Solid State Science and Technology, Vol. 26, No 1 (2018) 30-34
ISSN 0128-7389 | *http://journal.masshp.net*

THE INFLUENCE OF SHUNGITE NANOPOWDER MODIFICATOR ON WATER THICKNESS SWELLING AND WATER ABSORPTION OF THREE-PLY PARTICLE BOARD

Pitukhin Aleksandr Vasilyevich[1], Kolesnikov Gennady Nikolaevich[2],
Panov Nikolai Gennadievich[1,] and Vasilyev Sergey Borisovich[1]

[1]Faculty of Forest Engineering, Petrozavodsk State University, 33, Lenin Str., 185910, Petrozavodsk, Republic of Karelia, Russia

[2]Faculty of Civil Engineering, Petrozavodsk State University, 33, Lenin Str., 185910, Petrozavodsk, Republic of Karelia, Russia

Corresponding author: pitukhin@psu.karelia.ru

ABSTRACT

As the result of experimental investigation it was found out that the 10 % of shungite nanopowder when mixed in the glue decreases water thickness swelling of three-ply particle board up to 14.2 % and water absorption by 10.6-20.1 %. The influence of the 10 % shungite nanopowder additive on physical-mechanical indicators of particle boards depends on the resin type used for making the glue. Wooden particles of aspen and coniferous species as well as glue solution based on two types of carbamide-formaldehyde resin were used for boards manufacturing. The shungite nanopowder contained particles 50...100 nm by the size and specific surface 120 m^2/g. In the course of the experiment three-ply particle boards with the thickness 15.6 mm.

Keyword: shungite nanopowder; particle board; water thickness swelling; water absorption

INTRODUCTION

Here we present the methods and results of experimental investigation on the additive influence of shungite nanopowder (hereafter SNP) when mixed in the glue for three-ply particle board (hereafter PB) based on carbamide-formaldehyde resin (hereafter CFR). Previously made investigations and literature data considering, the hypothesis of SNP influence on physical-mechanical properties of wood PB was formulated. In consistency with this hypothesis in the process of hardening of melamine-formaldehyde, phenol-formaldehyde, or CFR, modified by the SNP additive the three-dimensional structure was formed, which strengthens physical-mechanical properties of the particle board [1,2,3,4,5,6]. That’s why the decision was made to carry out the investigation of physical-mechanical properties of three-ply PB, made with glue solution on the base of two different carbamide- formaldehyde resins. It should be mentioned that solutions were made both without SNP and with SNP additives. The quantity of SNP additives made 10 % of absolutely dry resin mass. As a result of conducted investigation it was planned to find the following:

1. If the SNP additive would change physical-mechanical properties of three-ply PB;
2. If the type of carbamide-formaldehyde resin would influence the SNP impact strength.

EXPERIMENTAL

Wooden particles for three-ply boards were taken directly from the PB industrial enterprise. The boards were manufactured with the help of laboratory mixer and hot press.

In total, four groups of boards were produced. The first one was produced with the help of glue made out of resin #1 water solution and hardening agent. The second board group was produced with the help of glue made out of resin #1 water solution, hardening agent, and SNP additive. The third board group was produced with the help of glue made out of resin #2 water solution and hardening agent. The fourth board group was produced with the help of glue made out of resin #2 water solution, hardening agent, and SNP additive.

The water absorption and thickness swelling of produced boards were defined. The results obtained at the second stage were used for the analysis of the change of physical-mechanical properties of three-ply PB, influenced by SNP additive mixed into glue solution based on CFR.

The particles to manufacture the boards were produced on the slicer out of coniferous wood (fur, pine) and aspen. The mixture composition was as follows: aspen particles mass share made 30 %, and coniferous particles share made 70 %. The porosity of particle mixture made 80 %, and the density made 309 kg/m3. The fractional composition of the particle mixture is shown at Table 1.

Table 1**:** Fractional composition of particle mixture for experimental three-ply PB

Mass particle fraction share, %, in layers	Screen hole size, mm						
	5.00	3.15	2.00	1.00	0.50	0.20	tray
External layer	0.0	0.0	0.2	12.5	44.4	32.6	10.2
Middle layer	24.9	17.3	29.8	21.9	4.1	1.2	0.8

The reference density of the external board layer was 850 kg/m3. The external layer share (by mass) made 40 %, from total board mass. The content of absolutely dry mass in external layers made 14 %. The reference density of the internal board layers was 700 kg/m3, internal layer share (by mass) made 60 %, the content of absolutely dry resin in the internal layer was 10 % of absolutely dry wood mass.

The shungite nanopowder was provided by the Laboratory of Physical-Chemical Investigations of Nano-Carbon Materials of the Institution of Geology of Karelian Research Center of Russian Academy of Science. According to the data of the above-mentioned laboratory the additive composition was as follows: C from 28.00 up to 31.00 %, SiO2 from 56.00 up to 60.00 %, Al2O3 from 4.30 up to 5.50 %, Fe2O3 from 2.00 up to 6.00 %, K2O from 1.30 up to 1.50 %, MgO from 0.90 up to 1.40 %, TiO2 not more than 0.45 %, Na2O not more than 0.40 %, CaO circa 0.10 %. The SNP powder contained particles 50...100 nm by the size and specific surface 120 m2/g.

Four types of glue solutions for external and internal layers were composed. The first one was prepared of 66 % water resin solution #1 and 20 % water hardening agent NH_4Cl. The amount made 1 % of resin solution prepared of 66 % water resin solution #2 and 20 % water hardening agent NH_4Cl. The amount made 1 % of resin solution mass. The fourth one was prepared of 66 % water resin solution #2 and 20 % water hardening agent NH_4Cl. The amount made 1 % of resin solution mass and 10 % SNP from absolutely dry resin mass. For preparation external and internal board layers, the glue solution of the same composition was used. Under experimental conditions two carbamide-formaldehyde resins were used (See Table 2).

