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Technology of Creating Decorative Panels Made of Thermomodified Veneer

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Abstract. Development of new technologies for creating artistic products in order to improve their functional, ergonomic and aesthetic properties is an important directions of improving the design of items. The article presents the technology of production of decorative composite panels obtained by gluing coloured veneer sheets made of low-value wood. Staining is proposed to proceed by thermomodification that allows you to obtain natural colours characteristic of valuable tree species, without using chemicals. Research on determination of the basic properties of the plywood produced on the basis of the heat-treated veneer are carried out. Studies have shown that high-temperature processing of veneer when manufacturing plywood provides an increase in the dimensional stability, moisture resistance and durability of the composite, without increasing its toxicity. It is established that in the process of thermomodification wood material changes its colour to darker, the texture is revealed more clearly. Thus, as a result of alternating veneer sheets with different degrees of heat treatment, it is possible to obtain a composite material with high decorative characteristics and interesting transverse texture.

1. Introduction
Decorative materials based on natural raw materials are distinguished by a wide variety of textures and colours, which explains their relevance to designers and architects all over the world. Wood is considered a self-renewable resource, and the products made on its basis can be called "eco-friendly" for the consumer. Since some wood species do not have a pronounced texture, but are of low cost, decorative composite materials based on them are considered promising [1]. At the same time, wood has negative qualities that make material with high strength difficult to obtain: significant volume-humidity deformations and development of swelling pressure; pronounced anisotropy; low biostability [1-3].

The existing problems are solved by protecting the wood surface with various materials that create waterproof and airtight films; impregnation with antiseptics; use of slowly growing or very expensive varieties of wood [4-7].

At the same time, it is known that to reduce hygroscopicity and increase resistance to decay, the technology of high-temperature wood processing without air-oxygen access is possible that is called thermal modification [8-10]. Today, there are various methods of thermal modification of wood: in hydrophobic liquids, in superheated steam, in flue gases, by a vacuum-contact method [11-14]. Thermal treatment of wood significantly reduces swelling, shrinkage, improves insulating properties [1, 4].

Scientists all over the world have been actively engaged in the study of the effect of preliminary thermal treatment of wood filler on the properties of composites in the last 8-10 years.

It was found in the work of Paul et al. [15] that preliminary thermal treatment leads to a decrease in the electromagnetic compatibility of OSB panels. The swelling thickness was significantly lower when using treated wood, regardless of the resin used.

The effect of pre-heat treatment of wood on a fiberboard was analyzed by Hosseinaei et al [16, 17], where increase in the modulus of elasticity in bending is observed. The swelling thickness and water absorption of the composite decreased after the extraction of wood raw materials. Thus, the dimensional stability increased.

The study of the effect of preliminary thermal treatment of wood on MDF showed a decrease in the thickness of the swelling, but at temperatures above 150° C the water absorption of the composite increases (Ayrilmis et al [18]). It was established in the work (Mohebby et al. [19]) that moist thermal pretreatment of wood in the production MDF, in fact, does not affect water absorption, improves dimensional stability, but reduces the mechanical properties of the composite.

In Russia, studies of the thermal modification of wood with the subsequent manufacture of composites are at the initial level, there are some developments, but they are not brought to industrial scale [20]. A method of increasing the moisture resistance of plywood has been developed in the works of the scientific group, under the guidance of A. Chubov. The process of obtaining moisture-resistant plywood consists of impregnating veneer with tall oil followed by their high-temperature treatment. However, this method of oil-thermal treatment of plywood is labor-consuming.

The results of the studies presented in the paper indicate a keen interest in the issues of preliminary heat treatment of wood in the production of wood composites because of the advantages of using less hydrophilic wood [18, 21]. Despite the fact that for some composited a number of mechanical properties reduced, the preliminary thermal modification of wood particles allows to increase significantly the performance of the composite and, as a result, to expand the areas of its possible use. The analysis of literature sources has shown that in recent years research has been actively conducted in the field of creating composite materials based on thermomodified reduced wood [21]. At the same time, the studies aimed at increasing the performance characteristics of glued materials by heat treatment of wood veneer, in fact, have not been carried out.

2. Materials and methods

In this connection, the studies about changing the properties and characteristics of wood material based on thermo-modified veneer and hot-curing glue based on urea-formaldehyde resin were carried out.

In the course of experiments, birch leaves of peeled veneer were used as wood material that is explained by its good quality characteristics and wide scope of application. Thermal modification of veneers was carried out by contact method in the temperature range 180-260 °C.

