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DETERMINATION OF THERMAL AND PHYSICAL CHARACTERISTICS OF DEAD PINE WOOD THERMAL INSULATION PRODUCTS

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Проведеними дослідженнями отримано можливість виготовлення теплоізоляційних матеріалів з сухостійної деревини сосни для облаштування приміщень. Сировиною для їхнього виробництва є деревні волокна, які формують у плоскі плити. Встановлено механізми процесу теплоізоляції при передаванні енергії через матеріал, що дає можливість впливати на цей процес. Доведено, що процеси теплоізоляції полягають у зниженні пористості матеріалу. Так, зі зменшенням об'ємної маси матеріалу, теплопровідність зменшується, і навпаки. Проведено моделювання процесу передавання тепла при спучуванні вогнезахисного покриття, визначено залежності теплофізичних коефіцієнтів від температури. За отриманими залежностями розраховано коефіцієнт теплопровідності для виробів з сухостійної деревини сосни, який сягає 0,132 Вт/(м·К). У разі оброблення виробів з деревини клейовою композицією зменшується до 0,121 Вт/(м·К), а при створенні теплоізолювальних плит із деревної шерсті знижується до 0,079 Вт/(м·К) відповідно. Особливості гальмування процесу передавання тепла до матеріалу, що виготовлений з деревної шерсті і клеєного в'яжучого, пов'язано з утворенням пор. Це пояснюється тим, що в не великих порах відсутній рух повітря, що супроводжується перенесенням тепла. Теплопровідність однорідного матеріалу залежить від об'ємної маси. Так, зі зменшенням об'ємної маси матеріалу до 183 кг/$м^3$ теплопровідність зменшується в 1,67 рази, і навпаки при застосуванні дошки теплопровідність знижується лише в 1,1 рази. Це дозволяє стверджувати про відповідність виявленого реальному механізму теплоізолювання і виявлених умов формування властивостей матеріалу на основі деревної шерсті і неорганічного та органо-мінерального в'яжучого та практичну привабливість запропонованих технологічних рішень, а саме застосування низькоякісної деревини. Останні, зокрема, стосуються визначення кількості складової в'яжучого. Таким чином, є підстави стверджувати про можливість спрямованого регулювання процесів формування деревинних теплоізоляційних матеріалів шляхом використання деревної шерсті і неорганічного та органо-мінерального в'яжучого, які здатні утворювати на поверхні матеріалу вогнезахисну плівку

Ключові слова: теплоізоляційні матеріали, деревна шерсть, теплопровідність, теплоємність, неорганічне і органо-мінеральне в'яжуче

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1. Introduction

Over the last decade, shrinkage of coniferous stands has grown at a threatening scale across much of Europe. Today, scientists say climate change is the most likely cause of shrinkage, leading to the spread of ipid bark beetle that quickly affects entire areas of healthy, ripening or mature stands (70 years and older) [1].

To date, no effective methods of protecting pine plantations from biological pests have been found. One of the main and most effective means of preventing pathological processes in forests that cause shrinkage is the elimination of shrinkage centers by carrying out sanitary and another intermediate felling [2], which results in a significant amount of raw low-quality wood. Such wood is characterized by low marketability due to mycological damage of various degrees and, consequently, lower cost. So it is considered suitable only for biofuel production.

The analysis of the use of dead wood as biofuel showed that it is low-profitable. In the pulp and paper production and manufacture of wood boards there are restrictions on the use of such wood (up to 15–30 %) due to a decrease in fiber length, pulp content reduction, formation of large amounts of wood dust in the process of chipping, which reduces the quality of products [3].

Today, interest in wood as a material based on renewable raw materials is growing rapidly, because wooden elements belong to the class of lightweight building structures, the use of which is one of the important directions for improving the efficiency of construction. However, active consumption of wood in the world has led to the fact that deforestation is 10 times higher than afforestation [4].

Thus, the majority of the countries are already experiencing a shortage of forests, especially industrial softwood, which is being actively used as structural. This state of affairs necessitates the search for additional wood reserves suitable for industrial use. Such reserve can be dead wood, which is found in forest plantations of all age groups and types of forest, the amount of which increases annually as a result of changes in environmental and climatic factors.

