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RESEARCH INTO THE FIRE PROPERTIES OF WOOD PRODUCTS MOST FREQUENTLY USED IN CONSTRUCTION

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Abstract. Analysis of various wood products tested under the exposure to 30 kW/m^2, 35 kW/m^2, 40 kW/m^2, 45 kW/m^2 and 50 kW/m^2 heat flows in accordance with LST ISO 5657:1999 "Reaction to fire tests – ignitibility of building products using a radiant heat source" was performed. Selected boards were subjected to reaction to fire tests in accordance with LST EN 13823:2010 "Reaction to fire tests for building products". The tests were performed on 6 mm, 10 mm, 15 mm and 18 mm thick oriented strand boards (OSBs) and 24-mm thick wood particle boards (WPBs), both impregnated with BAK-1 fire retardant solution and non-impregnated. The average time to ignition (TTI) was determined. The impact of the impregnator on heat release rate, smoke formation and carbon dioxide (CO_2) emission in the course of combustion of impregnated and non-impregnated OSB and WPB was studied. In the course of the research, statistical analysis was performed and empirical equations and their correlation coefficients were obtained. Conclusions were formulated at the end of the study.

Keywords: time to ignition; wood products; fire properties; heat release rate; smoke production; CO_2 emission.

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Introduction

In the modern global industry, wood has become very popular, thus its shortage is a growing problem. As many countries, including Lithuania, use wood in constructions, importance of this material must be taken into consideration. A wide choice of application options results in growing demand and requirements for the range of these products.

Fire safety is one of the main requirements set for buildings. Another important condition is to ensure that in case of fire, wood products would cause as low threat to civil population and fire-fighters as possible (Hakkarainen 2002; Frangi *et al.* 2009). This goal can be accomplished by using products, the fire properties of which limit the speed of fire propagation (Richardson, Batista 2001). When assessing products in terms of fire safety, it is also important to perform all the required tests exposing products to various heat flows and assess the heat release rate, decomposition (pyrolysis) of products and toxicity of substances emitted in the course of fire, including the amount of emitted smoke (Nyderis, Mačiulaitis 1999; White 2000; Bednarek *et al.* 2009; Šaučiuvenas, Griškevičius 2009).

Heat release rate, which is considered to be an important fire property, is highly significant for fire propagation. This statement is substantiated by the fact that fire temperature, which predetermines the propagation speed of fire itself depends on heat release rate and combustion time (Babrauskas, Peacock 1992; Władyka-Przybylak 1997; Mouritz *et al.* 2006; Filipczak *et al.* 2005).

Due to high temperatures, the combustion process is the main factor destroying materials and structures. This is the reason why even wooden structures should be made resistant to fire (Bednarek, Kaliszuk-Wietecka 2007; Chow, C. L., Chow, W. K. 2009).

Wooden structures are usually protected with the help of impregnation with fire retardant solutions; however, incorrectly selected impregnator may result in dramatic consequences in case of fire. Flammable

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substances contained in impregnators may accelerate fire propagation even further (Bridžiuvienė, Lugauskas 2003; Półka 2008; Praniauskas, Mačiulaitis 2010; Pereyra, Giudice 2009). Instead of extinguishing a small seat of fire, the fire-fighting team would have to extinguish the whole building enveloped in flames. Most importantly, a building should not be constructed using a lot of flammable materials, but rather substances that could arrest and limit fire propagation (Babrauskas 2005; Wang *et al.* 2007; Chou *et al.* 2009). Fire-resistance enhancing materials used for the protection of wood and wood products act as a firewall arresting fire propagation, extending fire resistance and improving the durability of structures in general (Draizdeil 1998; Mačiulaitis, Praniauskas 2010).

It must also be noted that the combustion of large-molecular substances causes the emission of extensive amounts of carbon dioxide (CO_2). CO_2 is the final product of carbon oxidation. CO_2 is a colourless gas with sour odour and flavour, approximately 1.5 times heavier than air. CO_2 forces people to breathe more frequently, this way leading to a greater intake of toxic combustion products.

It causes vasodilatation as well as changes in blood pH and increased content of adrenaline in blood. Pursuant to the available data, it can be stated that in case of a short-term exposure to CO_2 (15 minutes), the permissible concentration is 1.5% (Žukas *et al.* 2007).

The purpose of our study is to determine the impact of impregnated and non-impregnated (with fire retardant solution BAK-1) wood on fire propagation.

