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ESTABLISHING PATTERNS IN REDUCING FIRE-DANGEROUS PROPERTIES OF SIP PANELS FIRE-PROTECTED WITH REACTIVE COATING

An issue related to using SIP panels for building structures is to ensure their stability and durability during operation in wide ranges. Therefore, the object of research was the change in the properties of wood-polymer material in case of fire and its protection when applied with a reactive coating capable of forming a pinocoke layer under the influence of high temperature on the coating. It has been proven that in the process of thermal action on the fire-resistant coating, the heat insulation process of SIP panels involves the formation of soot-like products on the surface of the material. Thus, under the action of the radiation panel on the surface of the OSB sample, after 120 s of thermal exposure, the process of intensive formation of a layer of foam coke, which thermally insulated the wood-polymer material, began; instead, after the radiation panel was exposed to the fire-resistant polystyrene foam sample, the process of destruction began at a temperature of about 100 °C polystyrene foam. When determining the flammability of a fire-resistant SIP panel, it was established that the temperature of the flue gases during the tests was no more than 110 °C, the length of the damaged sample did not exceed 460 mm. At the same time, the mass loss did not exceed 200 g, and independent combustion of the SIP panel sample did not occur despite the high temperature. According to these data, the SIP panel, fire-resistant with a reaction coating, belongs to group G1 (low flammability) and is a non-flammable material. The practical significance is that the results were taken into account during the design of buildings from SIP panels. So, there are reasons to assert the possibility of targeted regulation of the fire protection processes of SIP panels through the use of reactive coatings capable of forming a protective layer on the surface of the material that inhibits the rate of heat transfer

Keywords: fire retardants, structures from SIP panels, thermal destruction of the surface, fire protection of SIP panels, swelling of the coating

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1. Introduction

The construction of frame houses is gaining immense popularity throughout the world market. The basis of such houses is a SIP-panel, consisting of OSB plates (orientated chipboard) and insulation, which is polystyrene foam. Among the positive characteristics of frame houses, high speed of construction, cost-effective maintenance, and energy efficiency can be highlighted. But there are also negative features of frame houses, in particular, the risks of wood rot, insufficient noise insulation, and the use of combustible materials.

The SIP panel structure consists of three layers: OSB board – insulation (polystyrene foam) – OSB board. Special adhesive mixtures are used to connect the layers together. Gluing takes place under pressure, which helps increase the strength of the structure. However, the fire safety of such materials is at an inadequate level. The insulation is made of petroleum products, which predetermines high heat transfer rates during combustion. As a result, the ignition quickly spreads over the entire area of the building, destroying it beyond the possibility of reconstruction. In addition, in the process of thermal decomposition, polystyrene foam emits formaldehydes and carbon monoxide, which are toxic to humans and can be fatal if inhaled even within a few minutes.

One of the methods of increasing the level of fire safety of objects where building structures made of SIP panels are used is their fire-resistant treatment with special coatings.

And because liquid glass-based fire retardants do not provide sufficient adhesive strength with the building structure during fluctuating temperature and humidity fields, they fall off, which reduces the fire-retardant efficiency. The use of environmentally safe substances based on reactive coatings requires conducting fundamental studies on the effect of high temperature on the resistance of a SIP panel to destruction.

Therefore, it is a relevant task to carry out studies on determining fire-resistant properties during fire protection of SIP panels with a reactive coating and establishing the number of coating components to inhibit the burning process.

2. Literature review and problem statement

In [1], it is stated that the sandwich panel with active protection using expandable graphite (EG) was developed to prevent the release of hazardous gases during fires in sandwich panel buildings by using the excellent thermal performance. Under the influence of heat, EG expands and forms a barrier, effectively preventing the spread of fire and blocking the emission of harmful gases generated by the insulating material. Fire resistance tests have shown that EG sandwich panels exhibit significantly lower peak and total heat generation, as well as reduced smoke generation, and have confirmed their lower toxicity. A cone calorimeter test showed that sandwich panels with EG showed a significant 67.1 % reduction in peak heat release rate (HRR) and 51 % reduction in total heat release compared to panels without EG (PF). In addition, overall smoke production was reduced by an impressive 94 %. This study confirms the effectiveness of EG in improving fire resistance and reducing harmful gas emissions in sandwich panels. In addition, the analyzed effect of EG on increasing fire resistance indicators is important using the method of fractional effective dose analysis, which evaluates the respiratory resistance of humans to combustion byproducts. However, the definition of optimal solutions regarding its concentration has not been established.