Therefore, the use of dead wood in construction requires the determination of certain properties, in particular, thermophysical characteristics necessary for the manufacture of thermal insulation products, which is the aim of this work.

2. Literature review and problem statement

In recent years, there have been some known works in the field of wood utilization, aimed at the development of panel boards for thermal insulation of buildings and production of wooden wall panels. The technologies are based on pressing a mixture of plant fibers with mineral additives such as various natural materials (asbestos, mica, basalt) with hydrophobic components [5, 6]. In [5], the effect of the amount of plant fiber (flax fiber – cotton fiber) on the density and flexibility of the material obtained by aeration deposition is studied. The effect of binder on the properties of flexible thermal insulation materials is also considered. But the issue related to thermal conductivity remains unresolved, which reduces the quality of the results obtained. In [6], the assessment of the thermal conductivity of insulating wood-fiber boards at different temperatures and relative humidity is carried out. It is found that accurate datasets on the thermal behavior of insulation materials are crucial in numerical modeling approaches, which will improve the correct construction of enclosure buildings. However, it is not specified how thermal conductivity is determined. The paper [7] presents data on production technology, thermophysical properties of the material made of hemp and gypsum binder and shows the possibility of using it as thermal insulation material. But questions remain about the joint action of the components in thermal insulation. The materials given in [8] are made on the basis of basalt fiber and are characterized by high thermal insulation ability, but the technology of their manufacture, method for determining this indicator and strength characteristics are not shown.

Accuracy and efficiency of forecasting heat transfer in wood panels made of particle board are becoming increasingly important to describe their behavior, especially for changing environmental conditions. For modeling heat transfer in wood panels, it is necessary to enter reliable data on their thermal properties, so the procedure was developed so that the thermal conductivity anisotropy was taken into account, with thermal conductivity being 0.12 W/(m·K) and heat capacity 1500 J/(kg·K), respectively [9]. However, it is not known what wood was used to make the products to confirm this process, the corresponding physicochemical calculations are not given. This is primarily due to the fact that decorative wooden panels containing packages of materials were prepared. These centers, in turn, change on a phase basis, since they represent the phase transition temperature and latent heat saving, which is suitable for construction works [10]. In the direction of these studeies [11], the mathematical model is proposed describing the dynamics of heat conduction and retention on a fiber insulation coating taking into account “internal” features of the insulator (gran size and porosity of the fiber insulation made of a mixture of natural and synthetic fibers). However, this model does not consider the effect of changes in pore shape on the heat transfer to the structure itself.

Studies are also made of the insulation materials made of carpet waste mixed with a solution of colemanite ore, one of the boron minerals and a solution with colemanite waste [12]. It is shown that due to the estimated optimal ratios it is possible to adjust the content of the components to ensure the thermal insulation process. In addition, knowledge about permanent panels, understanding of non-uniform boards are improved due to the identification of two major components [13]. This is knowledge of the internal microestructure of the bark board, which allowed creating a numerical model of thermal conductivity based on finite difference methods. The results obtained for voids were slightly different. So voids with vertical particles were 0.025 W/(m·K) and with horizontal particles 0.028 W/(m·K).

The main thermophysical characteristics of pine wood for the calculation are given in the State Building Codes DBN V.2.6-31 [14]. These are primarily specific heat capacity of 2.3 kJ/(kg·K) and thermal conductivity of 0.18 W/(m·K) in the longitudinal and 0.09 W/(m·K) in the transverse direction. But how they are obtained is unknown.

Data on thermal conductivity and heat capacity of dead wood thermal insulation products are not revealed and for the use of such products it is necessary to determine these indicators.

3. The aim and objectives of the study

The aim of the study is to determine the thermophysical characteristics of dead pine wood construction products, which will allow determining the conditions of suppression of thermal conduction of the building structure.

To achieve this aim, the following objectives were set:

– to carry out modeling of the parameters of the heat transfer process for dead pine wood construction products;

– to substantiate the features of the thermal conductivity of the dead pine wood building structure.

