Improvement of fire retardant properties of wood materials

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Improvement of fire retardant properties of wood materials

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Abstract. Any kind of construction involves the use of wooden structures that require the achievement of an appropriate class of their fire hazard with the provision of the required fire protection indicators. Currently, fireproofing of wood materials is carried out mainly by impregnating wood with fireproofing compositions. And the search by scientists for relatively cheap and environmentally friendly fire retardant materials (flame retardants) for impregnating and treating wood is still relevant. This article discusses the role of fire retardant for wood material. The experimental study using 4% tetraethoxysilane is described. An optimal method of applying a composition for increasing fire resistance and a fire-retardant efficiency group of the test composition have been experimentally established. The positive effect of this composition on the fire-retardant properties of the wood chip board was also established. Time characteristics during soaking and drying of samples are recommended.

1. Statement of a problem

Today, the protection of the population and buildings and structures from fires - undoubtedly remain priority areas of work of educational, scientific institutions and industrial enterprises. And the proportion of wood materials used in construction does not decrease, but in some cases is dominant.

One of the central issues in the use of wooden structures in construction is the provision of the required fire hazard and fire resistance indicators. According to Article 58 of the Federal law "Technical Regulations about Fire Safety Requirements" of 22.07.2008 the fire resistance and a class of fire hazard of building constructions have to be provided at the expense of their constructive decisions, use of the corresponding construction materials and also use of means of fire protection [1-5].

There has been extensive national and global experience in the use of flame retardants to protect wood materials from fire. However, existing flame retardants do not provide some kind of adequate fire protection for building structures.

After analyzing the various compositions used to protect building structures from fire, an aqueous solution of tetraethoxysilane of 4 % was selected to study its flame retardant properties with respect to wood chip board (CPD) [6-11].

Tetraethoxysilane is an ether of orthosilicic acid and ethyl alcohol with formula (C_2H_5O) 4Si, a volatile transparent colorless liquid with a characteristic spice-sweet, somewhat similar to alcohol, smell.

2. Carrying out pilotstudies

For an experiment samples chipboards of 100 x 100 x 10 mm in size which were in advance wetted in structure for 3 hours, for 6 hours, for 12 hours were taken. In the experiment three samples are immersed in a bath with this composition for deep impregnation of wood, the fourth sample remains without impregnation for comparison of self-ignition time [11]. After the soaking time had elapsed, the samples were placed under the same conditions for further drying for 140 hours, 164 hours and 188 hours. An ignition test apparatus was used to determine flame retardant properties. The samples were exposed to temperatures of 500 and 700 ºC.

Figure 1a shows samples that were exposed to 500 ºC. During combustion, the applied composition absorbed heat and intensively released gas preventing further ignition. Samples did not ignite. Figure 1b shows samples that were exposed to 700 ºC. During combustion, the composition also absorbed heat, but the release of gas, which prevented fire, deteriorated. This reduced the fire resistance time of the samples and ignited the samples. This can be seen in tables 1 and 2 below.

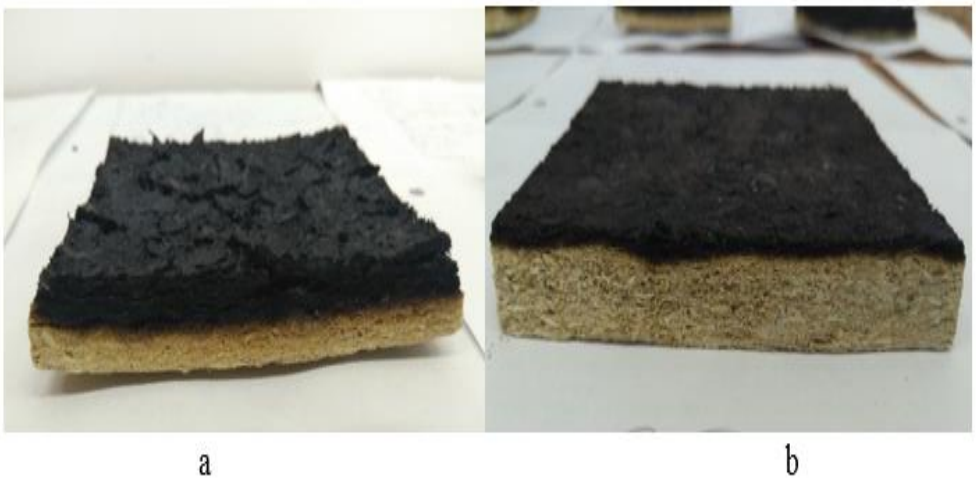

Figure 1. Samples after the following ignition tests.

Table 1. Samples exposed to 500 ºC.

