Justification of conditions of application of thermo modified veneer for protection of wooden products from moisture

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Abstract. The analysis of the process of thermal modification of wood was carried out an it was found that the treatment causes chemical changes in the structures of wood components (lignin, cellulose and hemicellulose). It is proved that in the process of thermal modification there is a decomposition of hemicelluloses and amorphous part of cellulose, reduced water absorption, and also reduces the amount of substances that are the environment for the development of fungi, which leads to increased durability. In addition lignin and pseudolignin formed by the process of polymerization and pereropodilinyu in cell volume and cell walls provide higher density, hardness, increase the hydrophobicity (water repelling), thereby reducing their ability to absorb moisture and swell. It has been experimentally established that in comparison with unmodified veneer, which gained 22.41% of moisture in two weeks, veneer modified at 250 and 280 °C gained 2.5 times less moisture - on average 8.6%. It is established that with the increase of the modification temperature to 280 °C, the water absorption decreases more than twice. The results of the research will also allow to purposefully solve further problems on the creation of new methods of thermal modification of wood and the conditions of its operation at various sites.

1. Introduction
In construction is more intense search for new highly effective wood protection from destruction. But protection today must not only ensure the normalized stability of wood, but also to preserve its operational parameters, to solve environmental safety and durability.

To increase the level of wood exploitation, it is possible by modifying it, the essence of which is to give the wood the ability to resist moisture, bio-damage, which contributes to the destruction of wood and accelerate the process of destruction. But when modifying wood, there are difficulties with the technological modes of its processing, namely, such as time, temperature. This is due to the fact that the modification process may not be achieved, and the use of such wood leads to its destruction [1].

Knowledge of physicochemical properties of thermofomed wood, its quality indicators, the mechanism of action on temperature materials, allows to make a choice taking into account economic indicators, duration and safety of application, environmental aspects, etc. [2-5].

Therefore, the development of technological measures for wood modification, study of water absorption and impact on this process is an unresolved component of ensuring the stability of wood and determine the need for research.

2. Analysis of recent research and publications
Thermodified wood is becoming one of the best materials for cladding building structures and products [6]. In this regard, the humidity of thermally modified facades was measured and the low moisture content of thermally modified wood was revealed in comparison with the reference spruce. But it is not specified what was the degree and modes of wood modification. Mass loss, wettability, wood color and chemical transformations have since been widely studied [7], while work is needed to focus on quality control, modeling and study of the causes of improved properties of modified wood.

Extensive use of thermally modified wood has led to the need for quality control, including control of product deviations, which allows it to be carried out by a third party in the case of certification and...
regulation of complaints and consumer requirements [8]. However, it is not specified what methods are needed to characterize the change in quality in terms of improved target properties of modified wood during industrial production.

In [9] studied the swelling and surface roughness after heat treatment of wood. Established that the parameters of swelling and surface roughness vary considerably for the two two-temperature heat treatment durations. The value of swelling and surface roughness decreased with increasing treatment temperature and treatment time, but not listed under any technical indicators.

The assessment of changes in color and reflectivity wood surfaces through artificial weathering [10] obtained from the solar box camera that mimics the conditions and further leaching water. As the weathering time increases, the untreated surfaces of the wood samples darken, while the modified samples lighten to have a similar color or, in any case, to reduce the chromatic difference that was at the beginning of the weathering tests.

During heat treatment, many chemical reactions occur, leading to changes in the components of the primary cell wall of the wood and darkening of the material. Among other changes, thermomodified wood becomes more resistant to fungal decay and more stable than raw size, making it suitable for use indoors and outdoors as cladding, decking, flooring, garden furniture and window frames [11].

Laboratory tests have shown a positive effect of thermal modification on the durability, dimensional stability and thermal conductivity of wood [12]. The monitoring results showed that the elements and windows of thermally modified spruce have a significantly lower moisture content in the wood compared to windows of unmodified, and that the wax also has a positive effect on humidity.

Natural aging is usually a relatively slow process because the artificial aging plays a role important in assessing the results by reducing the time compared to the natural weathering conditions. The approach is to protect the surface with various types of commercial products such as water-based solvents with a high solids content, powder coatings and substance-free products [13].

One approach is the modification of wood – a set of processes that provide the treated material over the ability to cope with the damage caused by the environment, by increasing the duration of treatment. The process is also performed to enhance the physical, mechanical or aesthetic properties of wood and derived products with the advantage that they are not as harmful to users and the environment as natural wood [14-16].