1. Materials tested and test methodology

The tests were performed with non-impregnated boards and boards impregnated with fire retardant solution BAK-1: 24 mm thick wood particle boards (WPB) and oriented strand boards (OSBs) of different thickness (6 mm, 10 mm, 15 mm and 18 mm). Five samples for both impregnated and non-impregnated wood products of each board type were prepared.

Fire hazard tests were carried out in accordance with the requirements of the standards LST ISO 5657:1999 (Fig. 1) and LST EN 13823:2010 (Fig. 2).

In accordance with the standard LST ISO 5657:1999, samples were cut out from test boards maintaining their real thickness (150×150 mm). Then, a frame wrapped in aluminium foil was prepared. It was placed on one side of the sample while exposing only a circular opening to a heat flow (the heat flow is radiated by a spiral heated up to a certain temperature). Then, while exposing the sample to selected heat flows, the time to ignition (TTI) of the test boards was determined with the help of a stopwatch.

Fig. 1. LST ISO 565:1999 standard burning furnace

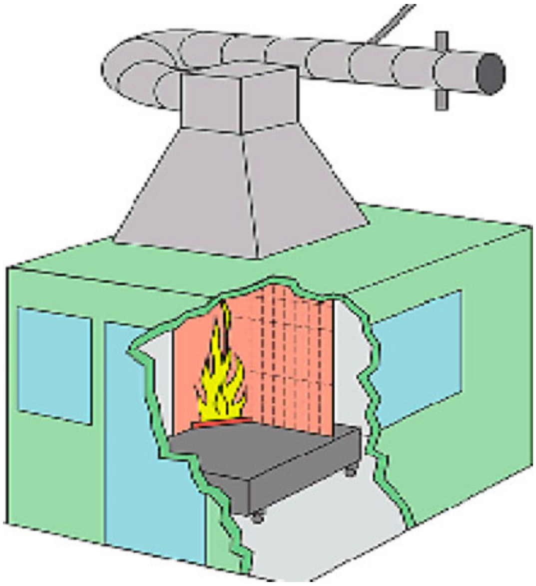

Fig. 2. LST EN 13823:2010 standard burning furnace

In accordance with the standard LST EN 13823:2010, the sample was made of two parts with dimensions 1500× 495 mm and 1500×1000 mm (height×width) and exposed to the flame of the burner equipped at the bottom of the corner. Flame was obtained by combusting propane gas with a heat capacity of (30.7±2.0) kW supplied through a sandbox. The duration of the test was 25 minutes. However, during the first 5 minutes, an auxiliary burner was burned. It was equipped father from the sample, and the sample was not directly exposed to the flame. By means of the auxiliary burner, only the heat capacity and smoke formation of the burner were measured; therefore, the programme evaluated the heat capacity and smoke formation of the burner itself as well as provided only the test results of the sample once the sample was exposed to the flame of the main burner. The sample was exposed to the flame of the main burner for 20 minutes. The following operating parameters were obtained: heat formation, smoke formation, lateral flame spread and fall of flaming droplets and particles.

In order to summarise the test results, the average values of the obtained indicators were used.

2. Test results and discussion

First of all, non-impregnated products were tested in order to determine the ignition point. It was determined that at the heat flow of 10 kW/m^2 (380 °C) and 20 kW/m^2 (500 °C) products did not ignite but charred. This might have happened because in order to initiate flame combustion, a certain concentration of volatile products (emission from the sample at the time of thermal decomposition when it is exposed to heat flows) and oxygen should be reached. However, in this case, under the exposure to smaller heat flows, a sufficient quantity of volatile products and concentration of the mix (of volatile products and oxygen) necessary for flame combustion was not reached. Therefore, only charring of the board and emission of volatile products without flame combustion proceeded. The test wood products that did not ignite after 900 seconds was terminated (see Table 1).

Ignition was obtained only at the heat flow of 30 kW/m^2 (590 °C). When gradually increasing the heat flow, the time to ignition decreased correspondingly as concentration of volatile products and oxygen necessary for flame combustion was reached faster. However, it is possible to suggest that the ignition of neither WPB or OSB depends on the board thickness or the difference is minimal. The data presented in Table 1 prove that a thicker board may ignite faster than a thinner one. This may be influenced by additives used in board production and their concentration on the board surface because in case of a higher concentration of additives on the board surface, the concentration of volatile products and oxygen required for flame combustion may be reached faster or slower (White 2000; Richardson, Batista 2001; Morkevičius, Papreckis 2004).

