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Ignitability of wood impregnated with fireproof agent based on diammonium hydrogen phosphate, citric acid and sodium benzoate

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Abstract: *Ignitability of wood impregnated with fireproof agent based on diammonium hydrogen phosphate, citric acid and sodium benzoate*. This paper examines the impact of pine and beech wood impregnation with fireproof agent, based on diammonium hydrogen phosphate, citric acid and sodium benzoate, to their ignitability. Retention of the product was 49 kg per 1 m^3. It was noted that impregnated pine wood, as well as beech wood did not sustain burning after removing the source of fire. At the same time, these materials require about 1.5 times higher oxygen index values to obtain the same effects of burning as unprotected samples.

Keywords: pine wood, beech wood, fireproofing protection, reaction to fire, oxygen index

INTRODUCTION

Wood is a valuable material that people use in construction for many years. However, besides a number of beneficial characteristics, it is burdened with defects and one of them is lack of fire resistance. Wood ignites at temperatures of 210 - 350 °C, where ignition temperature largely depends on the species of timber and the heating conditions (Drysdale 2001, Osipiuk 2001, Krajewski and Witomski 2005). In order to reduce the ignitability, fireproof agents are used. Their application allows to extend the time of inflammation, reduce or eliminate flaming phase of burning, reduce the speed of fire spreading, or accelerate creating a layer of charcoal on wood surface resulting in limited heat transfer inside the material.

At present, new wood preservatives reducing ignitability, based on ecological and non-toxic organic ingredients, which allows to use them in human environment, are available on the market. One of them is fireproof agent based on composition of diammonium hydrogen phosphate, citric acid and sodium benzoate (US 7736549). In this work, the impact of pine and beech wood impregnation (with the use of aforementioned agent) for its ignitability was defined.

MATERIAL AND METHODS

Pine and beech slats without visible defects (nominal dimensions: 90 x 250 x 5 mm^3, density 516 kg/m^3 for pine and 716 kg/m^3 for beech) were protected with fireproof agent based on composition of diammonium hydrogen phosphate, citric acid and sodium benzoate. The product was used as a water solution having a concentration of 20%. Samples were pressure protected. They were immersed in preparation and put into the chamber, in which vacuum was produced. After 15 minutes, air was injected, which restored the atmospheric pressure. Then, tested samples were removed from the chamber and weighed in order to determine the amount of solution injected into each slat. Samples, which do not fulfill the assumed level of retention, were re-immersed in preparation for a time necessary to absorb assumed quantity of fireproof agent. For both, pine and beech slats, average retention was

49 kg per 1 m^3. After impregnation, slats were dried at 50 - 60° C, to the moisture content of about 5%. Simultaneously, unprotected pine and beech slats were dried under the same conditions, to a moisture content of about 5%. For each variant 10 slats were prepared of which samples were produced for further study.

Ignitability of wood was studied by two methods:

1. method of reaction to fire, according to EN ISO 11925-2. Samples dimensions were: 250 x 90 x 5 mm^3. As a measurement result it was noted: whether the ignition of the sample took place, whether the top of the flame reached a height of 150 mm above the location on which the flame work, what is the visual condition of the sample.
2. oxygen index method based on the standard ISO 4589-2:1999. Oxygen index is the lowest content of oxygen in air mixture (expressed in percentage), which in laboratory conditions supports constant burning of the material. Dimensions of tested samples were 100 x 10 x 5 mm^3. Oxygen index measurement method is applied for comparison of the ignitability of different materials while assessing the modification of the same type of material, and the impact of additional fillers including various types of flame retardants. Oxygen index does not classify materials with respect to fire hazard.

RESULTS AND DISCUSSION

The results of reaction to fire tests are presented in Table 1. Generally, it can be stated that both, pine and beech slats impregnated with the tested product did not sustain burning after contact with flame for 30 seconds. At the point where the flame has been in contact with the sample, appeared a thin, compact layer of charred wood, which limited emissions of flammable compounds from wood to the environment. For unprotected samples, all pine slats and 1 of 3 beech slats were ignited. Flame height after 30 seconds was over 2 times lower in case of impregnated pine slats than for unprotected samples. For beech wood, the noted flame height after 30 seconds was similar for both, protected and unprotected samples. Examples of slats after reaction to fire test are presented in Figure 1.

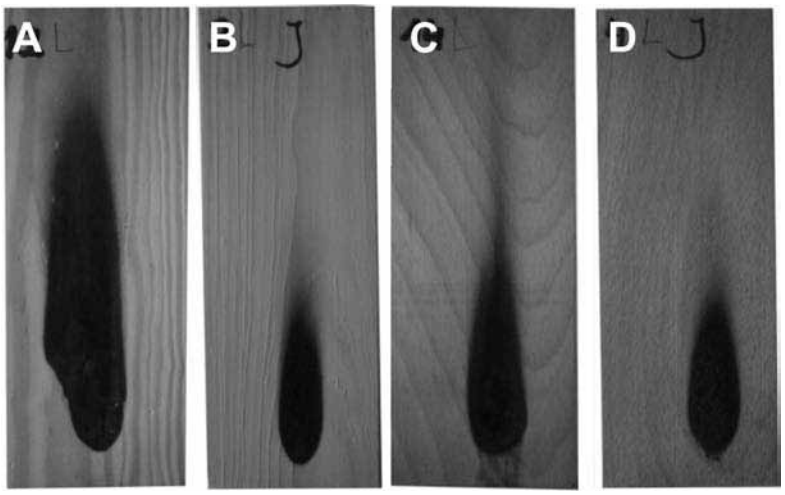

Fig. 1. Samples after test of reaction to fire: A - unprotected pine slat, B - impregnated pine slat, C – unprotected beech slat, D - impregnated beech slat.

