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STUDY OF FIRE RESISTANCE OF WOOD MODIFIED WITH MINERAL POWDER

Irada Shirinzade, Ayten Hamidova,
[1]*Azerbaijan University of Architecture and Construction*
irada.shirinzade@azmiu.edu.az, aytenibrahimlihemidova@gmail.com

Abstract

It is well known that the greatest drawback of wood and wood products is their low fire resistance. In recent years, various methods and compositions have been used to improve the fire resistance of wood materials. This research study examines the effect of mineral powders on the fire resistance of wood. Chemical flame retardants were also used for comparison. Basalt powder and bentonite clay powder were used as mineral powders. Experiments show that powders of both minerals have a positive effect on the fire resistance of wood. Using mineral powders reduces wood mass loss during combustion by 40-45%. However, the ignition time of the material also increases significantly, which is also significant.

***Keywords**: wood, flame retardant, mineral powders, fire resistance, wood impregnation*

Introduction

The environmental friendliness of wood materials, their high quality factor, ease of mechanical processing, and the possibility of recycling the raw materials have led to their widespread use in construction throughout history. However, along with the aforementioned positive properties of wood, there are also disadvantages. Among these, the flammability of wood and its products is a significant one. Therefore, when using wood materials in construction, fire protection measures must be taken.

Various methods exist for improving the fire resistance of wood. One of the most common methods of protection is impregnating the wood with various solutions. For impregnation, fire retardants, dyes, and various additives are used. However, there are still gaps in the development of the scientific basis for these methods and compositions. Although fire retardants used to improve fire resistance to some extent improve the fire resistance of a product, they have a negative impact on its decay.

In the 20th century, many foreign scientists, especially Russian ones, conducted extensive research on improving the fire resistance of wood materials. Among these scientists, the research of A.A. Chernukha [1, 2], A.Yu. is noteworthy. Korolchenko [3, 4], M.D. Groshevina [5], A.M. Gazizova [7]. A.A. Chernukha [1, 2] studied the use of silicate systems that cause combustion to improve the fire resistance of wood and developed a mechanism for the influence of silicate gels on the fire resistance of wood materials. A.M. Gazizov proposed treating the wood surface with marble chips to improve its fire protection. He found that the fire resistance of wood samples treated with marble chips was higher than that of samples impregnated with fire retardants [7].

At the same time, we [8, 9] conducted research to improve the fire resistance of wood using both traditional flame retardants and mineral materials. It was found that wood materials coated with chemical flame retardants mixed with perlite powder were more resistant to flame exposure.

According to the standard [6], wood materials are divided into three classes based on fire resistance (mass loss on combustion): Class I – hardly flammable wood materials. The mass loss on combustion of these wood materials should be ≤9. Class II – hardly flammable wood materials. The mass loss on combustion of these wood materials should be 9-25%. Class III non-fire-resistant wood materials. The mass loss on combustion of these wood materials is greater than 25%.

Wood materials are widely used in modern construction and other industries, so improving their properties is always important.

Main Part

The following materials and methods were used in the study:

- pine wood, widely used in construction;
- Ammofos-A fire retardant;
- basalt from the Kalbajar deposit;
- bentonite clay from the Dash-Salahli deposit.

The chemical composition of Ammofos-A fire retardant is MH4H2PO4, consisting of 9-11% N and 42-50% P2O5. Its solubility in water at 200°C is 370 g/L, its hydrogen indicator pH is 4.0-4.5, and its melting point is 190°C.

The fire resistance of wood samples was determined in accordance with GOST 16363-98 "Methods for Determining the Fire Resistance of Wood."

The purpose of this research is to substantiate the use of impregnating wood materials with mineral compounds to improve their fire resistance and to develop an impregnation regimen. Basalt powder was used as the mineral material.

For the experiments, 21 softwood samples measuring 50 x 50 x 50 mm were cut and prepared. Three samples were impregnated with a traditional fire retardant (Ammophos-A, NH4H2PO4) under normal conditions. Nine of the samples were coated with basalt powder mixed with an Ammophos-A solution, and nine were coated with bentonite powder mixed with an Ammophos-A solution. In all three cases, the prepared mixtures were applied to the samples twice (two layers).

During the experiment, the amount of Ammophos-A fire retardant in the solution remained constant (15%), while the amounts of basalt and bentonite powders were 5, 10, and 15%, respectively. The prepared samples were stored at standard room temperature (20±50°C) and 60% relative humidity for 24 hours, after which their fire resistance was determined. Fire resistance is defined as the mass loss after exposure to flame.

Propane and a laboratory gas cylinder were used for the tests. The gas cylinder was secured to a fixed surface, and a tripod was used to support the samples. The prepared samples were placed in a flame source at a temperature of 300ºC. The charring, smoldering, and ignition times, as well as the mass before and after the test, were recorded for each sample.

The results are presented in Table 1.

