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Influence of flakes impregnation with salt flame retardants on selected physical and mechanical properties of OSB

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Abstract: *Influence of flakes impregnation with salt flame retardants on selected physical and mechanical properties of OSB.* In this study, selected physical and mechanical properties of OSB made from flakes impregnated with two fireproof agents: A) on the basis of quaternary ammonium compounds and boric acid and B) on the basis of diammonium hydrogen phosphate, citric acid and sodium benzoate. It was concluded that impregnated flakes increase fire resistance of the material, reducing the mechanical properties at the same time.

Keywords: OSB, fire resistance, physical and mechanical properties.

INTRODUCTION

Solid wood, despite the fast price growth is still widely used as:

- construction timber (beams, squared log, batten, latch) for engineering structures, and roof constructions et al.,
- building timber on scaffolding, fencing and roof covering,
- sawnwood used for furniture, joinery and panelling,
- timber semi-products (strips, batten) for further processing (Kobiela 2004).

Problem of the high-quality structural timber deficit, forces its replacement with wood based materials (Hikiert and Oniśko 2006). The main raw material for the wood-based panels industry is small and medium sized wood, as well as waste material. Produced materials characterize with relatively low specific weight in relation to their strength properties.

In the upcoming years, wood-based panels industry will evolve in the direction of new materials production, lighter, with better properties, using materials with lower densities. Production processes are being changed for better efficiency, energy savings, as well as are becoming more environmentally friendly. Unfortunately, wood and wood-based materials are flammable and susceptible to all kinds of corrosion caused by biotic and abiotic factors (Osipiuk 2001). Therefore, solutions for eliminating a large extent of these disadvantages are researched (Giancaspro et al. 2009). Protection of finished wood-based panels with antipirens was not yet generally applicable. Using flame retardants to impregnate the grinded material during the manufacturing process, immediately after grinding of round wood into particles might be a better solution (Ayrilmi 2007, Drysdale 2001).

MATERIAL AND METHODS

Researches of strength properties were performed on three-layer OSB with thickness of 10 mm, and density of 600 kg/m^3. Flakes for OSB production have been previously impregnated with two fireproofing agents: A) based on quaternary ammonium compounds and boric acid and B) based on diammonium hydrogen phosphate, citric acid and sodium benzoate. Pine flakes were used. At the beginning of studies, impregnants in form of 10% solutions were applied on flakes by spraying in a rotating tumbler, and then they were dried at 80 °C to moisture content of 6%. Parameters of the boards production were: glue content - 10%, the unit press pressure of 2.5 MPa, unit pressing time - 18 sec/mm of thickness, temperature of 130 °C. Phenol-formaldehyde resin with the addition of resorcinol was used for boards production in order to reduce the pressing temperature from 180 ºC to 130 ºC. Three levels of retention were used: 15 kg/m^3, 30 kg/m^3 and 45 kg/m^3. Series of control boards, without fireproofing agent was also produced.

From produced OSB, samples were cut for following tests:

- Flammability of products subjected to direct impingement of single-flame according to PN-EN ISO 11925-2:2004.
- Oxygen index flammability test according to PN ISO 4589-2:1999.
- Determination of modulus of elasticity in bending and of bending strength according to PN EN 310.
- Determination of perpendicular tensile strength to the surface of the boards according to PN EN 319.

Test samples were cut along the fibres.

RESULTS AND DISCUSSION

Results of the flammability test of products subjected to direct impingement of single-flame are presented in Table 1. Edge exposure study was conducted. None of the variants were ignited during the operation of the flame for 120 seconds.

Table 1. Single-flame source flammability test

Agent and its retention	Was there ignition after 15 sec?	Was there ignition after 30 sec?	Is burning self-sustained?	Average flame height after 120 sec	Were drops and waste produced?	Characteristics of produced smoke
Control	No	No	No	87.5 mm	No	Trace amounts
A 15 kg/1m^3	No	No	No	67.5 mm	No	
A 30 kg/1m^3	No	No	No	57.5 mm	No	
A 45 kg/1m^3	No	No	No	45.0 mm	No	
B 15 kg/1m^3	No	No	No	77.5 mm	No	
B 30 kg/1m^3	No	No	No	76.0 mm	No	
B 45 kg/1m^3	No	No	No	70.0 mm	No	

Boards made of flakes impregnated with agent A, with retention of 45 kg/m^3, achieved the highest fire resistance - after 120 seconds of flame exposition, carbonization has reached only 4.5 cm. This is almost twice better result than for the sample impregnated with agent B at the same retention. Generally, boards protected with agent A showed better resistance to a single flame. Impregnating with both agents had a positive impact on the fire resistance. During the arson, smoke was produced in small ammounts, and there were no wastes. Burning was not sustained. Test samples satisfy one of the classification criteria Fs <150 mm after a period of 20 seconds, allowing to qualify them for Euro Class Bfl or lower (Cfl, Dfl, Efl) (according to PN-EN ISO 11925-2:2004). Appearance of the boards after conducted fire test are presented in Figure 1.

