

Mechanical Activation of Wood for Adhesive-free board Production

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Abstract. This paper proposes to use hydrodynamic treatment of wood for the manufacture of wood-based panels from sawdust without using adhesive materials. It was found that such a treatment of wood particles (sawdust, dust, wood powder) allows producing panels with high physical-mechanical properties and water resistance. It is proved that the hydrodynamic treatment allows providing maximum energy of autoadhesion interaction in the moulding material due to increase of specific surface with small changes of geometric size of particles in comparison with mechanical methods of milling.

Keywords: wood boards, fraction, hydrodynamic treatment, sawdust, wood dust, wood powder, cavitation, strength, milling.

Introduction

Mechanical conversion of wood produces large quantities of waste. A significant part of the waste is kept in the storehouse or is recycled by burning for heat energy. The problem is particularly acute for reprocessing of milled wood (sawdust) the amount of which is up to 12 % of the volume of raw material [1]. Use of sawdust for the production of boards can be a possible solution of this problem. The most common materials are HDF and MDF boards which are produced in large quantities worldwide and have high mechanical properties [3]. Strength and water resistance of these boards is ensured by addition of synthetic glue, which significantly impairs their environmental specifications. Herewith production of wood boards requires certified raw material, and the use of sawdust as raw material does not allow obtaining the required quality of boards [1].

There are known technologies of board production without using adhesives made from wood particles preliminary chemically, mechanically and biologically treated [2, 4]. This allows to increase the specific surface area and to provide structure formation of the wood boards. Mechanical methods based on the wood milling are the most widespread methods of wood processing. Some authors note [8, 6] that physical-mechanical properties of board materials significantly depend on the fractional composition of the original woodpulp. For example, the paper [7] states that reducing the size of the particles of lignocellulosic raw materials allows to increase physical-mechanical properties of the boards without using adhesive materials. But nevertheless production of material is possible only due to the impact of high pressure and temperature. Therefore material with acceptable properties and a density



of at least 1000 kg/m^3 can be produced. These technologies are technically difficult to implement, and such boards have limited field of application.

Being based on the analysis one can come to the conclusion that the use of mechanical disintegrating is ineffective. It is more practical to find methods which allow not only to mill the wood, but also to increase the specific surface area due to fibrillation.

For this purpose the method of wood treatment in a hydrodynamic dispersion machine was chosen. According to the study [5], this method allows to produce homogeneous plastic mass which can be used for production of free-adhesive boards with a wide range of density from 300 kg/m^3 to 1200 kg/m^3 . Herewith boards with density comparable to the density of MDF-boards comply with requirements of EN 622: bending strength is 27 MPa, longitudinal strength perpendicular to the sawn face is 0.8 MPa. The amount of through-thickness swelling of these plates does not exceed 8.4 %, which indicates their increased water resistance.

Materials and methods

To confirm the fact that the hydrodynamic treatment allows to increase the specific surface area significantly, the fractional composition of the wood pulp produced by the hydrodynamic machining was studied. At the same time fractional composition of wood powder and wood dust produced by wood grinding was determined. Studies were carried out with the help of cytoanalyzer WU-4. Fractional composition of wood dust and wood powder were determined. Table 1 shows the obtained results.

Table 1 — Fractional composition of wood particles

Fraction size, mm	Sawdust produced by hydrodynamic treatment	Grinding dust	Wood powder
0.5	0	10	7
0.1	70	85	79
less than 0.1	30	5	14

According to the obtained results, size of studied particles does not differ significantly. Special studies were carried out in order to prove that the hydrodynamic treatment increases the specific surface area of the particles due to the fibrillation. Using the same technology there were produced boards from hydrodynamically treated sawdust, dust, hydrodynamically treated dust, wood powder and hydrodynamically treated wood powder. All boards with specified density of 800 kg/m^3 were produced in a single-storeyed laboratory press at temperature of $190 \text{ }^\circ\text{C}$ and pressure of 3.5 MPa. Specific pressing time is 2.0 min/mm.

Results and discussion

After pressing the boards were weathered in the laboratory for 72 hours and then subjected to physical-mechanical testing. Table 2 shows the obtained results.

Table 2 — Physical-mechanical properties of wood-boards

Physical-mechanical property	Sawdust after hydrodynamic treatment	Grinding dust		Wood powder	
		without treatment	after treatment	without treatment	after treatment
Bending strength, MPa	28.1	7.3	24.6	3.4	16.8
Longitudinal strength perpendicular to the sawn face, MPa	0.82	0.15	0.94	0.11	0.79
Through-thickness swelling over 24 h	7.8	56.7	18.5	55.5	19.9

According to the obtained results, boards produced from hydrodynamically treated sawdust are characterized by maximum strength and minimal swelling. It is noted, that the boards made of wood powder, which is characterized by a comparable particle size, have 8.2 times lower bending strength. Approximately the same difference is found for longitudinal strength perpendicular to the sawn face. Boards of wood dust had a bit higher physical-mechanical properties, but at the same time destruction of the samples at the end of the swelling test was observed. This shows low water resistance of the materials. When wood particles (wood dust and wood powder) were preliminary hydrodynamically treated, a significant improvement of the properties of wood boards was observed. The values of the mechanical properties increased more than 4 times and the swelling amount decreased more than 3 times. Significantly different values of physical-mechanical properties of boards indicate that the hydrodynamic treatment of wood particles with comparable sizes allows to increase the specific surface area and thus to improve energy of autoadhesion interaction. Generally, the obtained results confirm the assumption that in the process of hydrodynamic treatment of the wood with the cavitation effect a more intense fibrillation is possible, which allows to increase specific surface area significantly and to produce free-adhesive materials with different density.

Conclusions

Hydrodynamic treatment allows producing wood particles with a large specific surface. This creates conditions for production of free-adhesive wood boards of different density. Boards made by this method meet the requirements of EN622.

Development of technologies based on hydrodynamic treatment of wood is a promising direction of waste recycling as it allows to produce competitive products.

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