4. Materials and methods of the study in the development of thermal insulation characteristics of dead pine wood construction products

4. 1. Materials used in the experiment

Samples of dead pine wood in the form of boards (Fig. 1) were treated with:

– inorganic binder (the patent of Ukraine for utility model No. 95440 "Fire retardant coating for wood") on both sides;

– organic-mineral binder (Skela-w coating) on both sides.

Samples of thermal insulation material based on wood wool and binder were prepared by pressing in 150×150×20 mm metal molds. For the filler of boards, wood wool preliminarily made of low-quality pine wood dried up to 10 % humidity was used. The sizes of fibers (wool strands) were: length – 50–400 mm, thicks ness – 0.5 mm and width – 5 mm, respectively. Preparation of the binder consisted in bringing its viscosity to 10 s by the VZ-4 viscometer with water and applying it to the wood surface, modeling a certain construction product. Molding was performed in accordance with [15].

In addition, dead pine wood samples in the form of 4 mm thick, about 150 mm long and wide slabs, joined in a 18÷21 mm thick sandwich (Fig. 1) were used to study the thermal conductivity of the material.

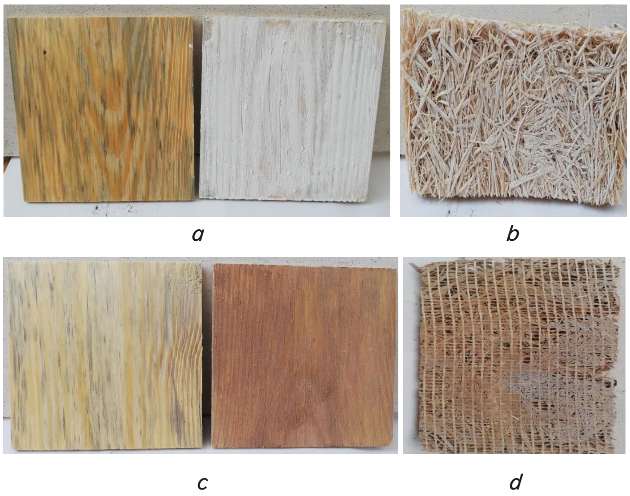

Fig. 1. Model samples of thermal insulation material: *a* – based on dead pine wood and organic-mineral binder (δ=4 mm); *b* – based on wood wool and organic-mineral binder (δ=20 mm); *c* – based on dead pine wood and inorganic binder (δ=4 mm); *d* – based on wood wool and inorganic binder (δ=19 mm)

4. 2. Method for determining the properties of samples

Modeling of thermal conduction of dead pine wood under thermal action was performed using the basic provisions of mathematical physics [16].

To obtain the values of thermal conductivity of plant raw materials, special equipment was developed and manufactured and a flat electric heater modeling a low-calorie heat source was used (Fig. 2). The heater was manufactured as follows: a nichrome wire with a resistance of 83 Ohms and applied voltage of 30 V was wound on a 100×100 mm 1 mm thick electric insulating plate. The heater was placed in a thermal insulation plate to reduce heat loss around the perimeter.