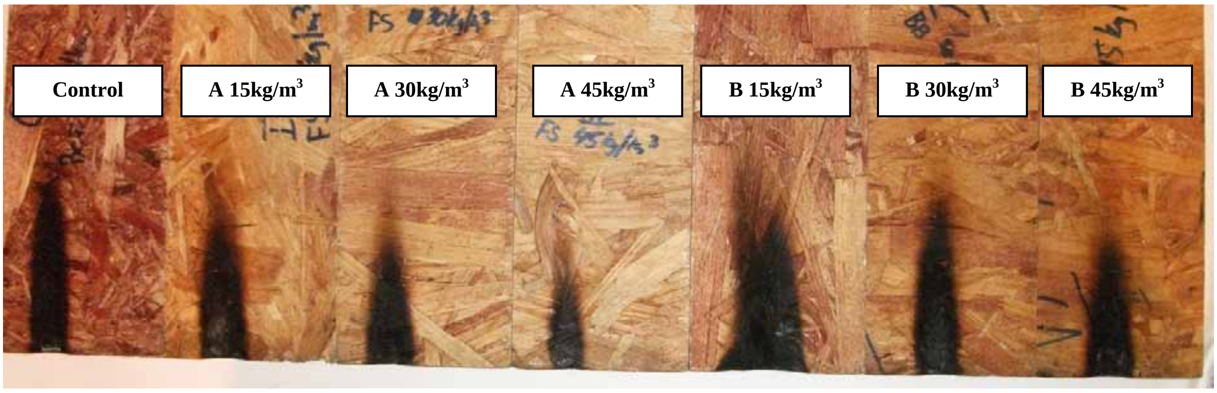

Fig. 1. Samples after single-flame source test – test was conducted on the basis of oxygen index method.

The results obtained in oxygen index flammability tests are shown in Figure 2. The study showed increased fire resistance of produced OSB. Highest oxygen index was achieved by boards impregnated with agent A at the retention of 45 kg/m^3. To sustain burning of the sample, oxygent content of 51% in the air was needed. Control samples achieved oxygen index of 27%. As an example, oxygen index for wood ranges from 22.4% to 24.6%. Increase of fire resistnace of control boards may have been a result of applied resin and a high degree of compression of material. Boards made of flakes impreganted with agent A showed a higher oxygen index than boards impregnated with agent B at the corresponding retention. Oxygen indexes for agents A (30 kg/m^3) and B (45 kg/m^3) hardly differ, but the consumption of agent B is much bigger.