Paper [2] reports the results of an experimental comparative analysis of the fire resistance behavior of two sandwich panels with a structural function, consisting of a core of polyisocyanurate foam (PIR) and a fabric reinforced with glass fiber, dimensions 3150×2800×150 mm. The first panel system was covered with gypsum boards on its fire side and the other system with ceramic boards. The parameters to be compared for both systems were structural stability, tightness, and thermal insulation. To do this, a fire resistance test was conducted, evaluating the behavior of each of the samples exposed to fire for comparison with each other. According to the results obtained in this study, the materials used to form the sandwich panel structure and the coating material affect the parameter results and fire resistance. Thus, in this study, the plasterboard coating system showed better performance in terms of the evaluated parameters and a longer fire resistance time than the ceramic coating system, testing the thermal insulation and fireproofing qualities of the plaster. However, it is not said how these materials affect the environment.

Paper [3] describes an experimental study on the fire resistance of composite floor sandwich panels made of glass fiber reinforced polymer (GFRP) surfaces and a polyurethane foam core subjected to a standard fire and mechanical loading scenario. Three full-scale sandwich specimens were tested: an unprotected specimen and two specimens protected by calcium silicate (CS) plates attached to or suspended from the underside of the panel to form an air cavity. The study looked at the thermal and mechanical response of the panels, including the evolution of:

I) temperature distribution;

II) deflections and deformations;

III) types of destruction;

IV) time to destruction, as well as the influence of fire protection systems in these reactions.

The results confirm the susceptibility of composite sandwich panels to fire: the unprotected panel failed after only ~25 minutes through a failure mode that included different damage mechanisms, such as rupture of the bottom surface glass fibers, complete core degradation, and top surface buckling. On the other hand, with the protection of CS boards, due to the thermal insulation provided by the sandwich panels, the fire resistance was significantly increased to ~80 min (adhesive) and ~100 min (air cavity). These tests also provide new insight into the thermomechanical behavior of composite sandwich panels during fire, indicating a gradual change in their structural system, from a beam system to an arch system and finally to a simple laminate (top face sheet) in bending. But it is not said how it affects the durability during operation.

In [4], it is shown that structural analysis using the finite element method, including temperature analysis and structural analysis, is important for the study of the stabilization effect. However, data on the thermal insulation layer of sandwich panels and intumescent paint for fire protection of steel sections is still scarce. This document summarizes the available thermal properties of these materials from the literature. 2D and 3D temperature analyzes were performed for steel sections with steel cladding, such as sandwich panels with mineral wool and polyisocyanurate (PIR) cores and trapezoidal sheets with mineral wool insulation. The results of the analysis were compared with the results of fire resistance tests conducted in the European research project STABFI (Stabilization of Steel Structures by Steel Claddings in Fire). The study demonstrates sufficient accuracy of modeling using existing data on thermal insulation properties of materials that depend on temperature. It also demonstrates the accuracy of thermal data for intumescent paint, specifically for an intumescent (IC) steel beam with mineral wool sandwich panel and trapezoidal sheet covering. A greater discrepancy between the finite element (FE) prediction and the test measurements was observed in the case of the PIR core sandwich cladding. Areas for further research are identified. The study also shows the heat dissipation effect of steel sections of sandwich panels with a mineral wool core. Therefore, it is recommended to include sandwich panels in the thermal analysis model for sandwich-clad steel sections.

In study [5], fire-resistant sandwich panels were invented with a lower density without compromising the fire-resistant characteristics. Three fire-resistant sandwich panels of different thicknesses were produced during two hours of fire-resistant tests. The fire-resistant sandwich panels were manufactured using an appropriate proportion of vermiculite mixture and reinforced with an intumescent binder using a molding technique. The temperature profiles of the fire-resistant panels were recorded, plotted, and analyzed. Fire-resistant sandwich panels with optimal results were determined by density, fire resistance, heat transfer rate, bond strength and bending strength. Fire-resistant *Z* sandwich panels scored best overall. The *Z* fire panel reached a maximum temperature of only 83.2 °C in the Bunsen burner test, indicating higher fire resistance with a lower heat transfer rate. Panel *Z* has the highest flexural strength and better fire resistance, and the lowest density at 578.98 kg/m^3. This study showed that the composition of the fire-resistant sandwich panel was a key factor in manipulating the density and fire resistance but did not say about the effect on the ecosystem.

