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Amorphous Silica Micro Powder Additive Influence on Tensile Strength of One-Ply Particle Board

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Abstract. The methods and results of experimental investigation on the additive influence of amorphous silica micro powder when mixed in the glue for one-ply particle board are presented in the article. Wooden particles of coniferous and hardwood species as well as glue solution based on carbamide-formaldehyde resin were used for boards manufacturing. The amorphous silica micro powder contained particles on the average 8 μm by the size and specific surface 120...400 m2/g was used in experiment. The samples were tested to determine their physical-mechanical properties. It was found that 1 % amorphous silica micro powder additive increases the breaking point of one-ply particle board under tensile stress by 143 %.

1. Introduction

On the basis of the previous investigations and literature data, the hypothesis of shungite nanopowder influence on physical-mechanical properties of wood particle board (PB) was formulated. The first test of this hypothesis was done in the course of semi-industrial experiments for one-ply PB production with the shungite nanopowder use. The test results [1-3] proved that shungite nanopowder added in glue solution considerably increased the strength under static tensile. The investigation has shown that the schungite nanopowder when mixed in the glue increases the physical-mechanical properties of a particle board. However, it should be noted that the cost of nanostructured powders of shungit is currently high. Also it remains unclear which of the components of shungite substance has the greatest effect on the strength of the glue and particle board as a whole. In our study shungit consists about 30 % of carbon and 60 % of silica. Silica is a more available and cheap material. Therefore, it was planned to investigate the effect of silica addition on physical-mechanical properties of particle boards.

Here we present the methods and results of experimental investigation on the additive influence of amorphous silica micro powder (ASMP) when mixed in the glue for one-ply PB based on carbamide-formaldehyde resin (CFR). It should be mentioned that solutions were made both with ASMP and without ASMP additives. The ASMP additives content was from 0.10 to 1.00 % of absolutely dry CFR mass. The purpose of the investigation was to determine the breaking tensile point. The results obtained were used for the analysis of the change of physical-mechanical properties of one-ply PB, influenced by ASMP additive mixed into glue solution based on CFR.

2. Investigation materials and methods

The wooden particles to manufacture the boards were produced out of mixture of coniferous (fur, pine) wood and hardwood (birch, aspen). The mixture composition was as follows: coniferous particles mass share made 60 %, and hardwood particles share made 40 %. The porosity of particle mixture made 80 %, and the density made 309 kg/m^3. The particle size was such that during

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stratification they have passed through a sieve with holes of 3 mm diameter. The wooden particles moisture content made 4 %.

Under experimental conditions the CFR was used with the following physical-chemical resin property indices: dry residue mass share – 68 %, gelatinization time at 100 ºC – 68 seconds, conditional viscosity (nuzzle 4 mm) – 80 seconds, hydrogen ions concentration at 20º C – 8.1, refraction coefficient at 20º C – 1.471, ultimate miscibility resin with water – 1:4.5.

The reference density of the board was 850 kg/m^3. The content of absolutely dry resin in the PB was 10 % of absolutely dry wood mass.

The average particle size of ASMP – 8 microns. The nanoporous structure of surfaces of the particles provided the specific surface 120...400 m^2/g.

Five types of glue solutions for boards manufacturing were composed. The first one (the basic glue solution) was prepared of 66 % water CFR solution and 20 % water hardening agent NH_4Cl. The content of hardening made 1 % of resin solution mass. Four other glue solutions were mixtures of basic one and ASMP additive. The ASMP addition was as follows: 0.10 %, 0.25 %, 0.50 %, 1.00 % of absolutely dry resin mass.

The sample PBs were manufactured with the use of laboratory equipment: a mixer and a hot press. The resinification of wooden particle was conducted in a laboratory mixture. The packages for boards shaping were made manually. The cold sub-pressing of packages was performed before pressing in hot press. The hot pressing was carried out at 190º C, pressure 2.5 MPa, the joining velocity of hot press boards was 3 mm/min. The package exposure in press after board joining was 2 minutes. After extracting a ready board out of the press, it was subjected to conditioning. In the course of the experiment one-ply particle boards with the thickness 16 mm, by dimension 280☐280 mm were produced.