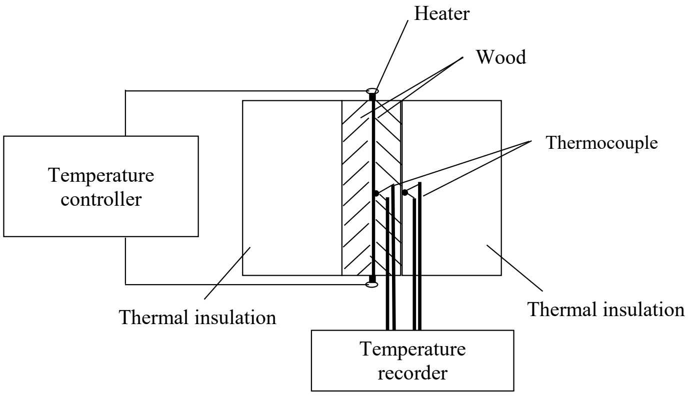

Fig. 2. Device for the study of thermal conductivity of wood

The bonded sample of wood was placed in the device, the heater with the thermocouple was placed between the studied wood plates, and the control thermocouple was placed on the opposite wall of the wood sample. The sample was fixed so that the end of the thermocouple was pressed against the inner surface of the sample. Electric heating was switched on, the heater and sample back surface temperature was measured. When the heater temperature increased by 40÷41 °C, the heater was switched off, and the temperature was continued to measure until $0.5T_{\max}$ on the back surface of the wood sample. The measured values were used to determine thermal insulation properties of the dead pine wood sample.

The criterion for determining the thermal conductivity of dead pine wood under thermal action is the value of $0.5T_{\max}$ on the back surface of the wood sample.

5. Modeling of heat transfer parameters for dead pine wood construction products

One way to use dead pine wood can be insulation of walls with the elements of the wood itself and adhesive bonded one and manufacture of insulation boards of dead pine wood wool. In view of the above, the question arises as to the study of the thermophysical properties of dead pine wood under thermal action.

It should be noted that determining the thermophysical characteristics of the adhesive binder film is associated with several obstacles, namely the need to measure temperature in the thin fire protection layer (up to 0.1 mm). Besides, this layer will not particularly affect the thermophysical properties.

In order to determine the thermophysical characteristics of dead pine wood, the method for solving the problem of thermal conductivity for the plate is proposed. A semi-bounded body at temperature T_0 is given. One of the surfaces is heated by a constant heat flux Q=const. The temperature changes in one direction (Fig. 2). Temperature distribution in this direction at any time needs to be found.

The differential equation that describes this process is as follows:

$$\frac{\partial^2 T(x,\tau)}{\partial x^2}-\frac{1}{\phi^2}\frac{\partial T(x,\tau)}{\partial \tau}=0,\quad (\tau>0;\ 0<x<\infty), \qquad (1)$$

with the initial and boundary conditions

$$T(x,0)=T_0, \qquad (2)$$

$$\lambda \frac{\partial T(x,\tau)}{\partial x} = q = \text{const}, \tag{3}$$

$$T(\infty,\tau) = 0, \tag{4}$$

$$\frac{\partial T(\infty,\tau)}{\partial x} = 0, \tag{5}$$

where T_0 is the initial temperature of wood, °C; $T(x, \tau)$ is the temperature field of wood at points with coordinates x at time τ, °C; $\phi = \sqrt{a}$; a is the thermal diffusivity of wood, m^2/s; τ is the residence time of the wood sample in the high-temperature environment, s; q is temperature flow, W/m^2; λ is the thermal conductivity of wood, W/(m·K).

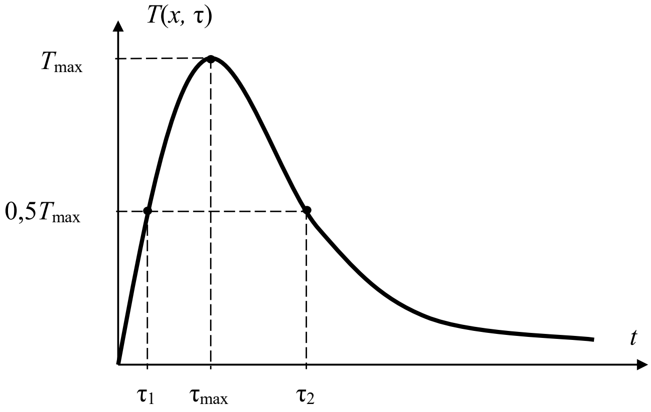

Fig. 3. Temperature history for the point $0{,}5\,T_{\max}$

The solution of equation (1) with the initial and boundary conditions (2)–(5) is given in [16] as follows:

$$T(x,\tau) - T_0 = \frac{2\cdot q\cdot \phi\cdot\sqrt{\tau}}{\lambda} erfc\frac{x}{2\phi\cdot\sqrt{\tau}}, \tag{6}$$

where

$$ierfc\,x = \int_x^\infty erfc\xi \mathrm{d}\xi = \frac{1}{\sqrt{\pi}}e^{-x^2} - xerfc\,x \tag{7}$$

is the error integral with inherent properties [13].