Table 2 presents the results of combustibility tests of impregnated wood products and average times to ignition.

The results of the tests with impregnated products are presented starting from 35 kW/m2 (620 °C) because the samples did not ignite when exposed to lower heat flows. Furthermore, the 24-mm thick WPB did not ignite even at 35 kW/m^2 (620 °C). It can be explained by the fact that when boards are covered with BAK-1 fire retardant solution and exposed to heat flows, it absorbed salts intumesce, forming an additional protective layer (see Fig. 3) over the board surface exposed to the heat flow, which retains a part of the heat flow. As a result, the board surface is heated to a lesser degree and the amount of emitted volatile pyrolysis products is smaller.

Most frequently, differences were observed when exposing 6 mm OSB and WPB to 35 kW/m^2 (620 °C) heat flow. After impregnation with fire retardant solution BAK-1, the ignition time of OSB extended

Table 1. The average moisture content and the TTI of non-impregnated wood products exposed to heat flows of different capacities (temperature)

Indicators	Average values of the TTI (s)				
	OSB (6 mm)	OSB (10 mm)	OSB (15 mm)	OSB (18 mm)	WPB (24 mm)
Moisture content, (%)	8	6	8	8	6
30 kW/m^2 (590 °C)	93.11	74.54	87.34	93.98	87.47
35 kW/m^2 (620 °C)	65.34	67.01	69.14	71.18	68.11
40 kW/m^2 (650 °C)	26.45	28.34	24.11	19.81	32.11
45 kW/m^2 (675 °C)	24.43	21.58	22.11	18.7	19.11
50 kW/m^2 (700 °C)	19.15	17.64	16.48	15.55	15.01

Table 2. The average moisture content and the TTI of impregnated wood products exposed to heat flows of different capacities (temperature)

Indicators	Average values of the indicators of samples (s)				
	OSB (6 mm)	OSB (10 mm)	OSB (15 mm)	OSB (18 mm)	WPB (24 mm)
Moisture content (%)	8	8	6	8	8
35 kW/m^2 (620 °C)	78.52	75.8	74.65	72.11	–
40 kW/m^2 (650 °C)	29.63	28.2	27.84	27.18	41.19
45 kW/m^2 (675 °C)	27.52	22.27	23.11	24.11	22.20
50 kW/m^2 (700 °C)	18.39	18.81	17.89	16.87	13.91

Fig. 3. Image of the intumescent protective layer which is formed during the test

by approximately 13 seconds, while WPB withstood the test and did not ignite.

When increasing the temperature, fire retardant provides worse protection against the impact of fire: the time differs from that of non-impregnated samples increasingly less and that difference amounts to 2–3 seconds on average. Therefore, it can be presumed that the impact of fire retardant is not as effective when increasing the temperature. When the heat flow of 50 kW/m^2 (700 °C) is reached, the results of impregnated products were similar to those of non-impregnated products; therefore, fire retardant becomes less effective at high temperatures. This might be explained by the fact that when exposed to high heat flows, the additional protective layer forming of the absorbed salts of the fire retardant arrests the heat flow; however, the heat flow that reaches the board surface is still sufficient for a concentration of the mix of pyrolysis gases and oxygen required for flame combustion.

Fig. 4. Flame retardant residues on OSB

On the other hand, OSB absorbs fire retardant solution differently, and one place of the board absorbs more salts, while another absorbs less. It can be observed after the test from the quantity of additional intumesced coating (Fig. 4).

The best result was achieved with WPB, which did not ignite at the heat flow of 35 kW/m^2 (620 °C) for as many as 23 minutes and more. The sample charred, although there was no flame, and it continued to smoulder. However, under the heat flow above 40 kW/m^2 (650 °C), fire retardant almost failed to protect WPB.

WPBs, 24 mm thick, and OSBs, 6 mm, were selected for further tests in accordance with the standard LST EN 13823:2010.

