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PHYSICO-CHEMICAL PROPERTIES OF FIRE-PROTECTIVE PLYWOOD UNDER HIGH TEMPERATURES

In the given article the received results of researches of physical and mechanical properties of fire-retardant plywood for facing of wooden beams as means of fire protection are processed.

The regularities of the influence of flame retardant impregnation in 2-mm birch veneer on the fire-retardant properties of 10 mm and 20 mm thick plywood have been established. It is established that fire-retardant veneer treatment increases the density of the obtained plywood, which in turn changes the physical and chemical properties of plywood, and compression is reduced, which partially saves wood raw materials, as the required thickness of 10 mm is obtained due to fewer veneer sheets.

The processes of heat exchange and heat and mass transfer occurring in veneer, which depend on the parameters of these processes (temperature, time, amount of moisture) and thermophysical properties of veneer, which are determined by thermal conductivity, specific thermal, thermal conductivity, thermogradient mass diffusion.

In addition, plywood belongs to the material, the decay and combustion of which under appropriate conditions is carried out in the form of decay, due to the structural properties of veneer sheets and gluing systems, it should be emphasized that in terms of chemical process we have identified patterns of rheological properties and rheokinetic parameters filled with epoxy compositions of protective plywood. The results of fire tests show that the content of flame retardant, in accordance with the requirements for impregnation (120, 5 kg / m3) in the veneer, has a positive effect not only on fire resistance but also on the depth of charring for different time intervals.

Key words: *fire-retardant plywood, mathematical modeling, fire temperature, fire propagation, field methods.*

Formulation of the problem. At the present stage, the prospects for the progress of woodworking are mainly associated with the widespread use of wood composite materials with special properties. A special place among the composite materials are plywood and plywood. They are technological and widely used in furniture production, construction and many other industries.

However, a negative factor hindering the expansion of these areas of application materials, there is their increased fire hazard. To improve the exterior and interior and, at the same time, to protect high-rise buildings, hotels, theaters, children's institutions, as well as passenger premises ships and railway cars need refractory material that would have satisfactory appearance, physical and mechanical properties, under the action of elevated temperatures, as, in particular, when the flame did not emit toxic substances, provided high efficiency and durability of fire protection.

The properties of fire-retardant wood material depend on flame retardant, its cost and method of introduction into the wood material or application to the surface.

When applying protective compounds, the purpose of impregnation is the most suitable. Thin coating and surface impregnation are inferior in efficiency before deep impregnation by the method of complete absorption. However, strict dosing is necessary because oversaturation not only

degrades the economic performance but also has a negative effect on the basic performance characteristics of the wood. For this reason, it is necessary to determine the dynamics of absorption of antipyrene by veneer and to determine the optimal time of its impregnation.

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Analysis of recent achievements and publications. To solve this problem it is necessary to determine: types of flame retardants, method of fire-retardant impregnation and its description; describe the heat capacity of veneer and fire-retardant plywood in general.

The method of fire-retardant plywood is reduced to the introduction into the veneer mass of special fire-retardant substances, the fire capacity is determined by physical processes in the protected material: under the influence of heating components evaporate or dissociate with heat absorption sufficient to prevent temperature rise; coatings belong to groups I-III of fire protection efficiency.

According to [1], the specific heat is characterized by the properties of the material to absorb heat at elevated temperatures of 1130 J / (kg K); thermal conductivity coefficient when the heat flux is directed to the fibers perpendicularly and parallel to 0.150 and 0.300 W / (m K), respectively. The coefficient of thermal conductivity is characterized by the rate of temperature equalization at different points at certain temperatures depending on the veneer density of $12.84 \cdot 10^{-7}$ m^2/s at a density of 80 kg / m^3.

To determine the optimal time of impregnation of peeled veneer with anti-pyrene and to determine the absorption of flame retardant used birch veneer with dimensions of 200 × 200 × 2 mm. This veneer was dried to a humidity of 8-12% and weighed. After that, the veneer was immersed in flame retardant and kept in him at different intervals. Impregnated veneer sheets were dried in an oven at a temperature of 105 ° C until it reaches completely drystate.

The degree of absorption of veneer was determined by the formula:

$$Q = \frac{\rho_1 - \rho_2}{\rho_{\ 1}} \cdot 100\ \%, \qquad (1)$$

where: ρ_2 - veneer density after absorption, kg / m^3;

ρ_1 - veneer density up toabsorption, kg / m^3;

Five-layer plywood was pressed from the impregnated dried veneer using urea-formaldehyde glue, the consumption of which was 120 g / m^2. The temperature of the press plates was 125 ° C, the pressing pressure was 2.0 MPa, and the holding time under pressure was 5 minutes. Impregnation was carried out sequentially: in a hot bath at a temperature of the impregnating solution 80- 90 ºC for 30 minutes; in the cold at a temperature of 20 ºC for 40 minutes After impregnation and drying (at a temperature of 103 ºC) of veneer determined the absorption of flame retardant and recorded salting. Five-layer plywood was glued from impregnated and dried veneer on phenol-formaldehyde resin Vateks-244 and determined the fire resistance and strength of plywood. Plywood pressing mode: temperature of plates of a press - 120- 125 ° C, pressure - 1.8-2.0 MPa, duration - 10 min, glue consumption - 120 g / m^2 [2].

