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Вплив хімічного складу деревини на міцність з'єднань, утворених полівінілацетатними клеями

Наведено аналіз впливу хімічних компонентів деревини на міцність утворюваних полівінілацетатними клеями з'єднань. Показані результати випробувань на сколювання вздовж волокон масивної і клеєної деревини ясеня, а також взірців модифікованих вакуумно-кондуктивним термічним обробленням з метою зміни їх хімічного складу.

Ключові слова: клейова композиція, дисперсія, міцність на сколювання вздовж волокон, термообробка, целюлоза, геміцелюлоза, лігнін, екстрактивні речовини.

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THE RESEARCH OF THE STABILITY OF ADHESIVE JOINTS OF HARD-WOODED SPECIES (OAK WOOD), FORMED BY MODIFIED POLYVINYL-ACETATE (PVA) COMPOSITION, TOWARDS THE INFLUENCE OF WATER AND HIGH TEMPERATURES

The results of the research of adhesive joint strength changes of oak wood formed by adhesives on the basis of PVA dispersion of domestic and foreign production under the influence of cyclic temperature and humidity testing.

Keywords: adhesive composition, dispersion, modifying additives, ultimate split strength of wood along the fibers.

Problem statement. Today it is difficult to imagine furniture, carpentry and other products of woodworking industry, in which adhesive materials are not used. In fact, owing to their application we can provide savings of raw materials, facilitate technical process, and change the physical and mechanical, operational data of gluing materials.

Along with expanding the use of adhesives, the requirements change. First of all, adhesive compositions should meet operational and technological requirements as well as be available from an economic point of view. Besides, more attention is given to environmental requirements, which is very important for the manufacture of products for residential,

office and other premises where a person spends most of his/her life. The existing environmental regulations currently meet water dispersion and water-soluble thermoplastic or thermosetting compositions and there is also part of reactive adhesives without solvents with dry weight that is close to 100 %. In particular the compositions based on polyvinylacetate dispersion belong to such adhesives. However, a significant problem is that the domestic industry mainly produces adhesives based on PVA dispersion with low resistance to the influence of humidity, water, and high temperatures [5, 6-12].

Consequently, the purpose of the study was to examine the influence of modifying additives on the stability of joints based on PVA dispersion of domestic industry towards the influence of temperature and humidity load.

Materials and methods of research. The shape and size of the samples and the method of testing the strength of adhesive joints along the fibers were selected according to GOST 15613.1-84 [2]. The experimental study of the influence of temperature and humidity loads were conducted according to GOST 17580-82 [4]. However, the very standard designed for thermosetting adhesives is too hard to be followed while testing thermoplastic compositions, so, only five cycles of testing were used for the research. It was enough to see the effect of the modification, as joints formed mainly from one-component polyvinylacetate adhesives are being destroyed after 3...5th cycle of temperature and humidity loads.

In order to perform the research, oak bars 25 mm thick were used, which were exposed to planing to thickness of 20 mm. The following brands for adhesive compositions were used: PVA dispersion-40P, PVA dispersion-51P, 53P-PVA dispersion and BONIDUR W D3 by Bochem. In order to improve the operational characteristics of the composition PVA dispersion-51P, the polyvinyl alcohol and modifying additives are added to it: hydrogen peroxide (H2O2) and ferrous sulfate (FeSO4).

The formation of joints was conducted under the following operating conditions of gluing process: pressing pressure – 0.6 MPa, glue spread – 160 g/m2, open holding duration – 8 min., pressing duration – 40 min. The research was conducted by using laboratory equipment and production equipment in accordance with current standards.

The results of research. In order to determine the stability of adhesive joints of oak wood the pre-testing procedure of samples formed by PVA dispersion-40P and 53P-PVA dispersion was conducted. The second composition is being exhibited by manufacturer that meets European standards EN 204, by class of water resistance D3 (for forming joints, which will be operated in indoors premises where they could be subjected to short-term influence of water and (or) long-term influence of high humidity) [3]. The results are shown in Table 1.

Table 1.The results of temperature and humidity testing of oak wood joints based on PVA dispersion

№	Type of glue	The split strength of wood along the fibers after appropriate test cycle, MPa			
		Control samples	1	3	5
1	PVA dispersion-40P	10,95	0,92	0	0
2	PVA dispersion-40P	11,3	3,2	0,48	0,06

Fig. 1 shows a graphical interpretation of strength changes of load cycles. It is seen from graphic dependences that after the first test cycle the split strength along the fibers for oak wood joints formed by PVA dispersion-40P is 0.92 MPa, which corre-

sponds to 8.14 % of the initial strength, and after the third cycle the complete destruction of the researched materials occurs. Somewhat better manifested themselves joints formed by PVA dispersion-53P. After the first test cycle split strength is 3.2 MPa (28.6 % of the original), but after the fifth – 0.06 MPa. However, these figures are unsatisfactory, and such joints can be operated under the conditions of exposure to high humidity (relative humidity in the environment that exceeds the rate of normal conditions to 10 percent or more) or direct contact with water.