The fire resistance of lightweight carbon fiber/epoxy sandwich panels (SW) with a poly(methacrylimide) (PMI) foam core is investigated in compression under direct application of a high flame (heat flux=200 kW·m^{-2}) [6]. A bench-scale test procedure was used, in which the sample was held vertically. The epoxy decomposition temperature was quickly exceeded with rapid flash and gradual softening and decomposition of the core. The failure mode changes depending on whether the load is greater or less than 50 % of the undetected load, or, in other words, one or two shells are carrying the load. At high loads, the failure involved both shells with a single clear linear separation on each surface. There is an inflection in the fracture time ratio in the ~50 % load region, which corresponds to the time required for heat transfer to the rear surface, along with a change in the failure mode of the rear shell from separation to plastic hinge formation. The integrity of the carbon front surface, even if the resin has burned out, and the low thermal conductivity of the core play a key role in extending the integrity of the back surface, something to keep in mind when designing a future panel. Swelling coatings prolong the period before destruction. The ratio of time to failure with and without protection is proposed as a measure of their effectiveness. However, for insulating properties, their adhesion and resistance under the strong influence of fire play a key role.

Paper [7] deals with sandwich panels with structural, sound, fire, and thermal insulation properties, made of a foamed gypsum core with an open and closed cellular structure and facing of increased strength on both sides from ordinary plasterboard. Gypsum is used as a fire and acoustic material with excellent fire protection because it dehydrates at temperatures around 100 °C, absorbing energy and acting as a thermal barrier. This study shows that combining the desirable properties of gypsum as a high-density composition and a low-density composition can improve the material's overall properties and application diversity. It has been found that a thinner and lighter gypsum composite sandwich panel can resist fire longer than rigid gypsum board with a complex structure. However, it is not said about the conditions of operation of these products.

In study [8], the mass loss and flammability limits of different sandwich panels and their cores (polyurethane (PUR), polyisocyanurate (PIR) and rock wool) are studied separately using a specially designed furnace. Polystyrene foam and extruded polystyrene are tested only on their core. Studies have shown that the actual mass loss of synthetic and rock wool cores is comparable up to 300 °C. From 300 °C, the mass loss of PUR panels is significantly higher. The mass losses up to 350 °C are 7 %, 29 %, and 83 % for rock wool, PIR, and PUR respectively for the affected zone. In addition, delamination can be observed when exposed to temperatures above 250 °C for synthetic and 350 °C for mineral wool panels. Peeling occurs due to resin degradation between the core and metal panels and gasification (PUR) of the core. The lower limits of flammability were set experimentally at the level of 9.2 % m/m (PUR) and 3.1 % m/m (PS). An upper limit of 74 % was set for PUR. However, it was not possible to establish flammability limits for PIR and mineral wool.

The purpose of paper [9] is to evaluate and analyze the fire resistance of two SIP-panels for walls consisting of a core of expanded polystyrene (EPS) with dimensions of 3150×3000 mm. One is covered with cement board and the other is covered with plasterboard, both finished with intumescent paint. The samples were subjected to a fire curve based on the ISO 834-2014 standard and then analyzed and compared with each other. The results indicate that the use of plasterboard provides a 45-minute increase in the fire resistance limit compared to a system containing only cement board. In addition, the application of intumescent coatings has been found to be effective in providing better fire protection to SIPs. However, the values of these parameters do not cover a wide range of applications.