We show that equation (6) is the solution of the boundary value problem (1)–(5). If the temperature is measured in the heater plane (x=0), it follows from (6) that:

$$T(0,\tau) - T_0 = \frac{2\cdot q\cdot \phi\cdot\sqrt{\tau}}{\lambda\cdot\sqrt{\pi}}, \tag{8}$$

since the right side of equation (7) for x=0 is $\pi^{-0.5}$.

Denote the relation as the equation:

$$\frac{\lambda}{\phi} = b, \tag{9}$$

where b is the thermal storage capacity characterizing the thermal effusivity of the wood product, $W\cdot s^{1/2}/(m^2\cdot K)$.

We introduce equation (9) in (8) and obtain

$$T(0,\tau) - T_0 = \frac{2\cdot q\cdot\sqrt{\tau}}{b\cdot\sqrt{\pi}}. \tag{10}$$

Function (10) in the coordinate system $\tau^{0.5}=f(T-T_0)$ is the straight line passing through the origin with the slope ratio:

$$\operatorname{tg}\alpha = \frac{b\cdot\sqrt{\pi}}{2q}. \tag{11}$$

From dependence (11), the equation follows to calculate the thermal effusivity of the wood product:

$$b = \frac{2q\cdot\sqrt{\tau}}{\sqrt{\pi}\cdot\left(T(0,\tau) - T_0\right)}. \tag{12}$$

As can be seen from dependence (12), the maximum value of thermal effusivity is possible for x=0, i. e. at the highest temperature value of the heater.

In order for each experiment to have the same amount of heat, it is necessary to ensure that the resistance of the electric heater, the voltage supplied to the heater and pulse duration are constant. The heat flux density of the heater is accordingly:

$$q = \frac{U^2}{R\cdot 2S} = \frac{P}{2S}, \tag{13}$$

where R, U, S are the values of resistance, voltage and contact area of the heater.

Thermal diffusivity is determined by the delay time, that is, the time during which the temperature in the cross-section of the plate becomes the same as the temperature of the heater at time τ_1. For different time points τ_1 and τ_2, provided that $\tau_2>\tau_1$, we can write an equality between equation (6) and (8):

$$\frac{2\cdot q\cdot\phi\cdot\sqrt{\tau_1}}{\lambda\cdot\sqrt{\pi}} = \frac{2\cdot q\cdot\phi\cdot\sqrt{\tau_2}}{\lambda} ierfc\frac{x}{2\phi\cdot\sqrt{\tau_2}}. \tag{14}$$

After transformations we obtain the dependence:

$$\frac{\sqrt{\tau_1}}{\sqrt{\tau_2}\cdot\sqrt{\pi}} = ierfc\frac{x}{2\phi\cdot\sqrt{\tau_2}}. \tag{15}$$

The values of the left side are determined from the formula (15), which includes experimentally measured values. Using the table, the corresponding value of B is found, which is an argument of the function *ierfc*, the value of which allows obtaining the formula for calculating the thermal diffusivity from the right side (15):

$$a = \frac{1}{4\cdot\tau_2}\left(\frac{x}{B}\right)^2, \tag{16}$$

since $\phi = \sqrt{a}$.

Thermal conductivity of the wood product is found by the equation:

$$\lambda = b\cdot\sqrt{a}. \tag{17}$$

Accordingly, the specific heat capacity of the wood product is found from the ratio:

$$c = \frac{\lambda}{a\cdot\rho}, \tag{18}$$

where ρ is the wood product density, kg/m^3.

In any case, comprehensive determination of the thermophysical characteristics of the wood product based on the solution (6) implies knowledge of the nature of temperature variation over time at any two points of the test sample.

The dependences (16)–(18) are adequate to those obtained for determining the thermophysical characteristics of wood in [17], and the results of determining the thermophysical characteristics coincide within the research error.

Thus, the dependences were obtained, which allow estimating the thermophysical characteristics of wood under thermal action.

