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Research of the Efficiency of the Fire Fighting Roof Composition for Cane

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Abstract. Results of experimental researches about affectivity of firebiopotection products made from cane. Due to the unique properties of the cane, such as small volume weight, low thermal conductivity, rather high atmospheric resistance, high chemical resistance, the possibility of manufacturing parts at the site, efficiency, etc., cane products, despite the high pace of new technologies, are widely used in construction. Using cane in construction has a significant number of advantages, but needs protection from fire, from it produce a variety of products, equip the buildings. The unresolved issue of fire protection of products from such materials reduces the possibility of their use in construction. The experimental research on the determination of the fire-safety properties of the cane set the ignition of the raw sample, while for fire-proof - the process of ignition and propagation of the flame did not occur. Especially inhibition of the process of ignition and propagation of cane fire treated with a covering impregnation solution, which consist of fire retardants under the influence of temperature with the absorption of heat and the release of non-combustible gases (nitrogen, carbon dioxide), change in the direction of the expansion in the direction of formation of non-combustible gases and heavy-duty coke residue, reducing the combustion of the material and, accordingly, the index of flammability. This indicates the possibility of directed control of the processes of transfer of high temperature to organic material by using special covering compositions for cane products.

Introduction

In construction, the search for new high-performance building materials, in particular from natural raw materials, like cane, is increasingly being explored. Due to the unique properties of the cane, such as small volume weight, low thermal conductivity, rather high atmospheric resistance, high chemical resistance, the possibility of manufacturing parts at the site, efficiency, etc., cane products, despite the high pace of new technologies, are widely used in construction. The use of a cane in construction has a significant number of advantages, but needs protection from fire. At the same time, despite its light flammability and flammability, cane is now widely used in Ukraine as decorative material. From it produce a variety of products, equip the premises. The unresolved issue of fire protection of products from such materials reduces the possibility of their use in construction. Resonant facts of fires at objects with a massive presence of people (restaurants, cafes, etc.) indicate the relevance of fire protection of cane and products from it.

Therefore, for the purpose of providing fire safety at construction sites and protection against fires that may arise through the use of a cane, state building codes have been put into effect, according to which building materials are classified according to the following indicators of fire risk: flammability, flammability, flame spreading and others.

Analysis of Recent Research and Publications

Today, there are two ways of fire protection of building materials. The first one is the impregnation with antipyrene, most often on the basis of inorganic salts [1-3]. When moisturizing building materials, the fire retardants dissolve in a humid environment and are gradually washed to the surface, and then over time, the fire-retardant effect is reduced. However, the reed is characterized by a high density and hydrophobicity, and impregnation is not delayed in the material and flows from the surface [4, 5]. The second one is the application of a coating on the surface of an organic or inorganic astringent. The agent on organic binder has increased smoke formation and the release of toxic substances, therefore its use is dangerous [6, 7]. The most effective are fire protection coatings on inorganic astringent, properties of which have already been investigated. But these materials form a rigid coating on the surface that changes the color of the surface and, under the action of the atmosphere, loses adhesion and sinks [8, 9].

The Purpose of this Work

The purpose of this work is to study the components of a roofing material for cane fire resistance, their optimization and the establishment of the fire protection of the treated product.

Materials and Methods of Research

To establish the fire-retardant effectiveness of the cane, samples of cane were used which were treated with a composition that forms a colorless film on the surface and is capable of creating a coke-based foam on the surface under the influence of a high foam, namely, a roofing impregnation solution based on a mixture of organic and inorganic substances (a mixture of urea and phosphoric acids and natural polymer in different proportions).

The resulting mass was stirred and applied as a reed (Fig. 1).

For the study of the effectiveness of the fire-retardant material, samples of reeds were used with average sizes up to 10 mm in diameter and 310 mm in height, which were bound to a size of 310x140 mm and treated with a roofing impregnation solution, with a flow rate of 47.1 g/m^2.

The research on the determination of the thermal stability of the fire-retarded cane was carried out according to a methodology, the essence of which was to influence the shape of a fire-retardant canopy of the radiation panel and its ignition, measuring the temperature of the combustion products and the time of its achievement, the time of ignition and passing the flame front of the surface of the parts, the length of the burned part of the sample.

Figure 1. Model samples of cane for testing.