In work [10] it is said that SIPS are formed by laminating two facing plates from oriented strand board (OSB) and highly insulating foam based on a polymer, such as expanded polystyrene (EPS) or polyurethane (PUR). The resulting lightweight panels are commonly used as primary compression load-bearing members for buildings such as residential buildings, schools, and hotels. The normative fire resistance of SIPS, like many systems, is evaluated using a standard fire resistance test. However, it is generally accepted that this is only a comparative method to determine the relative effectiveness of one product compared to another; therefore, it gives little indication of the likely behavior of the components in a real fire. The research program exposed four two-story SIP buildings to natural fire scenarios using wood structures. Two buildings were constructed using SIPS core with EPS. The other two were made from a SIPS polyurethane core. Each set of materials was divided into a passive fire protection (PFP) specification. They were determined on the basis of 30 and 60-minute fire resistance. Experiments revealed a number of weak points in the performance of the SIP system of structures with engineered floors. First, where the PFP is out of specification or poorly installed, failure of the engineered floor slab is very likely. Mechanisms of fire propagation were also discovered, where the fastening parts were not properly sealed. In addition, there was little noticeable difference in the behavior of buildings formed with EPS or PUR Core SIPS. Finally, a number of system reserves and alternative load paths were identified that prevented the complete collapse of any of the test buildings. But it is not said about the cost of production.

Thus, it has been established from literary sources that fire-resistant coatings are able to protect the surface of SIP panels from the influence of fire during operation. But the parameters that ensure the resistance of the component panels to the action of high temperature, the values of which are necessary for design and manufacture, are not defined. The paucity of experimental studies to explain and describe the fire protection process of SIP panels leads to a decrease in their effective use. Therefore, establishing the parameters of fire protection of structures made of SIP panels and the effect of coatings on the process of thermal destruction predetermined the need to conduct research in this area.

3. The aim and objectives of the study

The purpose of our work is to establish the regularities of the formation of a fire-resistant coating on the surface of a SIP panel. This makes it possible to substantiate directions for expanding the scope of SIP panels in frame and modular home construction.

To achieve the goal, it was necessary to solve the following tasks:

– to establish inhibition of thermal destruction of SIP-panel components with a fire-resistant coating;

– to establish the features of reducing the degree of burnout of a fire-resistant SIP-panel sample during thermal action.

4. The study materials and methods

4. 1. The object and hypothesis of the study

The object of the study is the heat-insulating properties of the pinocoke layer formed during the thermal action on the reactive coating.

The scientific hypothesis assumes reducing the indicators of thermal destruction of the SIP panel during fire protection with a reactive coating.

In the course of the research, the following assumptions and simplifications were adopted, which relate to the peculiarities of the flow of heat exchange and other processes at the modeling object:

– those that determine the impact of changes in external conditions on the object of research and the lack of interconnection between process implementations, namely: the heat exchange processes in the SIP panel are the same, temperature, humidity, and pressure are not variable;

– a sample of OSB and expanded polystyrene is homogeneous.

4. 2. Researched materials used in the experiment

To determine the thermal stability of the fire-resistant components of SIP panels, OSB-3 samples were used, produced by Kronospan (Ukraine), size 320x140 mm, thickness 10 mm, density 620...670 kg/m^3, and polystyrene foam samples of the Polynor brand, produced by "Insola" (Lithuania), density 15 kg/m^3, size 320×140 mm, thickness 50 mm. A fire-retardant coating was applied to the surface of the samples ("FIREWALL-WOOD", Ukraine) with a consumption of about 330 g/m^2.

To establish indicators of the flammability group, samples of SIP panels made of OSB and expanded polystyrene were used, with a density of 25 kg/m^3, an average thickness of 55 mm, in accordance with the test methods and in accordance with their quantity. The size of the test samples was 1000×190 mm, the total thickness was 70 mm. The front side and side surfaces of the polyurethane foam were covered with an OSB plate, 10 mm thick. The back side of the polyurethane foam samples was not covered with an OSB plate. Three layers of fire retardant (reactive paint) for wooden structures ("FIREWALL-WOOD", Ukraine) were applied to all surfaces lined with OSB, as well as to the reverse side of polyurethane foam not lined with OSB, with a consumption of approximate 360 g/m^2. The thickness value is taken as the maximum thickness in accordance with the relevant requirements [11]. The appearance of the samples is shown in Fig. 1.

Fig. 1. The appearance of SIP-panel samples, during the application of "FIREWALL-WOOD" fire retardant on the surface of the OSB plate

After drying to a constant mass, fire-resistant SIP-panel samples were tested for thermal destruction.