Soaking time	Drying Time, hours	Wood Deformation Time	Ignition Time
Without soaking	-	-	40 s
3 hours	140 hours	6 min 03 s	-
6 ч hours	140 hours	6 min 56 s	-
9 hours	140 hours	7 min 03 s	-
3 hours	164 hours	5 min 35 s	-
6 hours	164 hours	6 min 16 s	-
9 hours	164 hours	5 min 47 s	-
3 hours	188 hours	6 min 56 s	-
6 hours	188 hours	6 min 35 s	-
9 hours	188 hours	6 min 20 s	-

Table 2. Samples exposed to 700 ºC.

Soaking time	Drying Time	Wood Deformation Time	Ignition Time
Without soaking	-	-	17
3	140	-	30
6	140	-	37
9	140	-	50
3	164	-	37
6	164	-	53
9	164	-	46
3	188	-	31
6	188	-	45
9	188	-	52

3. Received results

Graphs are based on these data for detailed analysis.

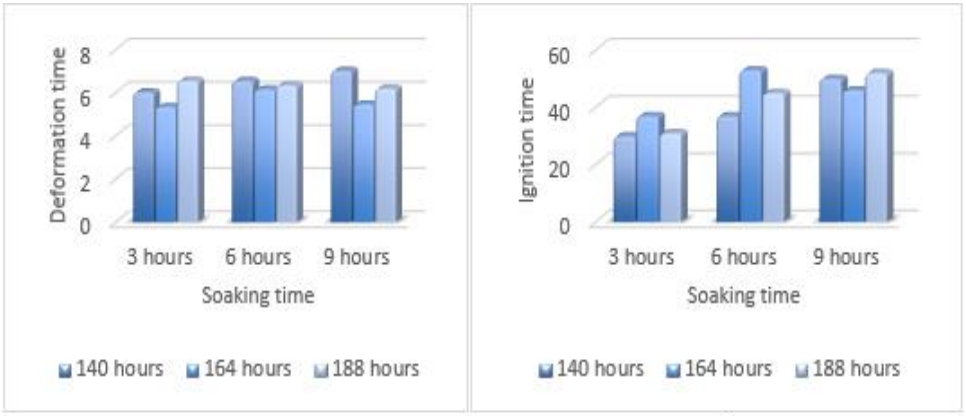

Figure 2. Dependence of deformation and ignition time on drying time.

According to the diagram in figure 2, and it can be seen that drying time does not affect deformation time. In contrast, deformation depends on the soaking time of the samples. The longer the sample was in solution, the faster the sample deformed and lost its holistic properties. Also in figure 2, b it can be seen that drying time does not affect self-ignition time, it indicates that over time CPD does not lose its fire-resistant abilities.

Mass loss during the 500 ° C test is determined to assess fire retardant efficiency.

Table 3. Mass of samples before and after exposure to 500 ° C.

Sample number	Swing time, h	Drying time, h	Mass before test, g	Mass after test, g
1	9	140	70	56

3	9	164	72	57
5	9	188	75	61
7	6	140	76	59
9	6	164	75	56
11	6	188	76	60
13	3	140	79	61
15	3	164	74	59
17	3	188	69	56

Weight loss of tested samples is calculated by formula

$$P_i = \frac{(m_{1i} - m_{2i}) \cdot 100}{m_{1i}} \quad (1)$$

where m_{1i} - is the mass of the sample before the test, g;
m_{2i} - the mass of the sample after the test, g;
i - the sample number.

The obtained calculation result is rounded to 0.1%.

Based on the test results, a fire-retardant efficiency group of the fire-retardant composition is established in this method of its use. If weight loss is not more than 9%, fire-retardant efficiency group I is established for OS. If weight loss is more than 9 %, but not more than 25 %, fire-retardant efficiency group II is established for OS. With a weight loss of more than 25%, it is considered that this composition does not provide fire protection of wood and is not fire protective. Calculation results are given in table 4.

Table 4. Mass loss of samples after testing.

Sample number	Soaking time, h	Drying time, h	Sample weight loss Pi,%	Fire retardant group
1	9	140	20	II
3	9	164	20,8	II
5	9	188	18,7	II
7	6	140	22,4	II
9	6	164	25	II
11	6	188	21,1	II
13	3	140	22,8	II
15	3	164	20	II
17	3	188	18,8	II

4. Conclusion

An analytical review of fire retardant data has shown that deep impregnation is the optimal method of applying flame retardant to increase fire resistance.

When examining the effect of deep impregnation on wood flammability, tetraethoxysilane showed good results. The 4% tetraethoxysilane solution has a positive effect on the fire resistance of wood materials. Experiements showed that after the expiration of time, impregnation does not weathered.

Experimental observations showed that the highest impregnation efficiency was achieved with a 6-hour impregnation time. This time ensures the penetration of the fire retardant composition into the pores, followed by their filling, without destroying the integrity of the samples.

It is established that the bearing structures and elements of the wooden structure impregnated with the above composition ignited an order of magnitude slower. Such a reserve of time allows not only to take all the necessary measures to eliminate the fire, but also to evacuate people and protect valuable property.

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