6. Experimental studies of thermal conduction of plant raw materials in the swelling of the fireproof coating and results

To determine the thermophysical characteristics of dead pine wood, studies were conducted regarding its thermal conductivity under the action of the heating device (Fig. 4).

Fig. 4. Process of determining the thermal conductivity of the wood sample under the action of the heater

The studies to determine the maximum temperature (0.5T, °C) and duration of induction time of temperature transfer through the wood layer were performed using the method and equipment above, the results are shown in Fig. 5, 6.

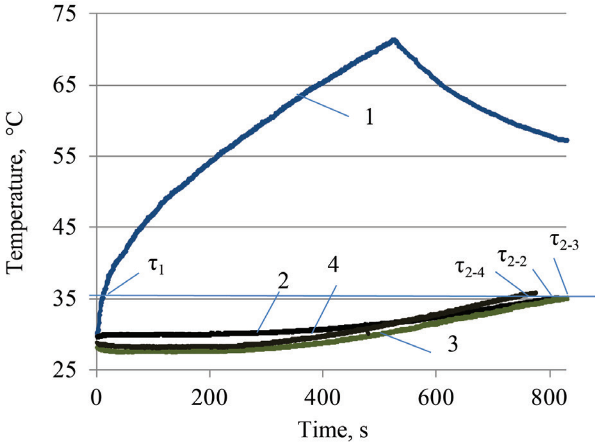

Fig. 5. Test results of thermal conductivity of four dead pine wood samples (sandwich): 1 — heating curve, 2 — temperature of the unbonded back surface; 3 —temperature of the organic-mineral bonded back surface; 4 — temperature of the inorganic bonded back surface. The points τ_1 and τ_2 according to Fig. 3

As can be seen from Fig. 5, under the action of the heater on the dead pine wood samples (sandwich), intensive heat transfer and slight temperature increase on the back surface of the sample began for about 800 s. The tests show that the thermal conductivity of these samples is characterized by the wood itself, inorganic bonding of wood increases the rate of temperature growth by 5 %, while inorganic bonding reduces the heat transfer by 3 %.

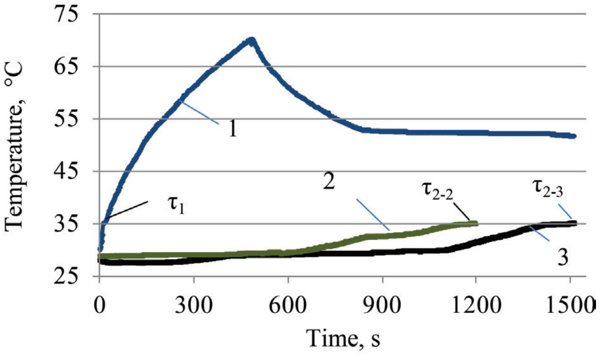

Fig. 6. Test results of thermal conductivity of dead pine wood wool: 1 — heating curve, 2 — temperature of the organic-mineral bonded back surface; 3 — temperature of the inorganic bonded back surface. The points τ_1 and τ_2 according to Fig. 3

When using dead pine wood wool (Fig. 6), the heat transfer process is increased to 1,200 s for the inorganic binder and more than 1,450 s for the organic-mineral binder. It is found that the mechanisms of the thermal insulation process in the energy transfer through the material lie in the formation of air barriers, which makes it possible to influence this process. They are to reduce the porosity of the material. Thus, with a derease in the material density, thermal conductivity and transfer decrease, and vice versa.

According to the measured temperature, the thermophysical characteristics of dead pine wood products were estimated by the obtained dependences (12), (16)–(18) (Table 1).

The studies showed that the sample of the dead pine wood thermal insulation product exhibits thermophysical properties, namely, thermal conductivity and thermal diffusivity (Table 1), which approximate those of ordinary wood [17] (λ=0.116 W/(m·K), a=1.5·10^{-7} m^2/s). Bonding of it did not significantly affect the heat transfer and is within the same limits. Instead, for wood wool, due to the formed air pores, the value of thermal conductivity decreases 1.5÷2.2 times, thermal diffusivity 2 times, and heat capacity increases 4 times.