4. 2. Methodology for determining the fire protection indicators of SIP panels with reaction coating

Research on determining the thermal stability of fire-resistant SIP-panel components was carried out according to the procedure, the essence of which was the effect on a sample of fire-resistant OSB and expanded polystyrene of the radiation panel and its ignition [12]. At the same time, the maximum temperature of the combustion products and the time to reach it, the time of ignition and passage of the flame front of the surface areas, the length of the burned part of the sample, and the value of the dimensionless flammability index are calculated. The destruction of the sample is visually assessed.

The requirements for the flammability of the coated SIP panel and its classification were carried out according to [13]. Evaluation of wood treated with a coating was carried out based on the results of thermal action of high temperature on a wood sample [14].

The method for determining flammability involves evaluating the samples after thermal action according to the following parameters: flue gas temperature, degree of damage by length, degree of damage by mass, duration of self-burning [15]. Depending on the values of the flammability parameters, building materials are divided into four flammability groups G1, G2, G3, G4 in accordance with Table 1. If different flammability values are obtained during the tests, they are assigned to the lower value.

Table 1

Classification of combustible building materials

Flammability group of materials	Flammability parameters			
	Flue gas temperature, °C	Degree of damage by length, %	Degree of damage by mass, %	Duration of self-combustion, s
G1	<135	<65	<20	0
G2	<235	<85	<50	<30
G3	<250	>85	<80	<60
G4	>250	>85	>80	>60

Materials must be assigned to a certain group of flammability, provided that all the values of the parameters specified in Table are relevant.

5. Results of determining the resistance to destruction of SIP panels with a fire-resistant reaction coating under thermal influence

5. 1. Inhibition of thermal destruction of SIP-panel components with a fire-resistant coating

In order to establish the thermal resistance of ta SIP panel, studies were conducted to determine the flammability index and the maximum temperature of the outgoing gases from the installation. The results of the research are shown in Fig. 2, 3, and given in Table 2.

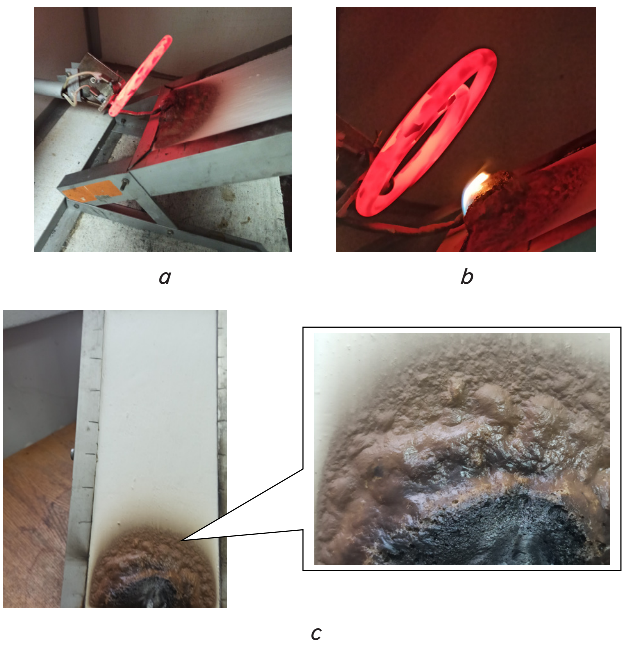

Fig. 2. Results of studying the ignition process and the spread of flame on a fire-resistant OSB-3 sample: *a* – the effect of the flame on the sample; *b* – swelling of the coating; *c* – a protective layer of pinocoke