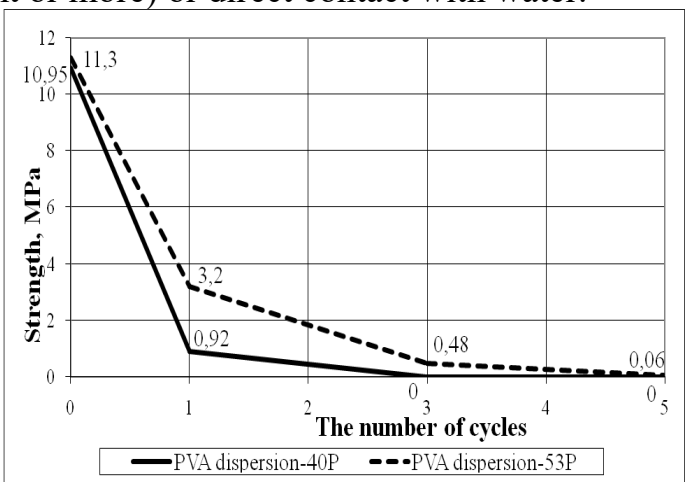
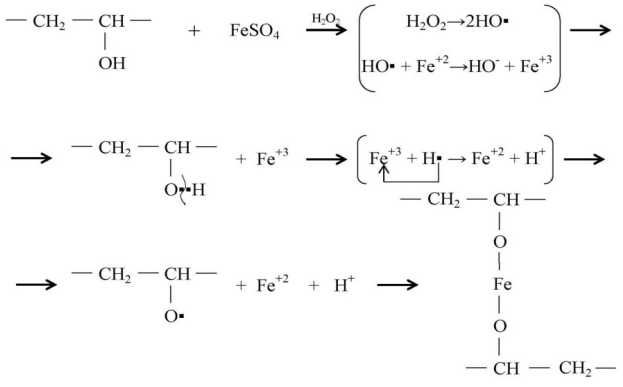


Fig.1. The dependence of the strength of oak wood glued with polyvinyl- acetate dispersions of domestic production on the number of cycles of temperature and humidity testing

The obtained results could be explained in the following way. Low water resistance of testing samples jointed with the presence of adhesive composition of an emulsifier – polyvinyl alcohol, which is a hydrophobic substance. Unsatisfactory thermal resistance connected not only with the properties of the emulsifier, but also with low thermal resistance of the polymer base (the softening begins at 40 ° C, and at 65-70 °C polyvinyl-acetate becomes viscous-flow state) [1].

The 51P-PVA dispersion produced by "Omega" is selected for the basis of modification. The characteristics of dispersion are slightly inferior to PVA dispersion-53P, but it is cheaper. Aiming at improvement of its operational characteristics, among which water, humidity and thermal resistance take the central place, it was offered to add to dispersion the ferrous sulfate (II) and hydrogen peroxide. The addition of these compounds aimed primarily at their interaction with emulsifier – polyvinyl alcohol. In order to increase the number of reaction centers, a small amount of free polyvinyl alcohol in form of water solution is additionally added to the mixture.

As a result of the reaction between polyvinyl alcohol and sulfate of iron (II) by the presence of the initiator in the formation of adhesive joint, the products with liquid structure are formed that results in improvement of operational characteristics and as a consequence – the formation of joint resistance to water:



For examination of the modification influence, oak wood joints formed by a new composition were tested, which we denote by abbreviations PVA dispersion-VS. The results are provided in Table 2. In order to compare the results with existing adhesives of European manufacturers, the samples with compositions by Bochem of class of water resistance D3 according to the standard of EN204 were produced for the check studies.

Table 2.The results of temperature and humidity testing of oak wood jointsbased on modifiedPVA dispersion

№	Type of glue	The split strength of wood along the fibers after appropriate test cycle, MPa			
		Control samples	1	3	5
1	PVA dispersion-VS	10,74	7,03	5,08	4,43
2	BONIDUR WD3	10,91	8,09	6,03	5,49

During the analysis of graphical characteristics, constructed according to Table 2 and provided in Fig. 2, it is seen that even the modified composition is slightly inferior to the stability of the glue BONIDUR W, but if to calculate the percentage of residual strength after the fifth cycle, it will account for 42 % of the initial values.