Problem statement and its solution. The shear strength of refractory plywood was determined accordingly to DSTU EN 314-1: 2003. To assess the fire resistance, the method "Ceramic pipe" (GOST 16363-98) was chosen. In addition, the density of plywood was determined, and also water absorption and swelling by thickness.

According to the results of experiments (table 1) it was found that saturation the solution passes in 10 minutes, after which the absorption stops. For this period, the degree of absorption of flame retardant veneer reaches 13%.

Tabla1 – Absorption of flame retardant with birch veneer

absorption time, c	2			10			20		
Absorption, %	7,5	5,6	3,3	13,2	12,4	11,7	12,9	11,6	11,2
thickness, mm	2	10	20	2	10	20	2	10	20

According to the results, it can be determined that within 10 minutes the flame retardant ceases to be absorbed. As can be seen from the table, that at 10 s and 20 s the absorption time at a thickness of 10 mm, the percentage of absorption is in the range of 11.6 - 12.4%. Increasing the mass fraction of flame retardant in all cases, the strength decreases, but its performance is higher than the values dictated by the standard. In addition, the use of ammonium chloride urea resin as a hardener has a negative effect on the bond strength of the flame retardant veneer (the strength of refractory plywood without the use of ammonium chloride is greater) due to the flame retardant.

According to experimental data, the average rate of charring of wood samples without fire protection was 0.9 mm / min These data are correlated with the data on untreated wood according to [3], which allows us to conclude that the results of experimental studies.

General view of all samples after fire tests with exposure time of 15, 30, 60 minutes, which corresponds to the time of the required degree of fire resistance, taking into account the design of samples-fragments of wooden beams time spent on burning fire-resistant plywood to create an experimental basis for the behavior of samples-fragments of wooden beams with refractory cladding and without it are shown in Fig. 1.

Figure 1 – Photo samples after fire tests

The paper presents a model [4] developed a model that describes the temperature distribution in non-charred wood under the charred surface at a distance x at a quasi-stationary charring rate v:

$$\frac{(T-T_0)}{(T_{cw}-T_0)} = exp\left[\frac{-vx}{\alpha_\partial}\right] \quad (2)$$

where: T - temperature;
T_0 - initial temperature of wood;
Tcw - surface of coal - wood, temperature 288 ° C;
v - charring speed, mm / min .;

x - depth in the wood from the surface of the coal - wood;
α_{∂} is the coefficient of thermal conductivity.

The quasi-stationary state lasts from 15 to 20 minutes after fire exposure according to the standard temperature curve. Temperature distribution for a time between 5 and 15 minutes.

Conclusion. Analysis of the physicochemical properties of fire-retardant plywood as a cladding material is one of the important factors of the study covered in this article. We conducted a study of the interaction of the components of the flame retardant with the adhesive and how they behave at high temperatures. In the first stage, the veneer sheets were subjected to gluing in plywood sheets, in the second stage, fire tests were performed. The obtained results gave a clear idea of thermal processes in the manufacture of fire-retardant plywood, namely: the content of flame retardant 120 g / m^3 is absorbed at a thickness of 10 mm - 12.4% in 10 seconds, and 11.7% at a thickness of 20 mm.

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ФІЗИКО-ХІМІЧНІ ВЛАСТИВОСТІ ВОГНЕЗАХИСНОЇ ФАНЕРИ ПРИ ДІЇ ВИСОКИХ ТЕМПЕРАТУР

У даній статті висвітлено отримані результати досліджень фізико-механічних властивостей вогнезахисної фанери для облицювання дерев'яних балок.

Встановлено закономірності впливу вогнезахисного матеріалу в березовому шпоні 2 мм на вогнезахисні властивості фанери. Встановлено, що вогнезахисна обробка шпону збільшує щільність отриманої фанери, а компресія знижується, що дозволяє частково економити деревну сировину.

Розкрито процеси теплообміну та тепло- і масообміну, що відбуваються у шпоні, які залежать від параметрів цих процесів (температури, часу, кількості вологи) та теплофізичних властивостей шпону, які визначаються теплопровідністю, питомою тепловою, тепловою провідність, термоградієнтна дифузія маси.

Крім того, фанера належить до матеріалу, горіння якого у відповідних умовах здійснюється у вигляді розпаду, слід підкреслити, що з точки зору хімії процесу ми виділили закономірності реологічних властивостей та реокінетичних параметрів, наповнених епоксидом композиції із захисної фанери.

Ключові слова: *вогнезахисна фанера, термодинамічні процеси, коефіцієнти тепло-масообміну, режим пожежі, вогневі випробування.*