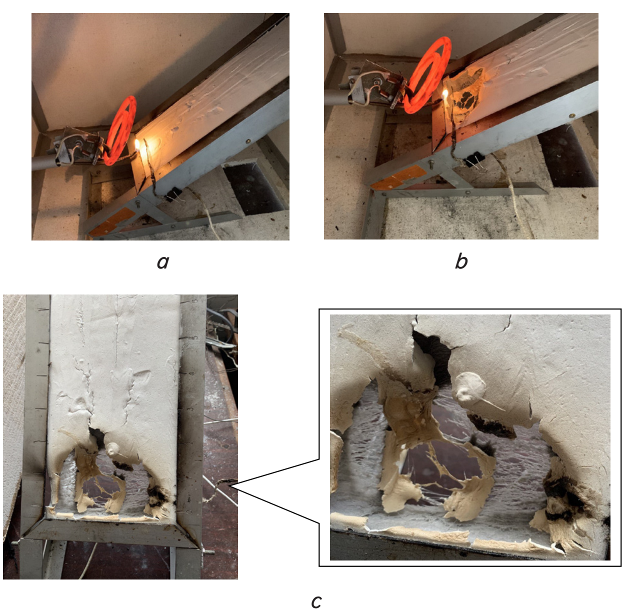

Fig. 3. Results of studying the ignition process and the spread of flame on a fire-resistant sample: *a* – effect of the flame on the sample; *b* – beginning of the destruction of polystyrene; *c* – result of the destruction of polystyrene foam

Table 2

Time for the flame front to pass the control points

Flame retardant specimen	Flue gas temperature, °C		Ignition time, s	Time of passage of the flame front of the sample sections, s									Time to reach flue gas T_{max}, s	Fracture length of the sample, mm	Flammability index
	T_1	T_{max}		1	2	3	4	5	6	7	8	9			
OSB	66.9	105	–	–	–	–	–	–	–	–	–	–	600	0	0
Polystyrene foam	68.2	107	–	–	–	–	–	–	–	–	–	–	600	80	0

Studies have shown that when a radiation panel acts on a fire-resistant OSB sample, after 120 seconds of thermal exposure, the process of intensive formation of a layer of pinocoke, which thermally insulated the wood-polymer material, began. On the other hand, after exposure of the radiation panel to the fire-resistant polystyrene foam sample, at a temperature of about 100 °C, the process of its destruction began, but ignition and flame spread did not occur. The decomposition of expanded polystyrene is also confirmed by the data given in [16].

5. 2. Features of reducing the degree of burnout of a fire-resistant SIP panel sample during thermal action

The results of research on the experimental determination of the flammability group of fire-resistant wood are shown in Fig. 4, 5, and given in Table 3.

Fig. 4. Samples of sip panels during flammability tests

Fig. 4, 5 demonstrate that a temperature was generated on the surface of the sample, which significantly exceeded the temperature of destruction of polystyrene foam, but the destruction of the SIP panel structure was not established.

Thus, it was established (Table 3) that during the determination of the flammability of SIP panels with a fire-resistant reaction coating, the temperature of the flue gases during the tests was no more than 110 °C. At the same time, the damaged length of the sample did not exceed 460 mm, the loss of mass did not exceed 200 g, and independent combustion of the SIP panel did not occur. According to the fire classification of building materials, fire-resistant SIP-panel samples belong to group G1 (low flammability).

a *b*

Fig. 5. SIP panel samples during flammability tests:
a – before tests; *b* – after thermal action

Table 3

Results of studies on determining the flammability group of a fire-resistant SIP panel

Parameter	Sample No.											
	1	2	3	4	5	6	7	8	9	10	11	12
T_i, °C	20	18	19	21	22	23	22	24	24	23	24	22
T, °C	108	103	106	102	107	106	104	103	108	105	110	101
Average value T, °C	104.80				105.00				106.00			
L, mm	442	431	447	439	432	446	438	435	450	438	454	423
ΔL_a, mm	439.80				437.80				441.30			
S_L, %	44.00				43.80				44.10			
m_1, g	3,368	3,374	3,380	3,362	3,370	3,364	3,388	3,372	3,360	3,382	3,376	3,384
m_2, g	3,172	3,184	3,188	3,170	3,184	3,170	3,192	3,186	3,168	3,186	3,174	3,186
Δm_a, g	192.50				190.50				196.00			
S_m, %	5.70				5.60				5.8			
τ, s	0				0				0			

Note: T_i – initial temperature; T – flue gas temperature; L – damage length of samples; ΔL_a – the average value of damage to the samples along the length; S_L – degree of damage to the samples along the length; m_1 – mass of samples before testing; m_2 – mass of samples after tests; Δm_a – the average value of sample damage by mass; S_m – the degree of damage to the samples by mass; τ is the duration of self-burning of the samples

6. Discussion of results of investigating the flammability process of SIP panels protected by a reaction coating

When studying the process of fire protection with a reaction coating, the process of inhibiting the transfer of high temperature to polystyrene foam through OSB is natural, which follows from our results (Fig. 4, 5, Table 3). This is due to the formation of a swollen layer of coke on the OSB surface during the decomposition of the coating under the action of the flame, which slows down the heat transfer processes.