The resinification of external and internal particle layers was conducted in a laboratory mixture. The packages for shaping boards were made manually. The cold sub-pressing of packages was made before pressing in hot press. The hot pressing was carried out at 190 °C, pressure 2.5 MPa, the joining velocity of hot press boards was 3 mm/min. The package exposure in press after board joining made 2 minutes. After extracting a ready board out of the press, it was subjected to conditioning. In the course of the experiment three-ply particle boards with the thickness 15.6 mm, by dimension 280´280 mm were produced.

Table 2: Physical-chemical resin property indices

Index	Index value	
	Resin #1	Resin #2
Dry residue mass share, %	68	66
Gelatinization time at 100 ºC, seconds	68	48
Conditional viscosity (nuzzle 4 mm), seconds	80	23
Hydrogen ions concentration at 20 ºC	8.1	7.9
Refraction coefficient at 20 ºC	1.471	1.470
Ultimate miscibility resin with water	1:4.5	1:3.5

The samples for experimental investigations 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 faces and edges were mutually transverse, and the edges were pairwise parallel. The sample length difference was not more than 0.5 mm. The thickness sample 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 %. To measure the samples the following tools were used: a trammel with 0.1 mm precision and a ruler with 1 mm precision.

The thickness of the sample swelling in the water and water absorption were found for the samples in the shape of rectangular parallelepiped with 15.6 mm thickness 100 ´ 100 mm dimension. The thickness of every sample was measured in four points, and each of them was at 25 mm distance from the two nearest edges. The sample thickness was assumed as simple average for the results of four measurements. The samples were weighed with 0.1 % accuracy. Then the samples were merged in a container filled with water at 20 ± 1 °C. A special device helped to hold the samples in vertical position below the water surface with 20± 2 mm depth. The samples didn't touch each other. The time of the water exposure was 24 ±0.25 hour. After exposure, the samples were excavated out of the water, and their surface was dried. Not later than 10 min after excavating the samples were weighed with 0.1 % accuracy, and the thickness was measured with trammel.

The thickness was measured with the same accuracy and in the same four points as it was before water merging. Same as at testing start, the thickness was accepted as a simple average for the results of the four measurements. The sample water absorption (D_w) in percent was calculated with the Eq. 1:

$$\Delta_w = \frac{m_2 - m_1}{m_1} \cdot 100 \ \%, \qquad (1)$$

where m_1 – the sample mass before water merging, g; m_2 – the sample mass after excavating out of water, g.

The sample thickness swelling in the water (t_w) in percent was calculated with the Eq. 2:

$$t_w = \frac{t_2 - t_1}{t_1} \cdot 100 \ \%, \qquad (2)$$

where t_1 – the sample thickness before water merging, mm; t_2 – the sample thickness after excavating it out of water , mm.

For the testing board result the simple average of all samples testing was accepted.

RESULT AND DISCUSSION

Water thickness swelling (t_w) of three-ply board samples made with the use of the glue solution on the base of resin #1 with SNP additive is lower than that of the samples made without SNP additives by 14.2 % (see Table 3). The discrepancies found with the use of resin #2 may be neglected.

The water absorption (D_w) of the samples made with the use of the glue solution on the base of resin #1 with the SNP additive is lower than that of the samples made without the SNP additive by 10.6 %. The samples made with the resin #2 showed more significant difference (20.1 %) and lower absolute results (see Table 3).

Table 3: Water swelling and water absorption experimental results

SNP content, %	Parameter value, %, for different resin types			
	t_w		Δ_w	
	#1	#2	#1	#2
0	27.5	51.6	43.3	139.0
10	23.6	52.7	38.7	111.0

CONCLUSIONS

1. The 10 % SNP additive decreases water thickness swelling of three-ply PB up to 14.2 % depending on the investigated glue type.
2. The 10 % SNP additive decreases water absorption by 10.6-20.1 % depending on the investigated glue type.
3. The influence of the 10 % SNP additive on physical-mechanical indicators of particle boards depends on the resin type used for making the glue.

REFERENCES

[1] B. Voigt, D. H. McQueen, M. Peliškova, N.Rozhkova, *Polymer. Composite* **26** 552 (2005)
[2] A. Chubinsky, K. Brutyan, Formation of Particle Boards with Low Toxicity, Proceedings of Saint-Petersburg Forest Engineering Academy, 186 (2009) 156.
[3] N. Panov, S. Rozhkov, A. Pitukhin Water Resistance increase in three-ply particleboards based on carbamide-formaldehyde resin resulting from injection of nanostructured shungite filler into adhesive, Proceedings of Petrozavodsk State University, 8 (2011) 88.
[4] N.G. Panov, A.V. Pitukhin, S.S. Rozhkov, V.E. Tsvetkov, V.G. Sanayev, O.V. Firulina, Wood chipboards of carbamide-formaldehyde resin modified with nanosized shungite, Proceedings of Moscow State Forest University, 2 (2012) 135.
[5] A.V. Pitukhin, S.B. Vasilyev, N.G. Panov, G.N. Kolesnikov, *Austrian Journal of Technical and Natural Sciences.* **7-8** 22-24 (2014)
[6] A.V. Pitukhin, N.G. Panov, G.N. Kolesnikov, S.B. Vasilyev, The Nanostructured shungite usage for particle board manufacturing from low quality wood, Petrozavodsk University Press, Petrozavodsk, 2014.