Thus, from the literature it is established that thermal modification of wood can give it the opportunity to resist destruction. All this gives reason to believe that it is appropriate to conduct a study on the determination of the parameters that ensure its stability. Therefore, research in this area is the unresolved part of ensuring the sustainability of building designs, which resulted in the need for research.

3. The purpose of this work
The purpose of this work is to study the process of water absorption by thermomodified oak veneer and substantiate the effectiveness of counteracting water absorption during thermal modification.

4. Materials and methods of research
To establish the efficiency of operation of the facades of furniture products at different temperature and humidity conditions, we used samples of oak veneer, which had previously undergone a heat treatment process. Thermal modification was performed in a convective chamber, for the reliability of the result, the veneer was fixed between the plates of porcelain. In general, the material was kept at temperatures of 160, 220, 250 °C for 10, 20 and 30 minutes and 280 °C for 10 minutes (Figure 1-4).

Samples of thermomodified oak veneer with a tangential cross-sectional surface 0.7 mm thick and 155x15 mm in size were used to study moisture absorption. The amount of water bending was determined on samples measuring 155x150 mm, 0.7 mm thick, which have undergone preliminary thermal modification according to the above parameters.
Figure 1. Samples of oak veneer after thermal modification at a temperature of 160 °C for: a – 600 s; b – 1200 s; c – 1800 s.

Figure 2. Samples of oak veneer after thermal modification at a temperature of 220 °C for: a – 600 s; b – 1200 s; c – 1800 s.

Figure 3. Samples of oak veneer after thermal modification at a temperature of 250 °C for: a – 600 s; b – 1200 s; c – 1800 s.

Figure 4. Samples of oak veneer after thermal modification at a temperature of 280 °C for 600 s.
Moisture absorption of wood – the ability of dry wood to absorb water vapor. Moisture absorption is defined as the change in mass during holding of a material in a humid environment for a certain time. The essence of the method is that strips of thermmodified oak veneer were placed in a desiccator (Figure 5) with a saturated solution of sodium, which was impregnated with filter paper to increase the humidity.

![Desiccator](image)

**Figure 5.** Desiccator for veneer moisture absorption tests.

The study carried out periodic weighing of veneer at the appointed time, namely after 2, 3, 6, 9, 13 days after placement in the desiccator.

The experiment was completed when the difference in mass of the last weighing’s did not exceed 0.01 g.

Water absorption – the ability of wood to absorb water in direct contact with it (Figure 6).

![Device for testing water absorption](image)

**Figure 6.** Device for testing the absorption of water by veneer.

The research method provides for the installation of veneer in the cassette, its immersion and exposure of the material in water with periodic weighing. The first recording was carried weight gain after 2 hours, then at 1, 2, 3, 6, 9 days. Weighing was stopped when the difference in readings was not less than 0.05 g.

5. **Research results**

In Figure 7 shows the process of moisture absorption of veneer samples.
Figure 7. Keeping the test samples in a wet environment.

The results of studies of moisture absorption showed that on the 13th day of aging in a humid environment, the mass of all samples did not increase – Table 1.

It was determined that the samples of oak veneer gained the most moisture from the environment in the first two days. The weight of unmodified veneer increased by 0.06 g, similar results showed veneer modified at lower temperatures. Thermmodified veneer at a temperature of 250 °C for 20, 30 min and 280 °C in the first two days gained 2 times less – 0.03 g. Over the next 11 days, the control samples gained another 0.09 g, slightly less samples modified at temperature 160 °C, and modified at 220 °C and above not more than 0.03 g. Compared with unmodified veneer, which in two weeks gained 22.41 % moisture, veneer modified at 250 and 280 °C gained 2.5 times less moisture – an average of 8.6 %.