Table 1. The results of pine and beech wood study for reaction to fire

Sample No	Sample ignition	Height of flame top achieved after 30 s [mm]	Overall sample condition
Unprotected pine slats			
P 1	Yes	179	Very bad, burning of sample
P 2	Yes	155	Very bad, burning of sample
P 3	Yes	163	Very bad, burning of sample
Impregnated pine slats			
PI 1	No	66	Carbonization on the sample's surface
PI 2	No	80	Carbonization on the sample's surface
PI 3	No	69	Carbonization on the sample's surface
Unprotected beech slats			
B 1	No	55	Bad, burning visible
B 2	No	59	Bad, burning visible
B 3	Yes	99	Very bad, burning of sample
Impregnated beech slats			
BI 1	No	62	Carbonization on the sample's surface
BI 2	No	66	Carbonization on the sample's surface
BI 3	No	76	Carbonization on the sample's surface

Table 2. The results of ignitability tests for pine and beech wood with the use of oxygen index - gray color indicates the lowest value of oxygen index for particular samples.

Sample No	Oxygen concentration (%)	Observations
Unprotected pine samples		
P 1	25.0	After 57 sec. 22 mm of sample were burned
P 2	30.0	After 34 sec. 50 mm of sample were burned
P 3	28.0	After 46 sec. 50 mm of sample were burned
P 4	27.5	After 166 sec. 41 mm of sample were burned
P 5	27.7	After 180 sec. 48 mm of sample were burned
Impregnated pine samples		
PI 1	40.0	No sample ignition
PI 2	45.0	After 38 sec. 50 mm of sample were burned
PI 3	42.0	After 22 sec. 50 mm of sample were burned
PI 4	41.8	After 12 sec. 10 mm of sample were burned
PI 5	42.2	After 31 sec. 50 mm of sample were burned
Unprotected beech samples		
B 1	25.0	After 94 sec. 12 mm of sample were burned
B 2	30.0	After 15 sec. 50 mm of sample were burned
B 3	28.0	After 40 sec. 50 mm of sample were burned
B 4	27.0	After 56 sec. 15 mm of sample were burned
B 5	27.5	After 113 sec. 50 mm of sample were burned
Impregnated beech samples		
BI 1	35.0	No sample ignition
BI 2	40.0	After 89 sec. 34 mm of sample were burned
BI 3	42.0	After 34 sec. 50 mm of sample were burned
BI 4	41.0	After 61 sec. 50 mm of sample were burned
BI 5	40.9	After 123 sec. 41 mm of sample were burned

The results of ignitability tests for pine and beech wood with the use of oxygen index are presented in Table 2. While the research was conducted, time of burning and length of burned part were difficult to compare - they only let to determine, if the trial was successful or not. The test was considered as a success when the sample was burning for 180 seconds, or if the flame burnt 50 mm of sample. Oxygen index (the smallest percentage of oxygen in the air mixture needed for combustion of 50 mm of samples, or allowing to keep burning for 180 seconds) was the only characteristic possible to compare in this study.

Tested pine and beech samples, which were not protected by agent, were burned (in the range tested) at the oxygen concentration around 28% in the air mixture. Protection of samples with tested product caused that in the studied conditions, they have been burnt (50 mm of sample) at a concentration of oxygen in the air at level of 41 - 42%.

CONCLUSIONS

On the basis of conducted research it can be stated, that impregnation of pine and beech wood, with the use of fireproof agent based on composition of diammonium hydrogen phosphate, citric acid and sodium benzoate, increases the fire resistance of these materials. None of the attempts of impregnated wood exposure to fire resulted in sustaining of the burning. Impregnated samples required about 1.5 times higher oxygen index values (higher oxygen content in the air) to meet the same conditions as burning of unprotected samples.

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Streszczenie: *Palność drewna zabezpieczonego środkiem ogniochronnym na bazie wodorofosforanu amonu, kwasu cytrynowego i benzoesanu sodu*. W ramach badań określono wpływ impregnacji drewna sosnowego i bukowego preparatem ogniochronnym opartym na kompozycji wodorofosforanu amonu, kwasu cytrynowego i benzoesanu sodu na ich palność. Retencja preparatu wynosiła 49 kg na 1 m^3. Ustalono, że zaimpregnowane drewno zarówno bukowe jak i sosnowe nie podtrzymywało palenia po usunięciu źródła ognia. Jednocześnie materiały te wymagały ok. 1.5 razy wyższych wartości indeksu tlenowego do uzyskania tych samych efektów spalenia co próbki niezaimpregnowane.

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