As may be seen from Figure 5, as soon as WPB was exposed to the flame of the main burner, the heat release rate immediately began to increase and the maximum heat release rate (HRR_{max}) was reached after approximately 160 seconds. The heat release rate is the most important fire property, which influences fire propagation speed and its physical and chemical properties (Mouritz *et al*. 2006). The change time of the HRR_{max} value has a particular importance: the shorter it is, the greater is the hazard for humans because if high temperatures are reached quickly, fire propagates faster blocking evacuation ways. When HRR_{max} is reached, heat release decreases as a result of the carbon layer, which inhibits the emission of flammable gases (Praniauskas *et al*. 2010). The decrease occurs gradually, and no heat surges as a

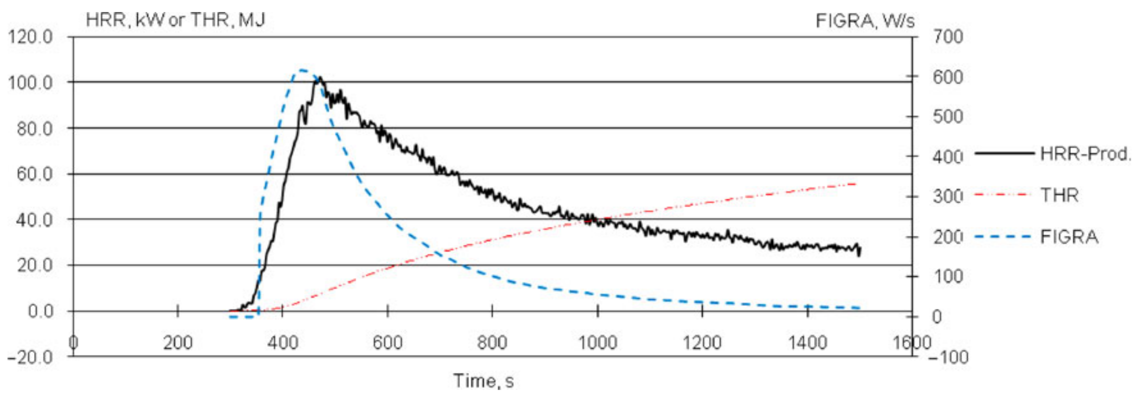

Fig. 5. HRR of non-impregnated 24 mm WPB

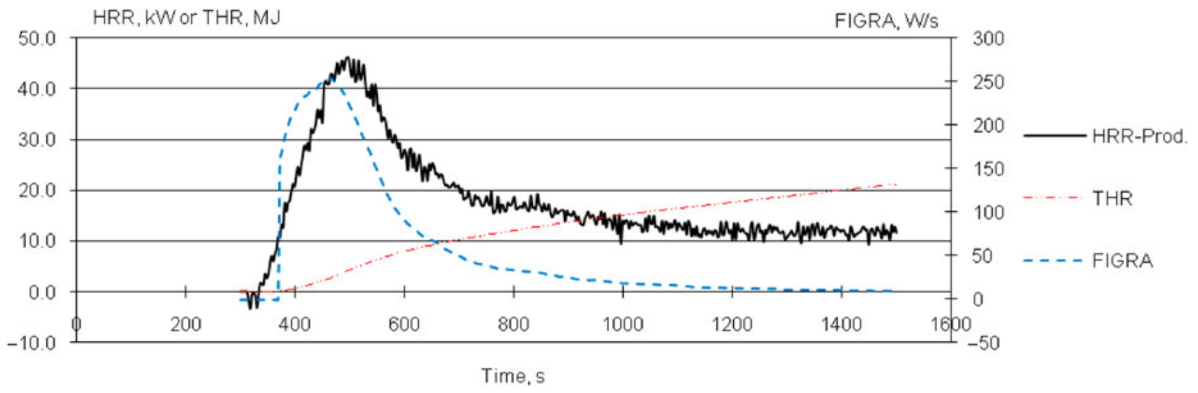

Fig. 6. HRR of impregnated 24 mm WPB. It was noticed that the amount of smoke released from a 24-mm thick WPB is nearly three times greater than that released from a non-impregnated board. It can be explained by the interaction between the fire retardant and a board as well as partial pyrolysis (Table 3)

result of the formation of cracks in the carbon layer are observed. The test was terminated in approximately 1500 seconds. According to FIGRA 0.2 MJ (the maximum relation between heat release rate and duration) equals to 615.7 [W/s], and the flammability class established according to LST EN 13501–1:2007 + A1:2010 standard is D (>250 [W/s] and ≤ 750 [W/s]).

Figure 6 presents the curve of the test of reaction of 2-mm-thick WPB impregnated with BAK-1 fire retardant solution to fire. The highest value of the relation of the heat release rate and duration FIGRA = 249.6 W/s. All the heat released from the sample during 600 s from the beginning of the exposure to the flame of the main burner THR_{600}=13.7 MJ. The total amount of heat released THR = 22 MJ. Within 10 minutes from the beginning of the exposure of the sample to the main burner, approximately 62% of the total heat emission was released, and approximately 38% of the total heat emission was released during the remaining 10 minutes. The HRR_{max} (HRR-Prod.) during the test was reached in approximately 4 minutes, after the sample was exposed to the flame of the main burner. In this case, the curves of HRR and FIGRA are very similar to those of WPB; however, they differ by values of these parameters. After WPB was impregnated with the fire retardant BAK-1 solution, the values of its parameters decreased as a result of the additional fire retardant protection.

