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Influence of Pressing Temperature on Wood Properties

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Abstract. Obtaining wood with high performance properties on the basis of chemical and mechanical action as a result of optimization of technological processes and the use of temperature exposure. The initial raw material is hardwood (aspen, alder), which are little used in construction and in the production of finishing materials. The condition for obtaining wood with high operating properties (increasing density, strength, reducing water saturation, ensuring the dimensional stability of samples for a long time) is the ability of wood as a natural polymer to change properties under the combined effect of temperature and pressure.

Introduction

Aspen and alder are practically not used in the production of building materials such as supporting structures and finishing. Although a feature of aspen wood is the absence of knots, resistance to moisture in the sawn state does not warp, does not crack during drying and storage in the air, but at the same time the wood is prone to drying out and does not have dimensional stability. Alder warps during drying, has moderate hygroscopicity and softness, is resistant to decay, which is why it is often used for equipping wells, as well as storerooms. These types of wood have significant advantages over other hardwoods - they are fast-growing, low purchase prices, low demand in the construction market. To improve the operational properties in 1973 and 1983. researchers have proposed technologies for the heat treatment of wood [1]. Using compression and high temperatures for wood processing, the researchers significantly improved the physical and mechanical properties of samples from beech, larch and pine.

The method of hot pressing of wood treated with formaldehyde resin was widely used [2,3]. It was based on the modification of wood in the form of shavings and sawdust in the production of particle boards. Treated wood with formaldehyde resins or compositions based on them is environmentally hazardous to human life, and since the end of the 80s of the 20th century, this technology has been banned from using in Europe and Russia.

Heat treatment of wood at temperatures of 200-280 ° C for 7-12 hours allows you to increase the density, hardness of the material, but at the same time increases the tendency to brittle fracture under force. Such wood is suitable only for finishing works [4, 5].

Researchers have devoted to the study of the issue of the influence of 130 0C and pressing pressure of 7 MPa on coniferous wood [6, 7]. It has been revealed that the technology of obtaining thermally modified wood makes it possible to obtain thermally stabilized wood with increased density, hardness and high water resistance.

Materials, research methodology

The purpose of the research is to identify the technological features of the production of modified hardwood (aspen, alder) in the Penza region by hot pressing with a force of 6.0 MPa. Press plate temperature 140-160 ° C.

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For the study, we used a hot press with a working surface of 600 × 600 mm at a maximum pressure of 12 MPa.

The wood underwent sawing and finishing to plates with dimensions of 250 × 250 × 16 mm. The holding time on the table of a hot press under pressure is 60 min. Table 1 shows the properties of the raw materials and technological regulations.

Table 1. *Raw material properties*

№	Wood	Density, [k/m^3]	Hardness, [MPa]	Humidity, [%]	Pressing temperature. [^{0}C]	Exposure time, [min.]	Pressing pressure, [MPa]
1	Aspen	510	23,6	3,56	140	60	12
2	Alder	486	27,3	4,00	140		12
3	Aspen	509	23,65	3,61	160		12
4	Alder	487	27,8	4,13	160		12

Determination of the hardness of wood samples was determined on samples with a size of 50 × 50 × 50 mm on a universal testing machine. The hardness of the wood was redistributed in accordance with GOST-16483.17-81, in accordance with the Brinell method. Tests for changes in the characteristics of the environment in the laboratory at a temperature of +26 ^{0}C and ambient air W-56 %.

The swelling of the wood was assessed by complete immersion in water for 24 hours, so that the top of the sample was 20-25 mm high. The temperature of the water in the chamber was automatically maintained at 20 °C.

The original dimensions of the samples before and after the tests were measured with a caliper. The results are in Table 2.

Table 2. *Properties of modified materials*

№	Wood	Reducing sample thickness, [%]	Density		Hardness		Pressing temperature. [^{0}C]	Swelling value, [%]
			[kg/m^3]	growth, [%]	[MPa]	growth, [%]		
1	Aspen	27,3	701	37,45	28,8	22,0	140	6,12
2	Alder	28,4	661	36,01	33,9	24,2	140	7,04
3	Aspen	30,2	737	44,79	28,3	19,6	160	2,98
4	Alder	31,4	684	40,45	32,9	18,4	160	3,56
control	Aspen	–	–	–	–	–	–	2,49
	Alder	–	–	–	–	–	–	2,86

Discussion

From the analysis of the data obtained (table 2), it can be seen that after the process of hot pressing of hardwood samples, the thickness changed significantly. In aspen and alder, the parameter changes significantly at a pressing temperature of 160 ° C than at 140 ° C.

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Swelling also shows that the pressing temperature has a significant effect. So at a pressing temperature of 160 °C, the swelling value is 5,56 % for alder, and 2,98 % for aspen. At a pressing temperature of 140 °C, the swelling value for alder is 7.04%, for aspen is 6,12 %. All hardwood samples that passed swelling tests showed that the control samples have 2,5 times lower values.

The hardness of aspen at a pressing temperature of 140 °C is greater than at a temperature of 160 °C by 12,2 %, in alder – by 31,5 %. At the same time, the increase in wood hardness is higher at lower temperatures. It is possible to explain the processes taking place if we consider the structure and structure of hardwood.

Wood is a composite material consisting of numerous microscopic, layered tubes oriented along the trunk. Cellulose incorporated into the lignin-hemicellulose matrix acts as a reinforcing agent [8, 9]. The spatial structure of the matrix is formed by interpenetrating networks: 1 – formed by lignin and carbohydrates; 2 – lignin and hemicelluloses; 3 – three-dimensional networks of lignin itself.

It was revealed by a number of researchers that at a relative humidity of wood equal to 27-30 %, cellulose already at 22-26 °C exhibits the properties of an amorphous-crystalline polymer in a highly elastic state [10-12].

During the experiment, the moisture content of the wood was less than 5 %, the temperature of hot pressing was 140 and 160 °C, according to the researchers [10], the glass transition temperature of dry wood ranges from 130 to 190 °C. Thus, the tested wood samples acquired the thermomechanical properties of the intercellular substance. This is a sign of an amorphous polymer with characteristic physical states - glassy, highly elastic and viscous fluid. In this case, the state of the samples is closer to glassy, since the samples are highly fragile. There is no reliable information in the open press about the glass transition temperature of the ligno-carbohydrate complex, and it is not necessary to carry out indirect studies, but rather aimed at understanding the pseudo reticular structure of wood, taking into account the possible volumetric targeted change in the anisotropic structure.

Conclusions

The studies carried out have shown the possibility of obtaining modified wood with high performance properties. By optimizing the technological process, it is possible to obtain finishing materials with high aesthetic and, most importantly, competitive with respect to rare varieties of wood.

The unique structure of a natural polymer (wood) is endowed with such properties as hydrophilicity, biological compatibility, thermal stability and polyfunctionality, which makes it possible to modify wood not only through mechanical and thermal effects, but also through the use of chemicals and various complexes.

The considered technological method for changing the natural structure of wood makes it possible to obtain wood similar to the texture of plane tree, elm from alder and aspen, provided that the original wood is additionally colored.

The growing need for the development of new and obtaining new cheap materials for construction and finishing purposes is determined by the fact that cellulose, as the main component of wood, is a renewable and rapidly growing raw material.

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