Estimation of the obtained thermal conductivity of the dead pine wood building structure was carried out under DBN V.2.6-31 according to the climatic conditions of Kyiv [14]. For the thermal calculation, the fragment of the wall structure based on a wooden frame with thermal insulation based on wood wool blocks with a wooden board on both sides (Fig. 7) was chosen.

As a typical fragment, a 6.5×2.5 m (height×width) ordinary wall frame panel, which is horizontally and vertically adjacent to similar wall panels is considered. The wall panel has a 1.5×1.6 m window opening. It is necessary to determine the minimum permissible thickness of the insulation layer to meet the regulatory requirements of DBN V.2.6-31.

According to DBN V.2.6-31, the minimum permissible value of the reduced thermal resistance for opaque parts of external walls in the I-th temperature zone of operation of Ukraine (Kyiv) is $R_{q\min}$=3.3 m^2 K/W.

Table 1

Thermophysical characteristics of dead pine wood products

Material	Thickness, mm	Weight, g	Estimated characteristics of wood products				
			Density ρ, kg/m^3	Thermal effusivity, W·s$^{1/2}$/(m^2·K)	Thermal diffusivity, m^2/s	Thermal conductivity λ, W/(m·K)	Heat capacity, kJ/(kg·K)
Dead pine wood 150×150×4 mm	17.5	231	423.2	340.3	$0.17\cdot10^{-6}$	0.132	2.4
Organic-mineral bonded	19.5	223	488	331.2	$0.16\cdot10^{-6}$	0.121	1.5
Inorganic bonded	19.3	212	485	305.9	$0.18\cdot10^{-6}$	0.129	1.7
inorganic bonded wood wool	19	146	341.7	337.5	$0.078\cdot10^{-6}$	0.094	3.6
organic-mineral bonded wood wool	20	82.6	183	326	$0.06\cdot10^{-6}$	0.079	7.29

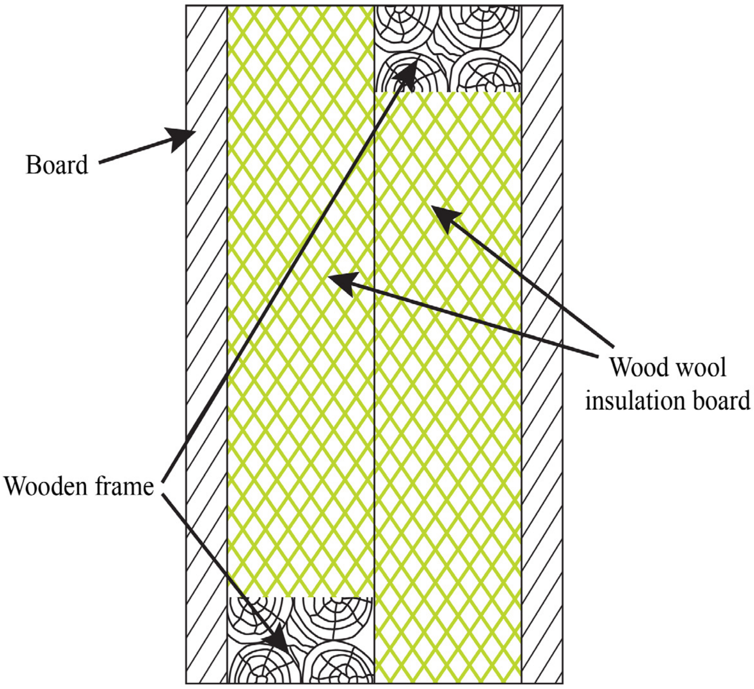

Fig. 7. Fragment of the wall structure made of dead pine wood products

In the first stage, the thermal resistance of the outer walls was determined with the following characteristics of the wall structure layers:

– δ_2=0.02 m, λ_2=0.132 W/(m·K) – characteristics of the pine board [15];

– δ_3=0.3 m, λ_3=0.079 W/(m·K) – characteristics of the organic-mineral bonded wood wool thermal insulation board (Table 1).