According to the results obtained during the test, the WPB impregnated with BAK-1 fire retardant solution according LST EN 13501–1:2007 + A1:2010 is 120 W/s and ≤ 250 W/s and classified in C flammability class.

It was noticed that the amount of smoke released from a 24-mm-thick WPB is nearly three times greater than that released from a non-impregnated board. It can be explained by the interaction between the fire retardant and a board as well as partial pyrolysis (Table 3).

Table 3. Smoke release values of impregnated and non-impregnated WPB

Smokiness parameter	Non-impregnated WPB (24 mm)	Impregnated WPB (24 mm)
SMOGRA	7.8	19.5
TSP_{600}	43.6	96.9
TSP	165	180

SMOGRA – smoke growth rate. The maximum value of the relationship between the rate and duration of smoke formation from the sample) [cm^2/s^2];
TSP_{600} – the total quantity of smoke forming from the sample within 600 s (300 s ≤ t ≤ 900 s) from the beginning of exposure of the flame of the main burner [m^2];
TSP – the total quantity of smoke forming from the sample [m^2];
FIGRA – fire growth rate. The maximum relationship between HRR and duration [W/s].

The test with a non-impregnated OSB was terminated because of rapid ignition. Sharp increase in the heat release rate is demonstrated in Figure 7. The test reached the maximum values and was terminated in approximately 200 seconds from the start of exposure of the sample to the main burner. The image of the sample at the time of the test and later is presented in Figure 8. Figure 7 shows that at the time of the termination of the test as FIGRA0.2 MJ [W/s] ~ 3000.

A 6-mm-thick OSB impregnated with BAK-1 fire retardant solution showed better results (Fig. 9) than a similar non-impregnated board (Fig. 7), with the test of the latter having been terminated because of high parameters that exceeded all criteria. The maximum relationship between the heat release rate and the duration *FIGRA*=555.5 W/s. The total amount of heat released from the sample within 600 s from the beginning of exposure to the flame of the main burner THR_{600}= 20.8 MJ. The total amount of heat released *THR* = 22 MJ. Approximately 94% of the total heat was released within 10 minutes from the beginning of exposure of the flame of the main burner and around 6% was released within the remaining 10 minutes. This