But according to the received data the value of the dimensionless index of flammability is calculated by the coefficient *I*:

$$I = \sqrt{\frac{q \cdot Q}{W} \cdot \frac{\Delta T_{max}}{\Delta T_{но}} \cdot \frac{\tau_{max} - \tau_0}{\tau_0} \cdot \left[1 + \frac{60 \cdot l_г}{l} \cdot \sum_{i=1}^{n} \frac{1}{\tau_i}\right]}, \tag{1}$$

where q – specific heat of gas combustion propane (23630), kDg·l^{-1};

Q – gas flow rate of the inflammatory burner (0.001), $l \cdot s^{-1}$;
W – power of the electric radiation panel, 0,5 kW;
ΔT_{max} – maximum increase in the temperature of flue gases:

$$\Delta T_{max} = T_{max} – T_o,$$

where T_o – ambient temperature, °C;
T_{max} – maximum temperature of flue gases, ° C;
$\Delta T_{НО}$ – the maximum increase in the temperature of the heating equipment:

$$\Delta T_{НО} = T_1 – T_o,$$

where T_o – ambient temperature, °C;
T_1 – the temperature of the outlet during operation of the heating equipment, °C;
τ_o – time of ignition of the sample, s;
τ_{max} – time to reach the maximum temperature of flue gases, s;
τ_i – time of passage of the front of the flame of control sites, s;
l – sample length, mm;
$l_г$ – length of sample damage, mm.

In Fig. 2 shows a testing chamber for conducting research.

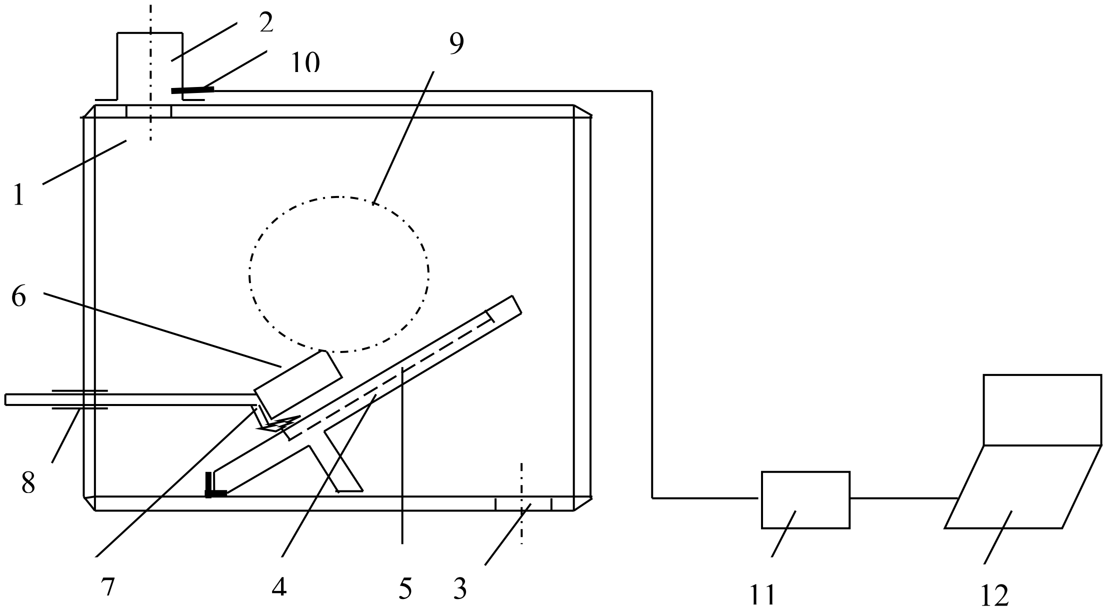


Figure 2. Test chamber for determining the parameters of ignition and propagation of the flame: 1 – test chamber; 2 – exhaust pipe; 3 – ventilation hole; 4 – sample holder; 5 – sample, 6 – radiation panel; 7 – ignition device; 8 – adjusting pipe; 9 – inspection glass; 10 – thermocouple; 11 – analog-digital converter; 12 – computer.

Determination of fire properties of products from a reed was carried out in accordance with DBN V.1.1-7 on the main indicators: flammability, flammability, the spread of flame surface.