Then the thermal resistance of the outer walls is 4.295 m^2·K/W.

In the second stage, the characteristic areas and types of thermal conduction inclusions were determined. On the considered fragment. there are the following thermal conduction inclusions relating to the opaque enclosure structure (DBN V.2.6-31):

– window jambs in the area of window header, window sill, lintel course – linear elements;

– guiding wooden bars and lath – linear elements.

As a result, the value of the reduced thermal resistance of the outer walls was determined, which is 3.316 m^2·K/W and meets the regulatory requirements of DBN V.2.6-31.

Estimation of the reduced thermal resistance of the outer walls when using 300 mm organic-mineral bonded dead pine wood panels is 2.65 K/W. This does not meet the DBN V.2.6-31 requirements and needs recalculation with a greater thickness of insulating material.

Thus, the minimum required thickness of the wall insulation on the basis of the wooden frame of organic-mineral bonded wood wool insulation boards is 300 mm.

7. Discussion of results of determining the thermal conductivity of thermal insulation wood materials

Wood and fiber materials are used for the rooms where the appearance of thermal insulation materials is subject to increased requirements. Raw materials for their production are wood fibers made in the form of flat slabs (ceiling or wall panels) or curvilinear and volumetric elements.

Thermal conduction is the process of heat energy transfer from heated room areas to less warm ones, and energy exchange will take place until the temperature is balanced. Thermal conductivity of some building materials depends on many factors: nature of material, structure, porosity, nature of pores, humidity and average heat transfer temperature. Fine-porous materials have lower thermal conductivity than large-porous ones. This is due to the fact that in large and connected pores there is a movement of air, accompanied by heat transfer. Thermal conductivity of homogeneous material depends on density (Table 1). Thus, as density decreases, thermal conductivity decreases and vice versa. In addition, building insulation materials and wood products must meet the following requirements: stable thermal insulation performance throughout the service life, fire resistance and environmental friendliness. This is consistent with the data reported in [6, 7], where the authors also relate the effectiveness of thermal insulation materials of organic raw materials and their thermal protection.

In contrast to the results of the authors' studies [8, 11], the obtained data on the influence of structure on the heat transfer process and changes in insulating properties allow us to state the following:

– the main regulator of the process is density and porosity of the material, as high density and low porosity lead to rapid temperature balancing, and with increased humidity and dampness of walls, their transmission rate will be higher;

– significant influence on the thermal conduction process when using wood material is in the direction of orientation of natural material.

The results of identifying the thermal conduction process of the material based on wood wool and inorganic and organic-mineral binder and related to the formation of the thermal insulation layer (Table 1) indicate its ambiguous effect on the binder efficiency. Such uncertainty cannot be resolved within the framework of the present study, since additional experiments would be required to obtain more reliable data. In particular, this implies the availability of data sufficient for effective heat transfer process and identification of the starting point of heat resistance fall. Such identification will allow investigating surface transformation of the organic-mineral bonded wood wool material, which moves towards high temperature with increasing transfer time. This will also allow identifying those variables that significantly affect the beginning of transformation of this process.

This work is a continuation of the research presented in [14], which fully describes the mechanism of fire protection of organic natural materials, movement and insulation of high temperature.

8. Conclusions

1. Modeling of the heat transfer process in the swelling of the fireproof coating is carried out, temperature dependences of thermophysical coefficients are determined. Based on the obtained dependences, thermal conductivity for dead pine wood products, reaching 0.132 W/(m·K), is calculated. In case of adhesive bonding of wood products, thermal conductivity decreases to 0.121 W/(m·K), and when creating insulating boards it decreases to 0.079 W/(m·K), respectively.

2. Features of inhibition of the process of heat transfer to the adhesive bonded wood wool material are associated with the formation of pores. This is because in small pores there is no movement of air accompanied by heat transfer. Thermal conductivity of homogeneous material depends on density. Thus, with a decrease in density to 183 kg/m^3, thermal conductivity decreases 1.67 times, and vice versa, when using the board, thermal conductivity decreases only 1.1 times.

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