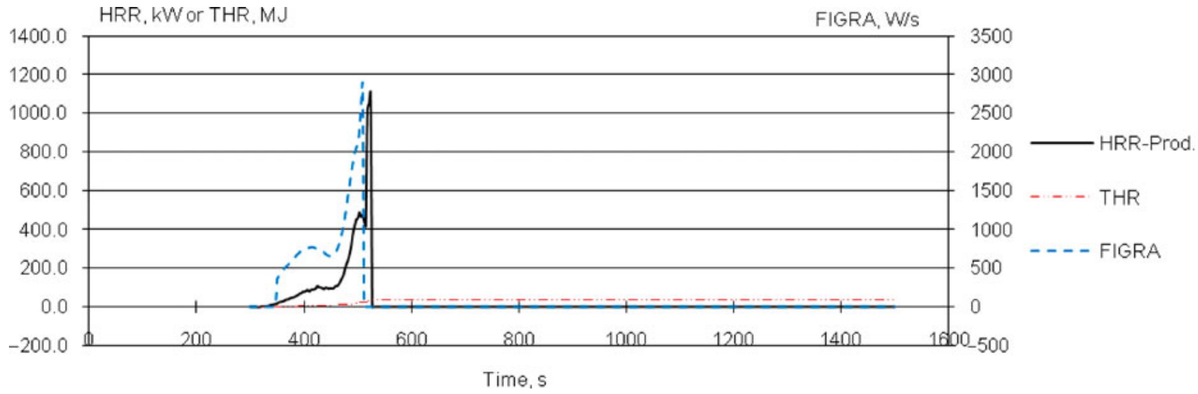

Fig. 7. HRR of non-impregnated 6 mm OSB

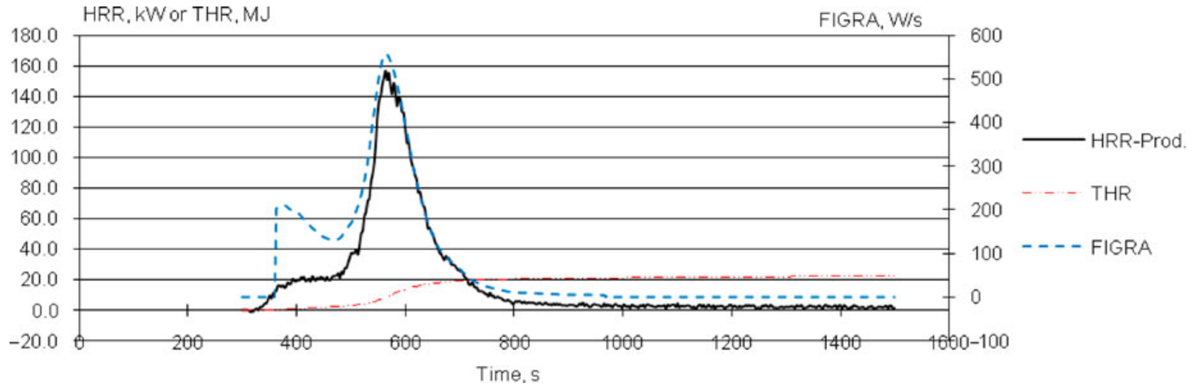

Fig. 8. Image of non-impregnated 6-mm-thick OSB during the test (a) and after terminating the test (b)

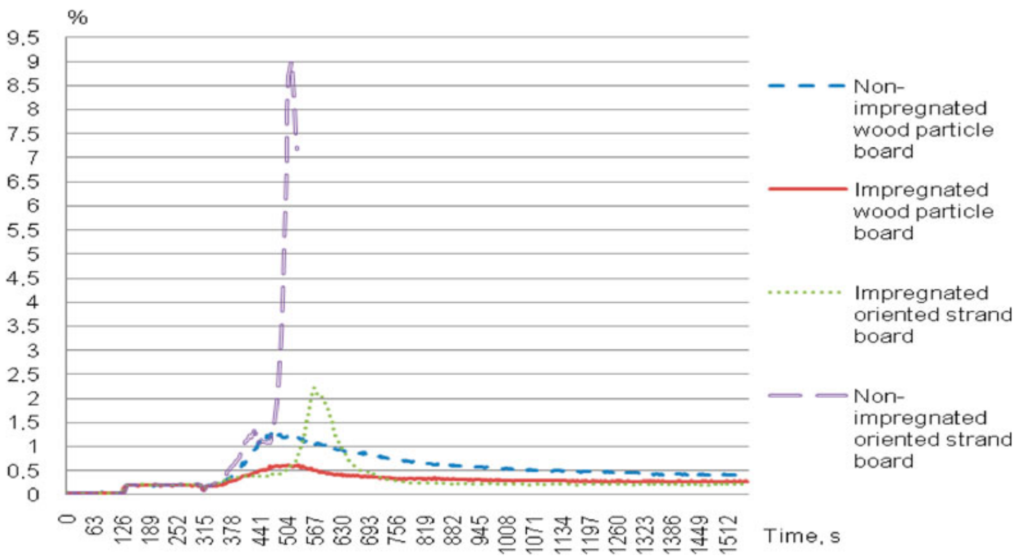

Fig. 9. HRR of impregnated 6 mm OSB

might have happened because after the first 10 minutes, the sample became burned through at the place where it was exposed to the flame and was no longer exposed to the flame. The HRR_{max} (HRR-Prod.) during the test was reached in approximately 5 minutes after the sample was exposed to the flame of the main burner (Fig. 9). According to the results obtained during the test, the OSB impregnated with BAK-1 fire retardant solution is classified in D flammability class.

Even after terminating the test on the basis of the values of SMOGRA, it can be concluded that smoke release rate decreased after impregnating the OSB with fire retardant solution. Therefore, the impact of

Table 4. Smoke release values of impregnated and non-impregnated (before terminating the test) OSBs.