Table 1. Effect of mineral dusts on the fire resistance of wood

№	Composition of the protective layer	Mass of samples, g		Mass loss		Average mass loss, %
		before the test	after the test	g	%	
1	Ammofos-A	51.0	42.0	9	17.65	19.99
2	Ammofos-A	52.1	40.5	11.5	22.12	
3	Ammofos-A	52.4	41.8	10.6	20.22	
4	Ammofos-A+5% basalt powder	52.8	44.0	8.8	16.66	17.35

5	Ammofos-A+5% basalt powder	52.5	43.5	9.0	17.14	
6	Ammofos-A+5% basalt powder	52.0	42.6	9.5	18.26	
7	Ammofos-A+10% basalt powder	53.1	45.2	7.9	15.16	14.62
8	Ammofos-A+10% basalt powder	53.5	45.8	7.7	14.39	
9	Ammofos-A+10% basalt powder	53.7	46.0	7.7	14.33	
10	Ammofos-A+15% basalt powder	54.2	47.8	6.4	11.80	12.44
11	Ammofos-A+15% basalt powder	54.0	47.0	7.0	12.96	
12	Ammofos-A+15% basalt powder	54.9	48.0	6.9	12.56	
13	Ammofos-A+5% bentonite powder	51.8	43.6	8.2	15.83	14.93
14	Ammofos-A+5% bentonite powder	51.5	44.3	7.9	15.33	
15	Ammofos-A+5% bentonite powder	51.3	44.7	7.0	13.64	
16	Ammofos-A+10% bentonite powder	52.6	46.9	5.7	10.83	10.40
17	Ammofos-A+10% bentonite powder	52.2	46.5	5.7	9.77	
18	Ammofos-A+10% bentonite powder	52.7	47.1	5.6	10.62	
19	Ammofos-A+15% bentonite powder	53.5	48.6	4.9	9.15	8.92
20	Ammofos-A+15% bentonite powder	53.8	48.8	5.0	9.29	
21	Ammofos-A+15% bentonite powder	54.0	49.5	4.5	8.33	

As can be seen from the table, the post-combustion mass loss in wood samples treated with surface mineral powders is lower than in samples treated with chemical flame retardants alone. While the post-combustion mass loss in samples treated with Ammofos-A flame retardant averages approximately 20% (19.99%), in samples treated with 5-15% basalt powder, this loss ranges from 12.44-17.35%, and in samples treated with 5-15% bentonite powder, the post-combustion mass loss was 8.92-14.93%. The lower post-combustion mass loss of samples treated with bentonite powder, compared to that of samples prepared with basalt powder, is most likely due to the better solubility of bentonite powder in water.

The experiment also determined the ignition onset time of the samples. The influence of the mineral powders used on the ignition time of wood is shown in the diagram and presented in Figure 1.

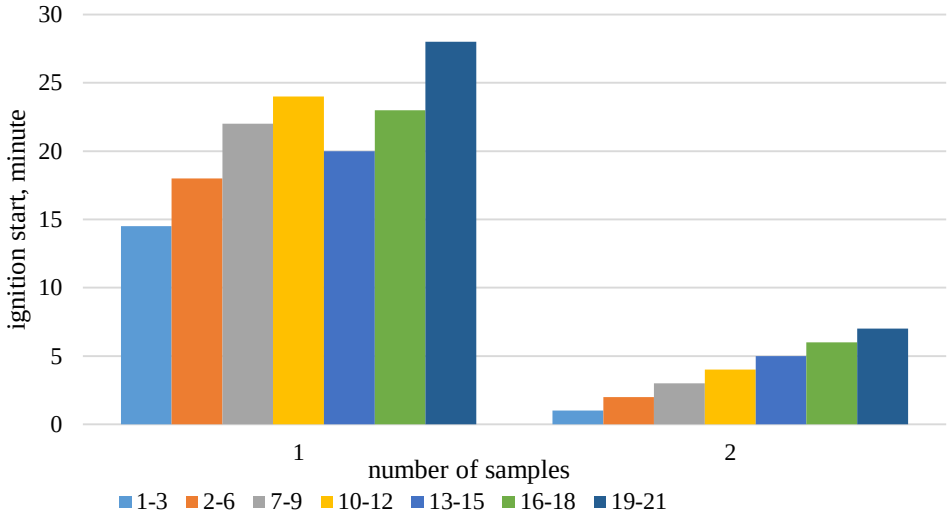

Figure 1. Diagram of the initiation of firewood ignition

Result

1. As a result of the conducted studies, the positive effect of bentonite clay powder and basalt powder on the fire resistance of firewood samples was determined. It was determined that when 15% basalt powder was treated with a chemical flame retardant, the mass loss during combustion of firewood was 12.44%, and in samples using bentonite powder, it was 8.92%.

2. It was determined that in all samples using mineral powder, the ignition stops when the ignition source is removed.

3. The use of mineral powders also significantly delays the start of the ignition period of firewood.

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