For high-temperature processing, an experimental unit was created, consisting of a thermally insulated sealed chamber with a heated lid. The interior of the chamber is connected with a pumping system including a gas blower and a condenser. The supply of thermal energy to the veneer is carried out by a contact method using heating plates [1].

A universal testing machine of the brand 5082-50 was used to study the wood material for compressive strength. In this case, a seven-layer plywood was used, 12 mm thick, cut out in the form of a rectangular prism with a base of 20x20 mm.

3. Results and discussion

To determine the degree of heat treatment of veneer, the dependences describing the influence of the regime parameters (temperature and time T, ° C and t, hour) on the degree of thermal modification of wood L:

$$L=a\cdot \ln x\cdot \ln T-b\cdot \ln T-c\cdot \ln x+d$$

where a, b, c, d - coefficients that depend on the species of wood.

The dependences make it possible to obtain heat-treated wood with a predetermined color solution. Its application extends the possibilities for creating a pattern of facing material, for example, the geometric one or a pattern imitating the texture of natural wood.

When wood is thermo modified, a complex process that flows inside the sawn timber and is accompanied by a change in the color of the material throughout the thickness is observed. This phenomenon is due to the fact that the main extractive substances that determine the color of wood (tannins, dyes, gums, monosaccharides, glycosides) react with acetic acid, as a result of which the material darkens at the molecular level [1]. The ratio of extractives and pentosans largely determines the rate of change in the degree of thermomodification of L wood (figure 1). The analysis of the presented data confirms that the rate of thermal modification depends on the treatment temperature and has the highest values at the beginning of the process, when the ratio of extractive substances and pentosans is maximum.

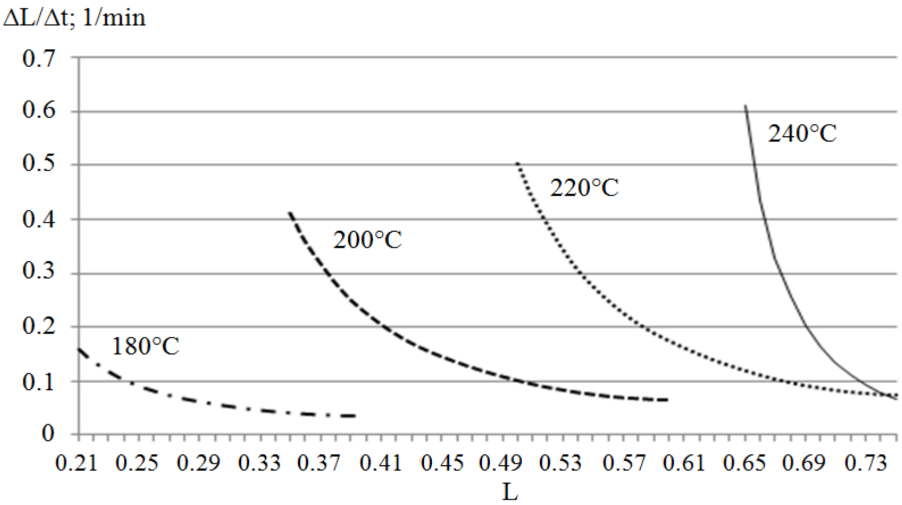

Figure 1. Rate of change of the degree of thermomodification of birch wood.

As a result of the studies, a change in the color scale of the thermoveneer has been established, depending on the degree of thermal modification. The results are shown in the table.

Then the thermo-modified sheets of veneers were sorted according to texture and color and subjected to gluing. Veneer sheets are glued and pressed (the binder can be transparent or colored to give the material an additional decorative effect) (figure 2). As a result, a sheet material is obtained, which is used, for example, for facing various products or as decorative panels with a variety of patterns, bulk blanks for further processing on numerical machines in the production of souvenirs are obtained as well. (figure 3).

Table 1. The color scheme and the degree of thermal modification for veneer from birch.

Temperature processing	The thickness of the veneer					
	δ = 1.5 mm			δ = 2 mm		
	Processing time 10 min	Processing time 20 min	Processing time 30 min	Processing time 10 min	Processing time 20 min	Processing time 30 min
< 210°C	0.33	0.48	0.57	0.27	0.44	0.51
						
> 260°C	0.75	0.97	0.99	0.71	0.90	0.98
						

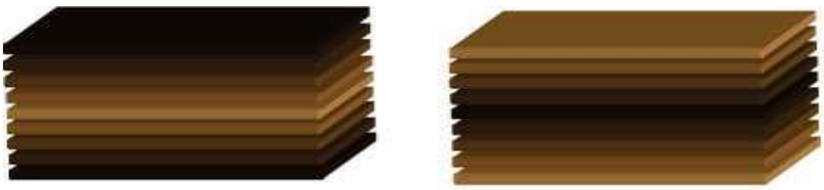

Figure 2. Schemes of forming a package of thermo-modified sheets of veneer.