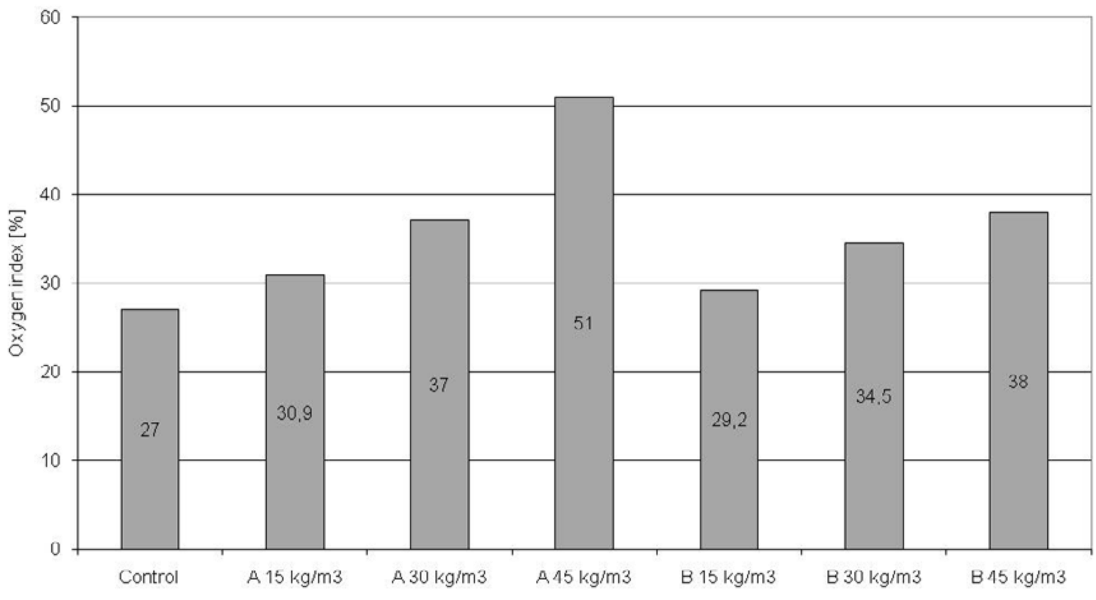

Fig. 2. Oxygen index values for peculiar variants.

Results of determination of static bending strength are presented on Figure 3 and the comparison of results of modulus of elasticity in bending strength, made of pine flakes impregnated with two types of fireproofing agents at three different retentions, are presented in Table 2.

Boards made of flakes impregnated with both agent A and B, with retentions of 30 and 45 kg/m^3, show similar static bending strength. Reduction of agent B retention to 15 kg/m^3 resulted in a slight (statistically insignificant) increase in strength relative to the control variant. Increasing the retention of the agent B to the level of 30 and 45 kg/m^3 resulted in lower bending strength (30 N/mm^2). This value is lower than the value for control sample. Standard PN EN-310 specifies the strength of OSB at 30 N/mm^2. The values obtained for samples impregnated with agent B are comparable. Samples impregnated with agent A are not eligible for this limit, with the bending strength of 20 N/mm^2.

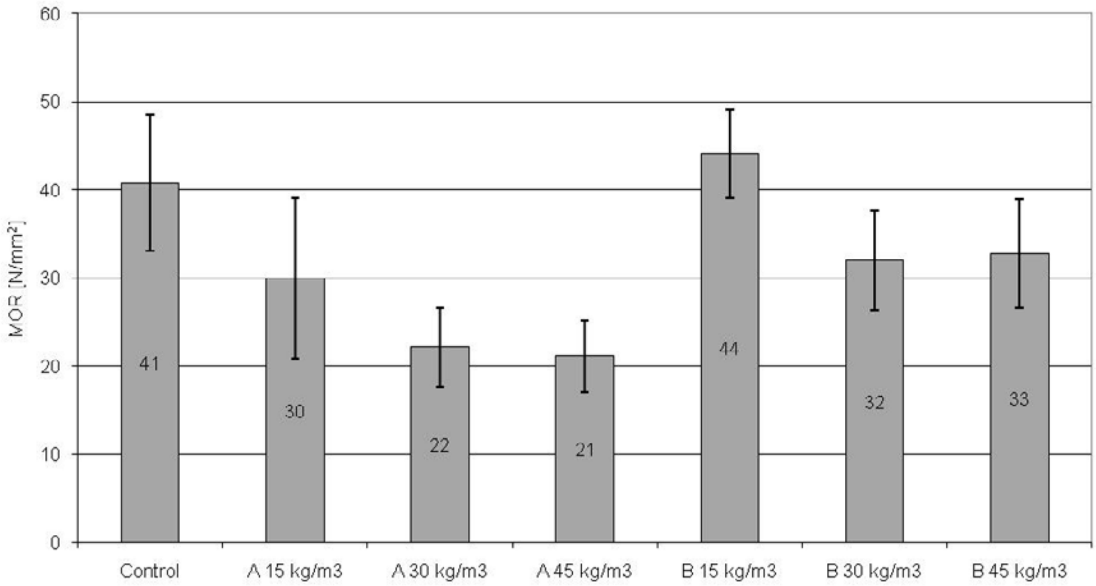

Fig. 3. Static bending strength (MOR) for particular variants.

Determination of modulus of elasticity in bending of tested materials showed its highest value for boards made of flakes saturated with agent B with retention of 15 kg/m^3. Addition of agent A had negative impact on the value of the modulus of elasticity Standard PN EN 310 specifies the modulus of elasticity for OSB/4 at the level of 4800 N/mm^2, and for OSB/3 at the level of 3500N/mm^2.