It should be noted that the presence of a reaction coating leads to the formation of an elastic film on the surface of the SIP panel, which is resistant to vibrations under normal conditions. Obviously, this mechanism of operation of this coating is the factor of regulation of the process, due to which the fire resistance of the SIP panel is preserved. In this sense, there is an interpretation of the results of determining the flammability of the SIP panel after exposure to flame, namely the formation of a heat-insulating layer of pinocoke under thermal exposure. The temperature of flue gases during the tests was no more than 110 °C, the length of damage to the sample did not exceed 460 mm, the loss of mass did not exceed 200 g, and spontaneous combustion of wood did not occur. This indicates the formation of a barrier on the surface of the material for temperature, which can be identified by the method of thermal impact on the studied samples.

This means that there is an opportunity for effective regulation of the properties of wood-polymer structures directly under the conditions of industrial wood processing at objects of various purposes.

A comparison of experimental studies of the formation of a pinocoke layer during the fire protection of SIP panels and studies of fire-hazardous properties indicates that the processes of high temperature transfer to the material are inhibited. At the same time, the temperature of the flue gases during the tests was no more than 110 °C, and the formed layer of pinocoke was more than 20 mm (Fig. 5). This does not differ from practical data, well known from works [4, 7], the authors of which also associate the effectiveness of fire protection with the formation of a layer of pinocoke during the decomposition of the coating under the influence of the burner flame. But, in contrast to the results of research reported in [17, 18], our data on the effect of the swelling coating on the process of retarding the transfer of temperature allow us to state the following:

– the main regulator of the process is not so much the formation of a significant amount of gases that are released during the decomposition of the coating and inhibit the flame but the suppression of combustion since individual fire-resistant coatings emit water vapor under the influence of high temperature;

– a significant influence on the process of fire protection of SIP panels when applying a fire-resistant reaction coating is carried out in the direction of the formation of a pinocoke layer on the surface of the material.

Such conclusions can be considered expedient from a practical point of view because they allow a reasonable approach to the fire protection of SIP panels with reaction coating, when expanded polystyrene is hidden behind OSB [19, 20]. From a theoretical point of view, they allow us to assert the determination of the process mechanism of both temperature inhibition and the formation of a layer of pinocoke, which are certain advantages of this study. However, it is impossible not to note that the results of the determination (Tables 2, 3) indicate an ambiguous influence of fire protection efficiency on the change of fire hazard properties. This is manifested, first of all, in the temperature that is formed on the surface of the sample during tests.

Such uncertainty imposes certain restrictions on the use of our results, which can be interpreted as the shortcomings of this study. The impossibility of removing the mentioned limitations within the framework of this study gives rise to potentially interesting areas of further research. They, in particular, can be focused on detecting the moment of time when the fall in fire-retardant properties and thermal destruction of SIP-panel materials under the influence of high temperature begins. This will make it possible to investigate the structural transformations of the coating, which begin to occur at this time, and to determine the input variable parameters of the process that significantly affect the beginning of such a transformation.

7. Conclusions

1. According to experimental data, it was established that when a radiation panel acted on a fire-resistant OSB sample, after 120 seconds of thermal exposure, the process of intensive formation of a pinocoke layer began, which thermally insulated the wood-polymer material. On the other hand, after exposure of the radiation panel to a fire-resistant sample of polystyrene foam at a temperature of about 100 °C, the process of destruction of polystyrene foam began and its significant destruction in the place of thermal action.

2. During the determination of the flammability of the fire-resistant SIP panel, it was established that the temperature of the flue gases during the tests was no more than 110 °C, the length of the damaged sample did not exceed 460 mm, the loss of mass did not exceed 200 g, and the spontaneous combustion of wood did not occur. According to these data, the SIP panel, fire-resistant with a reaction coating, belongs to group G1 (low flammability) and is a non-flammable material.

Conflicts of interest

The authors declare that they have no conflicts of interest in relation to the current study, including financial, personal, authorship, or any other, that could affect the study and the results reported in this paper.

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Data availability

All data are available in the main text of the manuscript.

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Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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