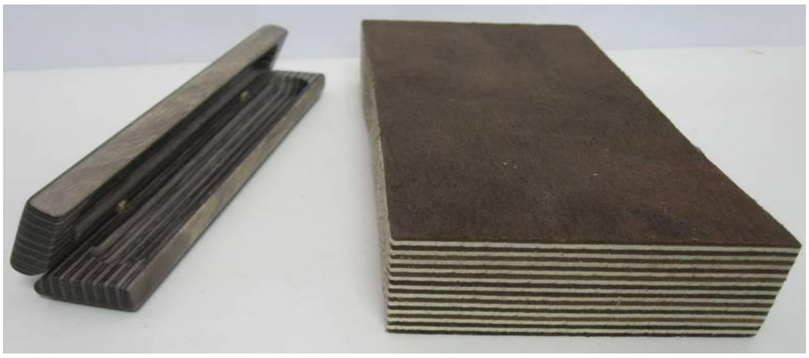

Figure 3. Samples of plywood and souvenirs made of birch veneer with varying degrees of thermal modification.

According to the results of the experimental analysis of the texture and color scale, when creating decorative plywood, the degree of thermal modification of the outer layers in the interval 0.5-0.75 was recommended.

Further, physical and mechanical properties of samples of decorative panels, created from sheets of veneer with the same degree of thermal modification, were examined.

Analysis of the results of a comparative evaluation of the strength of plywood in a dry form and after boiling in water for 3 hours (figure 4) indicates a reduction in the compressive strength of dry plywood with an increase in the degree of heat treatment of veneer. At the same time, a significant reduction in strength is observed when veneer is used with a degree of thermal modification higher than 0.75. In addition, for samples of plywood made of veneer with a degree of thermal modification in the range 0.45-0.55, boiling, in fact, does not cause a decrease in strength characteristics.

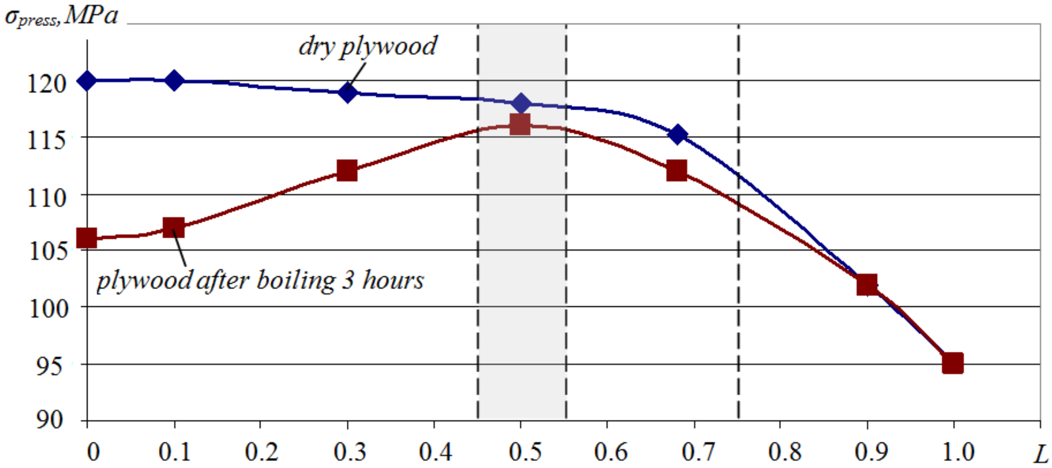

Figure 4. The change in compressive strength of samples of plywood depending on the degree of thermally modified veneer.

As a result of the researches of mechanical characteristics of plywood from thermomodified veneer, which were carried out, a rational degree of heat treatment of wood material in the interval 0.45-0.7 for plywood of general purpose is established, providing high aesthetic characteristics with a significant increase in humidity and water resistance and maintaining the basic strength parameters.

4. Conclusions

On the basis of the data given in the article, it can be concluded that in the heat treatment process wood acquires a number of new properties, such as biostability, dimensional stability and uniform color variation throughout the cross section of the material. The coloring of low-value rocks by heat treatment makes it possible to obtain natural shades, characteristic of expensive tree species, reduce the cutting of valuable forests and the cost of finished products.

The technology of production of composite material obtained by gluing multi-colored veneer sheet of low-value wood species is aimed at expanding the range of decorative tools used by artists and designers in creating souvenirs, decorative products, finishing panels and other materials based on wood.

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