Table 1. The results of studies of moisture absorption of veneer.

| Thermomodification mode temperature / duration | Mass of samples after keeping in a wet environment, g | Absorbed moisture,% |
|-----------------------------------------------|------------------------------------------------------|---------------------|
|                                               | Exposure in a wet environment, days                  |                     |
| Control                                      | 0  2  3  6  9  13                                   | 22.41               |
| 160°C /10 minutes                            | 0.67 0.73 0.76 0.80 0.82 0.82                       |                     |
| 160°C /20 minutes                            | 0.64 0.71 0.72 0.73 0.76 0.76                       | 18.12               |
| 160°C /30 minutes                            | 0.60 0.64 0.66 0.67 0.70 0.70                       | 16.74               |
| 220°C /10 minutes                            | 0.62 0.68 0.70 0.71 0.72 0.72                       | 15.85               |
| 220°C /20 minutes                            | 0.65 0.70 0.71 0.71 0.73 0.73                       | 11.61               |
| 220°C /30 minutes                            | 0.60 0.66 0.67 0.67 0.67 0.67                       | 11.78               |
| 250°C /10 minutes                            | 0.63 0.66 0.67 0.68 0.69 0.69                       | 9.58                |
| 250°C /20 minutes                            | 0.63 0.68 0.69 0.69 0.70 0.70                       | 10.66               |
| 250°C /30 minutes                            | 0.60 0.63 0.64 0.65 0.65 0.65                       | 8.87                |
| 280°C /10 minutes                            | 0.66 0.69 0.70 0.70 0.72 0.72                       | 8.37                |

In Figure 8 shows the process of water absorption by veneer.

The effect of high temperature also had a positive effect on reducing the water absorption of veneer in Table 2.
Figure 8. Exposure of samples in water.

Table 2. Change in the mass of samples of thermomodified veneer in water

| Thermomodification mode | Mass of samples after keeping in a wet environment, g | Absorbed moisture, % |
|-------------------------|----------------------------------------------------|----------------------|
|                         | Exposure in a wet environment, 0 | 0.1 | 1 | 2 | 3 | 6 | 9 |
| Control                 | 6.21 | 10.32 | 11.07 | 11.93 | 12.01 | 12.13 | 12.30 | 98.00 |
| 160 °C /10 minutes      | 6.41 | 10.55 | 11.17 | 11.86 | 11.93 | 12.38 | 12.44 | 94.33 |
| 160 °C /20 minutes      | 6.25 | 10.34 | 10.98 | 11.53 | 11.62 | 11.99 | 12.09 | 93.33 |
| 160 °C /30 minutes      | 6.27 | 10.32 | 10.89 | 11.55 | 11.63 | 11.86 | 11.99 | 91.33 |
| 220 °C /10 minutes      | 6.07 | 9.32  | 10.18 | 11.09 | 11.19 | 11.48 | 11.59 | 91.33 |
| 220 °C /20 minutes      | 6.14 | 9.56  | 10.43 | 11.29 | 11.22 | 11.58 | 11.70 | 90.67 |
| 220 °C /30 minutes      | 6.14 | 9.34  | 10.28 | 11.23 | 11.22 | 11.58 | 11.66 | 89.67 |
| 250 °C /10 minutes      | 5.85 | 7.62  | 8.52  | 10.17 | 10.34 | 10.90 | 11.14 | 90.33 |
| 250 °C /20 minutes      | 5.97 | 8.14  | 9.16  | 10.70 | 10.80 | 11.14 | 11.27 | 89.00 |
| 250 °C /30 minutes      | 5.87 | 7.61  | 8.48  | 10.12 | 10.34 | 10.81 | 10.93 | 86.00 |
| 280 °C /10 minutes      | 5.64 | 6.82  | 7.47  | 9.07  | 9.28  | 10.27 | 10.44 | 85.00 |

According to the results of research, it is seen that in the first two hours, all samples took a significant amount of water. Thus, unmodified veneer and thermomodified at temperatures of 160 and 220 °C absorbed 50...66 % of its initial weight, and modified at 250 and 280 °C – 20...36 %. The nature of moisture accumulation in the following days during the continuation of the experiment is interesting. Control samples of veneer and modified at lower temperatures with each subsequent weighing showed smaller values. But the samples modified at temperatures of 250 and 280 °C for the second day gained almost as much water as in the first two hours, then the difference decreased.

Control samples of veneer for the whole experiment gained 98 % of the initial mass in Figure 9.

Figure 9. The results of water absorption of veneer of various degrees of modification.
The best results showed samples of veneer thermofluid modified at a temperature of 280 °C, the weight of which increased by 85%.

6. Conclusions
Thus, as a result of experimental researches the positive influence of thermal modification of a veneer on water absorption is established. It is established that with the increase of the modification temperature to 280 °C, the water absorption decreases more than twice. The results of the research will also allow to purposefully solve further problems on the creation of new methods of thermal modification of wood and the conditions of its operation at various sites.

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