Smokiness parameter	Non-impregnated OSB (6 mm)	Impregnated OSB (6 mm)
SMOGRA	82	36.1
TSP_{600}	–	176.5
TSP	–	220

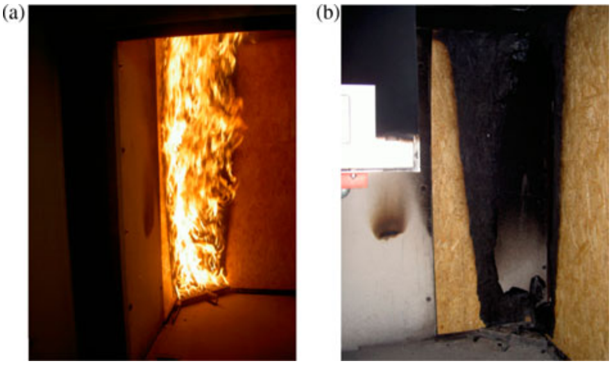

Fig. 10. CO_2 release test results of impregnated (BAK-1) and non-impregnated 6-mm-thick OSB and 24-mm-thick WPB

the fire retardant is absolutely positive in this case (Table 4).

Analysis of the emission of CO_2 determined during the tests shows that the amount of CO_2 emitted from wooden boards impregnated with BAK-1 fire retardant solution was lower than that from non-impregnated ones. CO_2 emission from non-impregnated OSB and WPB started to increase rapidly almost from the beginning of the test, as soon as the sample was exposed to the flame of the main burner. In the case of non-impregnated WPB, a CO_2 concentration limit of almost 1.3% was reached, while in the case of OSB, the hazardous CO_2 concentration limit of 1.5% was exceeded (Žukas *et al.* 2007) (Fig. 10). Impregnated OSB reached a CO_2 concentration limit of approximately 2.2%, and in the case of non-impregnated OSB, the CO^2 concentration limit was as high as 9% (Fig. 10). Therefore, fire retardant solution not only worsens the combustion properties of wood but also decreases the amount of CO_2 emission. As a result, there is a greater possibility to save lives as well as wealth.

The results of the tests performed in accordance with the standard LST ISO 5657:1999 were processed statistically in order to derive equations for forecasting the time to ignition. Three parameters were selected to derive the equations: TTI (time [S]), board thickness (thickness [mm]) and heat flow (Q [kW/m2]) to which the sample was exposed.

On the basis of regression analysis, it was established that the results obtained from the tests of non-impregnated and impregnated OSB (6, 10, 15 and 18 mm thick) and WPB (24 mm thick) were the most suitable to forecast the time to ignition. Since the correlation coefficients *R* of the first (*R* = 0.97826) and second (*R* = 0.98049) equation for non-impregnated boards were close to one, and the correlation coefficients *R* of the third (*R* = 0.99216) and fourth (*R* = 0.99415) equation for impregnated boards were also close to one, it can be concluded that the selected equation model with a turning point is correct, and there is a high interdependence between the parameters (Rudskienė, Kulvietienė 1995; Borovikov 1998; Kleinbaum *et al.* 1998).

Therefore, the following empirical equations can be used for the forecasting of time to ignition of non-impregnated (1) and (2) and impregnated (3) and (4) OSB and WPB:

$$y_1 = (52.128 - 0.683x_1)*(y_1 \le 45.276) + (201.774 - 3.818x_1)*(y_1 > 45.276); \quad (1)$$

$$y_2 = (60.725 - 0.762x_1 - 0.434x_2)*(y_2 \le 45.276) + (196.62 - 3.818x_1 - 0.421x_2)*(y_2 > 45.276); \quad (2)$$

$$y_3 = (74.334 - 1.137x_1)*(y_3 \le 34.74) + (299.813 - 6.416x_1)*(y_3 > 34.74); \quad (3)$$

$$y_4 = (75.430 - 1.106x_1 - 0.177x_2)*(y_4 \le 34.74) + (265.634 - 5.268x_1 - 0.488x_2)*(y_4 > 34.739), \quad (4)$$

where: $y_{1,2,3,4}$ – time to ignition [s]; x_1 – power of the superficial heat flow to which the sample was exposed [kW/m^2]; x_2 – thickness of OSB or WPB [mm]; *($y_{1,2} \le 45.27589$) means that the equation is applicable when time to ignition ≤ 45.27589 [s]. As demonstrated in Table 1, this equation is applicable when samples are exposed to heat flow power >40 [kW/m^2]; *($y_{1,2}$ >45.27589) means that the equation is applicable when time to ignition >45.27589 [s]. As suggested in Table 1, this equation is applicable when samples are exposed to heat flow power ≤ 40 [kW/m^2]; *($y_{3,4} \le 34.73916$) means that the equation is applicable when time to ignition ≤ 34.73916 [s]. As demonstrated in Table 1, this equation is applicable when samples are exposed to heat flow power >40 [kW/m^2], and the equation is applicable to WPB when samples are exposed to heat flow power >45 [kW/m^2]; *($y_{3,4}$>34.73916) – means that the equation is applicable when time to ignition >34.73916 [s]. As suggested in Table 1, this equation is applicable when samples are exposed to heat flow power ≤ 40 [kW/m^2], and the equation is applicable to WPB when samples are exposed to heat flow power ≤ 45 [kW/m^2].