The samples for experimental investigation of their physical-mechanical properties were made out of these boards. To determine one and the same index the samples were cut out of different board parts. The sample length difference was not more than 0.5 mm. The sample thickness difference was not more than 0.2 mm. The external sample surfaces were smooth. Also there were no edge chips and corner crumbles. Before testing the samples were conditioned during 24 hours at 20 ± 2 °C and relative air humidity 65 ± 5 %.

The tensile strength perpendicular to the board face was found with the use of the samples with 50 × 50 mm dimension. Special blocks were glued to the sample faces with the help of melting glue. The testing block was put into pinchers of the testing device, and then the distance between them was being increased with constant speed 10 ± 1 mm/min up to breaking point. Maximum loading was registered with arrow indicator with 1% precision.

3. Result and discussion

According to the investigation results it is established that the breaking point under tensile stress of one-ply PB made with the use of the glue solution on the basis of CFR and 1.00 % ASMP additive from absolutely dry resin mass exceeds the above-mentioned control sample value by 143.4 % (see Table 1).

Table 1. Experimental results for breaking point under tensile stress.

Tensile strength	ASMP content (x), %				
	0.00	0.10	0.25	0.50	1.00
Mean value, MPa (y)	0.99	1.01	1.23	1.33	1.42
STD, MPa	0.02	0.24	0.19	0.12	0.11

Thus, one can conclude that the ASMP additive increases the one-ply PB breaking point under tensile stress. It was also found that test data show a direct relationship between the breaking point value under tensile stress and ASMP content (figure 1).

Earlier researchers have found, that nano and micro powder of amorphous silica when mixed in the glue change its viscosity [4, 5]. This leads to an improvement of adhesive properties of glue composition and increases PB strength. From the other hand it was established that silica additive can build a reinforcing nanostructure mesh inside gelatinized glue [1]. This structure is the main cause of strength increase. Therefore, under certain conditions, an increase of shungite and silica additives does not increase the strength of the PB.

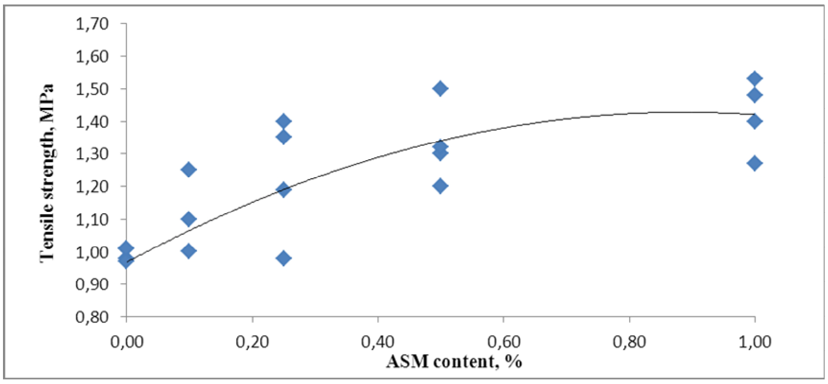

Figure 1. Polynomial approximation of the breaking point value under tensile stress of ASMP content.

4. Conclusions

The findings of our experimental investigation are as follows:

1. It has been established that the breaking point under tensile strength of one-ply PB made with the use of the glue solution on the basis of CFR can be increased by ASMP additive;

2. It was established that within the extremum was reached when ASMP additive content was 1.0 % of absolutely dry resin mass.

3. In the studied circumstances the correlation between ASMP additive content and breaking point under bending strength may be described by the equation $y = -0{,}5855x^2 + 1{,}0374x + 0{,}9675$, where y is the breaking strength under bending, MPa; x is the ASMP content, %.

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