Table 2. Value of modulus of elasticity (MOE)

Sample	MOE [N/mm^2]	MOE according to PN-EN 310 OSB/4 [N/mm^2]	MOE according to PN-EN 310 OSB/3 [N/mm^2]
Control	4607	4800	3500
A 15 kg/m^3	3280		
A 30 kg/m^3	2944		
A 45 kg/m^3	2691		
B 15 kg/m^3	4648		
B 30 kg/m^3	4341		
B 45 kg/m^3	3970		

Results of the determination of perpendicular tensile strength to the surface of the boards are presented in Figure 4. Just as in the previous examinations, boards made from flakes impregnated with agent B with retention of 15 kg/m^3 were the only ones that met the requirements of the standard and showed higher strength in comparison to the control variant. It should be noted that this difference was statistically insignificant for the level of confidence of 95%. With the increase of impregnant retention, perpendicular tensile strength (to the surface of the boards) of the boards significantly decreased. Standard PN EN-310 defines a tensile strength of the OSB/4 at 0.5 N/mm^2.

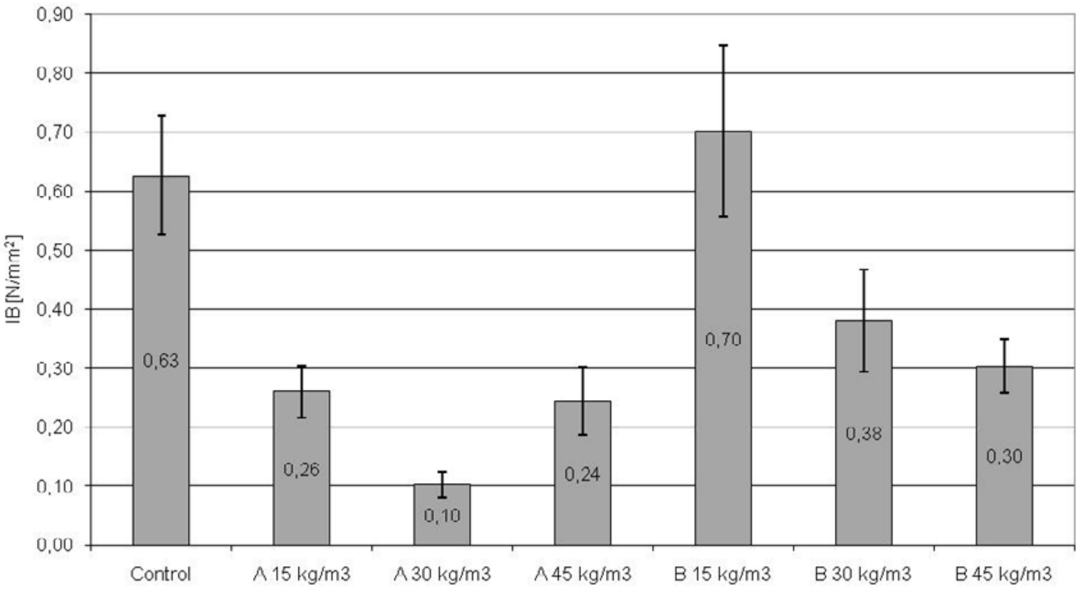

Fig. 4. Perpendicular tensile strength to the surface of the boards (IB).

CONCLUSIONS

Impregnation of flakes, before the process of pressing, with agents based on quaternary ammonium compounds and boric acid as well as diammonium hydrogen phosphate, citric acid and sodium benzoate, had a positive impact on the fire resistance of tested material. Agent A in greater extent than agent B improves the fire resistance of OSB, under the same retention. OSB unprotected with any impregnant has better fire resistance than solid wood. The use of fireproof impregnation in the retention of more than 15 kg/m^3 decreases mechanical properties of the material. Flakes impregnation with agent A definitely improves fire-retardant properties of boards, however it worsens their mechanical propeties, in comparison with boards where particles were impregnated with agent B.

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Streszczenie: *Wpływ impregnacji wiórów solnymi środkami ogniochronnymi na wybrane właściwości fizyko-mechaniczne płyty OSB.* W pracy zbadano wybrane właściwości fizyko-mechaniczne płyt OSB wyprodukowanych z wiórów zaimpregnowanych dwoma preparatami ogniochronnymi: A) na bazie czwartorzędowych związków amoniowych i kwasu borowego i B) na bazie wodorofosforanu amonu, kwasu cytrynowego i benzoesanu sodu. Stwierdzono, że zaimpregnowane wióry wstęgowe podwyższają odporność ogniową materiału, przy jednoczesnym obniżeniu właściwości mechanicznych

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