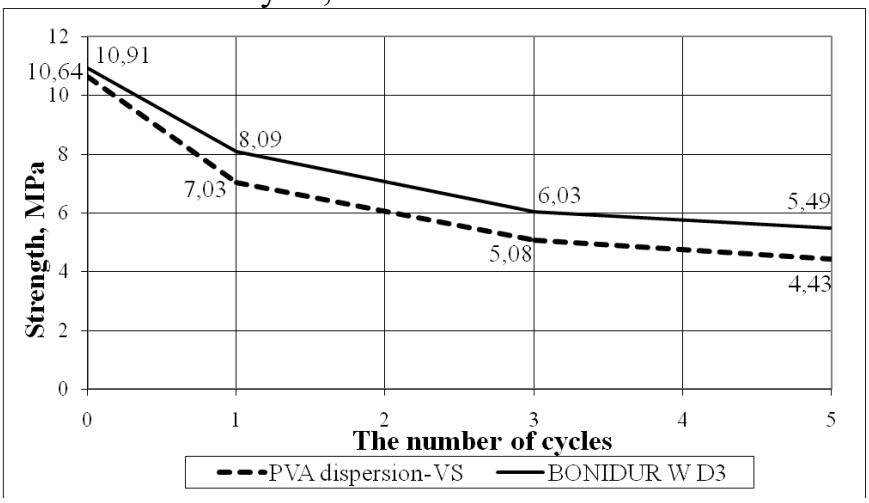


Fig. 2. The dependence of the strength of oak wood glued with the help of modified PVA dispersion-51P and BONIDUR W of the number of cycles of temperature and humidity test-

However, in order to see the modification influence, it is necessary to compare the test results of adhesive joints formed by PVA dispersion-VS with the results obtained when testing samples formed by PVA dispersion-40P and PVA dispersion-53P.

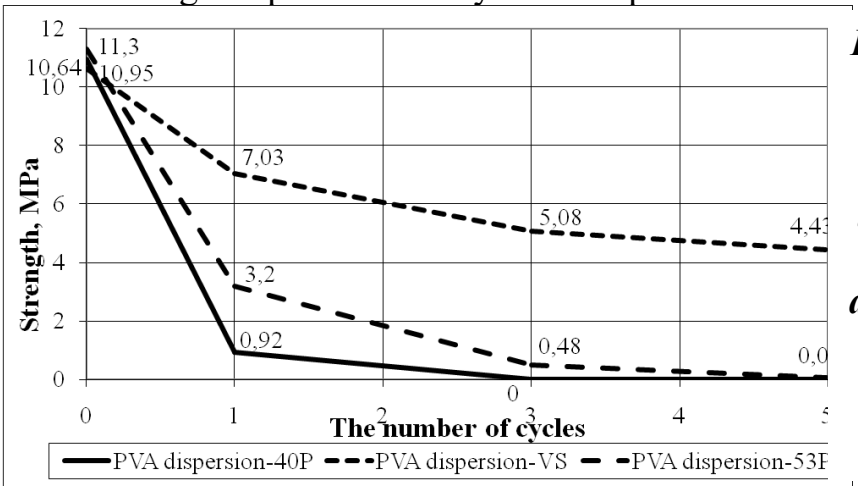


Fig.3. The dependence of the strength of oak wood glued with the help of modified and unmodified polyvinylacetate dispersions of domestic production of the number of cycles of temperature and humidity testing

From diagrams (Fig. 3) it is seen that the initial strength of the samples is rather smaller (10.64 MPa against 11.3 MPa and 10.95 in PVA dispersion-53P and 40P-PVA dispersion, respectively). Such difference can be explained by the fact that modifying additives occupy part of the contact areas of the polymer base (PVA) with wood, which leads to a slight decrease in

strength. However, after the first test cycle the positive effect of modifying additives can be observed. The samples strength formed by PVA dispersion-VS is 7,03MPa, while joints from PVA dispersion-40P are almost destroyed by minimum external force. Consequently, none of the domestic compositions withstand the five cycles of testing, except the modified one (strength of 0.06 MPa for samples formed by PVA dispersion-53P is unacceptable when used, as such joints could be broken even by slight contact with the product).

Conclusions. It is observed that in order to provide the stability of adhesive joints of wood on the basis of PVA dispersion of domestic production, it should be modified by metal salts with the addition of the reaction initiators to the mixture. In this case, the complex of sulfate iron (II) and hydrogen peroxide was chosen. In order to ensure the best indicators of water resistance it is also necessary to add polyvinyl alcohol to the mixture, because it increases the number of reaction centers. It is due to the fact that adding of modifiers is primarily focused on their interactions with additional components of polyvinyl-acetate dispersions, among which isthe emulsifier– polyvinyl alcohol. The results shows that additional modification of polyvinyl-acetated is persions of domestic production forms a composition that can compete with common adhesives of European manufacturers by the class of water resistance D3, as a product that has low cost of production and good operating characteristics.

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Дослідження стійкості клейових з'єднань твердолистяної породи (деревини дуба), сформованих модифікованою полівінілацетатною композицією, до впливу води і підвищених температур

Наведено результати досліджень зміни міцності з'єднань деревини дуба сформованих клеями на основі ПВА дисперсії вітчизняного і закордонного виробництва під впливом циклічних температуро-вологісних випробувань.

Ключові слова: клейова композиція, дисперсія, модифікуючі добавки, межа міцності при сколюванні вздовж волокон.