamic disperser. Dependences between the WRV indicator and the properties of boards made of this pulp by the hot pressing method without using adhesives have been identified. As the WRV increases, bending and breaking strength of boards perpendicular to the sawn face grows, and the swelling value decreases.

Key words: wood boards, hydrodynamic treatment, sawdust, cavitation, strength, grinding, water retention value, swelling.

1. Introduction

Wood boards are widely used in the development of the human environment. Therefore, ecological indicators of boards become very important and topical under modern conditions. One of the main priorities is to improve these indicators while upgrading wood board manufacturing technologies. A possible solution to this problem is to develop board production methods without using adhesives.

The previous studies [1] indicate a possibility of formation of autoadhesion interactions between wood particles that have been preliminarily treated in the hydrodynamic disperser. The process of pressing of wood pulp produced by this method allows manufacturing boards without using adhesives. The density of boards may vary from 300 to 1,200 kg/m³. Mechanical properties of these boards, at comparable density, are highly competitive with MDF, WCB (wood chipboards), WFB (wood fiber boards) and have higher water resistance. In addition, original raw materials for producing such boards are milled wood waste (sawdust, chips) the rational use of which is an important problem. This fact proves the potentials of the comprehensive study of this wood treatment method.

One of important questions is to choose a criterion of estimation of hydrodynamic wood treatment results on the basis of which it is possible to forecast the properties of boards.

The analysis of the conducted studies gives ground to suppose that the interaction between particles of hydrodynamically treated wood pulp takes place due to the physicochemical interaction between contacting surfaces. Thus, the more the surfaces are subject to contact, the stronger the autoadhesion interaction and the higher the strength of boards. As it is known, grinding increases an area of boundary surfaces. But according to the studies conducted with using wood dust, simple mechanical grinding brings no desired results. Also, particles should be fibrillated. This will allow us to increase the number of available boundary surfaces considerably. Due to a cavitation effect, hydrodynamic treatment provides the fibrillation of wood particles.

According to many researchers [5], the strength of paper depends mainly on the fibrillation of cellulosic fibers. In order to estimate a fibrillation degree in the paper industry, it is recommended to use the water retention value (WRV). This indicator is better than the Schopper-Riegler freeness value and characterizes the capability of fibers to form inter-fiber connections and produce tough paper [4]. According to this, we have accepted the WRV indicator in order to estimate the wood pulp produced by treatment in the hydrodynamic disperser.
2. Materials and methods
The special studies have been initially conducted in order to identify the dependence between the WRV indicator and the duration of treatment in the laboratory hydrodynamic disperser. Softwood sawdust has been used for conducting the experiments. The treatment has been carried out with hydromodulus 1:10. The water retention value has been determined according to the Jayme method [3] (Figure 1). Then, using the same technology, there has been carried out the hot pressing of treated wood pulp with the different WRV indicators. The pressing with the set density of 800 kg/m³ has been carried out in the laboratory press (brand) at the temperature of 190 °C, the specific duration of 2.5 min/mm and the specific pressure of 3.5 MPa. Upon pressing, the boards have been kept in laboratory conditions for 72 hours and then have been subject to physical-mechanical tests. The results are given in Figure 2.

3. Results and discussions
The results of the study of the wood pulp treatment duration influence on the water retention value are given in Figure 1.

\[ y = -0.001x^2 + 0.82x + 96.02 \]
\[ R^2 = 0.99 \]

Figure 1. Dependence of the water retention value on the number of passes through the disperser.

Figure 1 shows that there is correlation dependence in the form of polynom between the treatment duration in the disperser and the WRV. As the treatment duration increases, the water retention value grows, in case of sawdust it is 97.1%. As a result of the treatment, it increases 2.8 times and reaches the value of 264%. The most intensive growth of the WRV is observed during the first 30 minutes, and then it does not change considerably, which indicates a decrease in the effectiveness of further treatment. It can be explained by the destruction of a fibrillar structure and the destruction of components of a cellular wall of wood. This corresponds to the opinion of the authors [4] who have studied mechanical grinding of cellulose.

The results presented in Figure 2 indicate that the properties of boards depend substantially on the WRV indicator of initial wood pulp. Ultimate bending strength (Figure 2a) and ultimate tensile strength perpendicular to the sawn face (Figure 2b), when the water retention value grows, increase by 2.15 and 2.5 times respectively. The swelling indicator has an inverse dependence and decreases from 33.2% to 6.9%. A sharp increase in indicators of boards is observed after increasing the WRV by more than 220%. For example, when the WRV varies from 220 to 270%, there is an increase in ultimate bending strength of boards from 13.05 to 25.68 MPa, breaking strength perpendicular to the sawn face from 0.54 to 1.02 MPa. And the swelling value of boards decreases from 21.7 to 6.9 %.

The analysis of the obtained results shows that hydrodynamic treatment allows making ecologically safe boards with high rates of properties of wood waste without using adhesives.
4. Conclusions

High rates of autoadhesion interaction between wood particles can be reached due to their fibrillation. The WRV indicator may be used as a criterion of estimation of wood pulp produced by means of hydrodynamic treatment. There are correlation dependences between this indicator and the properties of produced boards.

The highest rates of properties are reached within the range of variation of the WRV from 220 to 270%.

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