Research Results

Studies have shown (Table 1) that the cane belongs to the combustible materials (after the action of the flame ignited), the impregnated sample of the reed withstood the temperature effect and refers to the heavy materials on the weight loss indicator. At the initial temperature of gaseous combustion products T = 76 ºC, under the influence of the radiation panel on the protected sample, the temperature of the gaseous combustion products was T≤120 ºC.

Table 1. Time passing the front of the flame control points.

Fireproof sample of cane	Tempera-ture of flue gases, °C		Time of ignition, s	Time of passage of the front of the flame of sample parts, s									Time to achieve maximum temperature of flue gases, s	Length of burning-in sample, mm	Index of flamma-bility
	T_1	T_{max}		1	2	3	4	5	6	7	8	9			
Rough/Raw	61	323	52	2	8	7	10	6	8	7	6	7	101	294	177,5
Roofing impregnation solution in the proportion of antipyreens to a polymer of 2 : 1	62	114	595	–	–	–	–	–	–	–	–	–	596	22	0,42

During the test of cane samples it was found that the raw sample took 52 s, the flame spread throughout the sample for 100 s instead, a sample of flame retardant, roofing impregnation solution, namely a mixture of urea and phosphoric acids and natural polymer in the amount of 47.1 g/m^2, it occupied 595 s, the spread of the flame surface occurred only on the first site, the maximum temperature of flue gases was 114 °C over time more than 5 times, and the index of flammability decreased to 0.42.

In order to determine the fire-resistant processed cane as a building material, a study of its flammability parameters at given levels of influence on the surface of samples of heat flame and flame from the source of ignition (Table 2, Fig. 3).

Table 2. Results of determination of flame retardant fire.

№ Sample number	The value of heat flux, which acts, for example, kW/m^2	Time span before ignition, s	Critical surface density of the heat flow, kW/m^2
1	30	105	30
2	20	Absent	
3	25	Absent	
4	25	absent	
5	25	Absent	
6	30	195	
7	30	169	

It has been established that during the action of a heat flux with a critical surface density of 25 kW/m^2, ignition of processed cane samples did not take place for 900 seconds, which classifies the material as moderately flammable (B2). Raw samples are classified with flammable materials (B3).

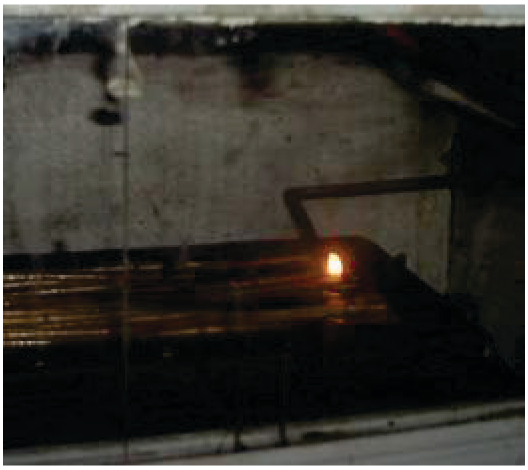
Figure 3. Appearance of cane beams treated with a protective composition after the influence of the heat flux during the determination of flammability.

Experimental researches have been conducted to determine the group of flame propagation by the surface of cane samples (Table 3, Fig. 4).

Table 3. Results of determination of the group of flame propagation by the surface of cane samples.

A sample of cane	The length of the damaged sample surface	Critical surface density of heat flow, kW/m2	Flame distribution group
Rough/Raw	1000	3,1	4
Flame-protected	318	7,8	2

a



b

Figure 4. Results of determining the flame rate of a cane sample: a – raw; b – flame retardant.

Thus it is determined that fire-retardant materials from the reeds belong to the group 2 (do not spread the flame), and unprocessed – to 4 (much extends the flame surface).

Conducted experimental researches to determine the group of flame propagation by the surface of the building structure (Table 4, Fig. 5).

Table 4. Results of researches to determine the fire resistance group of the cane.