Tables 5 and 6 present the forecasted TTI values calculated in accordance with the Eqns (1)–(4) as well as the actual average TTI values for impregnated and non-impregnated OSB and WPB. As the obtained

Table 5. Actual and forecasted values of TTI for non-impregnated OSB and WPB

Non-impregnated OSB and WPB											
	Actual *TTI* value (s)					*TTI* according to the Eqn (1), (s)	TTI according to the Eqn (2), (s)				
Q, kW/m^2	OSB (6 mm)	OSB (10 mm)	OSB (15 mm)	OSB (18 mm)	WPB (24 mm)	OSB (6 mm); OSB (10 mm); OSB (15 mm); OSB (18 mm); WPB (24 mm)	OSB (6 mm)	OSB (10 mm)	OSB (15 mm)	OSB (18 mm)	WPB (24 mm)
30	93.1	74.5	87.3	94.0	87.5	87.23	79.55	77.87	75.77	74.5	71.98
35	65.3	67.0	69.1	71.2	68.1	68.14	60.46	58.78	56.68	55.41	52.89
40	26.5	28.3	24.1	19.8	32.1	24.81	27.64	25.91	23.74	22.43	19.83
45	24.4	21.6	22.1	18.7	19.1	21.39	23.83	22.1	19.93	18.62	16.02
50	19.2	17.6	16.5	15.6	15.0	17.98	20.02	18.29	16.12	14.81	12.21

Table 6. Actual and forecasted values of *TTI* for impregnated OSB and WPB

Impregnated OSB and WPB											
	Actual TTI value (s)					TTI according to the Eqn (3), (s)	TTI according to the Eqn (4), (s)				
Q, kW/m^2	OSB (6 mm)	OSB 10 mm	OSB (15 mm)	OSB (18 mm)	WPB (24 mm)	OSB (6 mm); OSB (10 mm); OSB (15 mm); OSB (18 mm); WPB (24 mm)	OSB (6 mm)	OSB (10 mm)	OSB (15 mm)	OSB (18 mm)	WPB (24 mm)
35	78.5	75.8	74.7	72.1	–	75.25	84,18	76.37	73.93	72.47	–
40	29.6	28.2	27.8	27.2	41.2	28.85 (OSB); 43.17 (WPB)	30.13	29.42	28.54	28.00	43.20
45	27.5	22.3	23.1	24.1	22.2	23.17	24.67	23.89	23.01	22.47	21.41
50	18.4	18.8	17.9	16.9	13.9	17.48	19.07	18.36	17.48	16.94	15.88

results suggest, TTI values can be forecasted promptly and accurately enough in accordance with the Eqns (1) and (3). However, slightly more accurate results can be obtained when forecasting uses the Eqns (2) and (4).

Conclusions

The TTI of OSB and WPB when exposed to a heat flow with powers exceeding 35 kW/m^2 almost does not change compared to similar non-impregnated samples.

When exposed to a heat flow with power of 35 kW/m^2, some WPB samples did not ignite but rather charred. Therefore, it is recommended to use WPB impregnated with fire retardant.

The HRR_{max} (HRR) values (i.e. the highest amount of heat released during combustion) for all samples was reached after approximately 160 seconds after ignition. It is a very short period of time, which would pose danger to human life in case of real fire.

The best fire resistance properties were demonstrated by WPB impregnated with fire retardant solution, the fire growth rate (FIGRA) and the entire amount of heat released of which were almost 2.5 times lower than that of a non-impregnated board.

Fire retardant solution not only worsens the combustion properties of wood and increases the flammability class but also decreases the amount of CO_2 emission.

Prompt forecasting of the TTI (s) can be made according to the heat flow (*Q*, kW/m^2) to which the sample is exposed and more accurate forecasting is possible once its thickness (*D*, mm) is also taken into consideration. The aforementioned indicators are sufficient for making rather accurate forecasting and deciding on the combustibility of OSB and WPB.

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