Parameters	№ sample											
	1	2	3	4	5	6	7	8	9	10	11	12
Start temperature T, ºC	26	28	28	26	23	24	23	25	24	25	24	27
Temperature flue gases T, ºC	90	88	88	90	89	89	90	90	91	88	88	90
Average temperature value flue gases T, ºC	89,00				89,50				89,25			
Damage length samples L, mm	390				390				370			
Damage length samples L, mm	390	390	370	390	370	355	380	350	385	380	380	375
Average value of specimen damage in length ΔL_{cp}, mm	385,00				363,75				380,00			
The degree of specimen damage along the length S_L, %	35,00				33,00				34,54			
Mass of samples to test m_1 x 10^3, kg	2795	2970	2870	2860	2790	2945	2830	2630	2510	2800	2595	2870
Mass of samples after test m_2 x 10^3, kg	2610	2710	2695	2620	2600	2750	2630	2480	2350	2630	2445	2685
The average value of specimen damage by weight Δm_{cp} x 10^3, kg	215,00				183,75				166,25			
Level of damage to samples by weight S_m, %	1,87				1,64				1,54			
Uration of self-burning samples τ, s	–				–				–			

Figure 5. Results of determining the flammability of a fire retardant cane sample.

Experimental researches to determine the fire resistance group of the cane as a building material have been established:

1 – the temperature of flue gases (T) was 90 ºC;
2 – the degree of damaged samples in length (S_L) was up to 34%;
3 –the degree of damage to samples by weight (S_m) was up to 1.87%;
4 – the duration of self-burning (τ) was 0 s.

According to research results, fire retardant materials belong to combustible building materials of moderate flammability (G1), while raw materials are classified as building materials of high flammability (G4).

Conclusions and Perspectives of Further Research

The experimental research on the determination of the fire-safety properties of the cane set the ignition of the raw sample, while for fire-proof – the process of ignition and propagation of the flame did not occur. The braking of the combustion process and the propagation of flame for such a sample is due to the decomposition of fire retardants under the influence of temperature with the absorption of heat and the release of non-flammable gases (nitrogen, carbon dioxide), by changing the direction of the decomposition towards the formation of non-combustible gases and heavy-duty coke overshoot. This is mean that the possibility of a cane transition when the composition is treated to materials that are moderately flammable and flammable, which does not spread the flame surface.

Further research may be aimed at establishing the relationship between the components and properties of the coatings and their optimization.

References

[1] N.A. Tichino, Features of the practical application of fire and bioprotective agents for wood impregnation. Fire and explosion hazard of substances and materials, 6, (2002) 38-43.
[2] A.A. Leonovich, Chemical approach to the problem of reducing the fire hazard of wood materials. Fire and explosion hazard of substances and materials, 3, (1996) 10-14.
[3] O. Bondarenko, S. Guzii, E. Zacharchenko, Development protective materials based glass & slag containing portland compositions. Eastern-European Journal of Enterprise Technologies, 6/11 (78), (2015) 41-47. DOI: 10.15587/1729-4061.2015.56577.
[4] Yu. Tsapko, A. Tsapko, Modeling the heat conductivity process at the effect of the process on the field of fighted exchange. East European Journal Enterprise Technologies, 2/10 (92), (2018) 50-56. DOI: 10.15587/1729-4061.2018.128316.
[5] Yu. Tsapko, V. Kyrycyok, A. Tsapko, O. Bondarenko, S. Guzii, Increase of fire resistance of coating wood with adding mineral fillers. MATEC Web of Conferences, Vol. 230, 02034 (2018), EDP Sciences, (2018). DOI: 10.1051/matecconf/201823002034.
[6] Yu. Tsapko, A. Tsapko, O. Bondarenko, Establishment of heat-exchange process regularities at inflammation of reed samples. Eastern-European Journal of Enterprise Technologies, 1/10 (97), (2019) 36-42. DOI: 10.15587/1729-4061.2019.156644.
[7] P.V. Krivenko, E.K. Pushkarjeva, M.V., Sukhanevich, S.G. Guziy, Fireproof coatings on the basis of alkaline ип.nium silicate systems. Developments in Strategic Materials: Ceramic Engineering and Science Proceedings, 29, 10, (2009) 129-142.
[8]. P. Kryvenko, Ju. Tsapko, S. Guzii, A. Kravchenko, Developing of the effect fillers on the intumescent ability of the organic-inorganic coatings of building construction. Eastern-European Journal of Enterprise Technologies, 5/10 (83), (2016) 26-31. DOI: 10.15587/1729-4061.2016.79869.
[9] Bezpeka ob'kktiv budivnitstva DBN V.1.1-7-2002, Dzhudbud Ukrainy, (2003).