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THE EFFECT OF THE HEAT FLUX ON THE SELF-IGNITION OF ORIENTED STRAND BOARD

Siegfried HIRLE, Karol BALOG

SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA,
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA,
INSTITUTE OF INTEGRATED SAFETY,
ULICA JÁNA BOTTU 2781/25, 917 24 TRNAVA, SLOVAK REPUBLIC
e-mail: siegfried.hirle@stuba.sk, karol.balog@stuba.sk

Abstract

This article deals with the initiation phase of flaming and smouldering burning of oriented strand board. The influence of heat flux on thermal degradation of OSB boards, time to ignition, heat release rate and mass loss rate using thermal analysis and vertical electrical radiation panel methods were studied. Significant information on the influence of the heat flux density and the thickness of the material on time to ignition was obtained.

Key words

thermal degradation, oriented strand board, thermal analysis, mass loss, heat release rate, time to ignition, heat flux

INTRODUCTION

Fire technical characteristics of materials such as flash temperature, self-ignition temperature, critical temperature of thermo-oxidative degradation, the rate of weight loss during combustion of materials are not physical-chemical constants, and are strongly influenced by the test conditions and the history of the sample (1, 2, 3, 4).

Application of fire technical parameters in practice, when assessing the fire hazard, such as flash point, ignition temperature and self-ignition temperature, is very difficult. Based on these data, we cannot accurately determine the safety distance of flammable materials from ignition sources (5, 4, 6).

When real fire occurs mainly in closed spaces, heat flux plays a significant role in the spread of fire especially radiation. In order to determine the critical heat flux to ignite materials, a large-size and various lab tests were used (7, 8). Currently, the most commonly used test method is based on the principle of oxygen consumption during combustion, and the ignition source is electrically heated by conical heater (9, 10,11,12).

MATERIALS AND METHODOLOGY OF EXPERIMENT

Samples of oriented strand board (OSB) from Kronospan Jihlava, marked OSB/3 SUPERFINISH ECO without any surface adjustments were chosen for the experiments (13). Dimension of the OSB boards samples were (165 x 165 x 8) mm, (165 x 165 x 14) mm and (165 x 165 x 25) mm. The selected board materials were conditioned at a room temperature of 23 °C ± 2 °C and at a relative humidity of 50 ± 5%.

Thermogravimetric analysis

Samples testing was performed using the TG method regarding to (14) a Mettler Thermal Analyzer 3000 TA with a processor TC 10A and a TG 50 weights module in a dynamic atmosphere of air and flow rate of 200 ml.min^{-1} at a heating rate of 10 °C min^{-1}.

Differential Scanning Calorimetry

The experiments were performed according to the standard EN ISO 11357: 2000 (15). Samples testing was performed using a Mettler Thermal Analyzer 3000 TA with a processor TC 10A and a DSC 20 measuring cell, in a dynamic atmosphere of air and flow rate of 50 ml.min^{-1} at a heat rate of 10 °C min^{-1} .

Method of Vertical Electrical Radiation Panel

Vertical Electrical Radiation Panel (VERP) heated by electric coils was used in the experiment (Figure 1). This panel is heated by electrical coils and has dimensions of 345 mm × 515 mm.

Fig. 1 *Vertical Electrical Radiation Panel with radiometer*

Vertical electrical radiating panel is powered from the electric grid by 400V and the electric output of emitter can be controlled using three circuit breakers. The emitter output can be regulated in the range of 5 kW, 10 kW and 15 kW. Sample is attached to a vertical sample carrier.

Installing the Radiometer and Adjusting the Heat Flux Density for the Tests

Heat flux density at a chosen distance was verified using the SBG01–200 radiometer regarding to ISO/DIS 14934-4 [10]. This radiometer is designed to measure the heat flux up to 100 kW.m^{-2}.

Installation of the heat flux meter to specimen: When a heat flux meter is installed into a specimen of OSB, holes are drilled in the specimen to accommodate the body of the heat flux meter. Table 1 shows the measured values of the heat flux for the chosen radiation output at a distance of 50 mm from the radiation source.

Table 1 The output impact of the electrically heated radiation panel on heat flux level at a constant distance from the testing samples

Radiation panel output	5 kW		10 kW		15 kW	
Source distance [mm]	Output voltage [V]	**Heat flux density [kW.m^{-2}]**	Output voltage [V]	**Heat flux density [kW.m^{-2}]**	Output voltage [V]	**Heat flux density [kW.m^{-2}]**
50	7.08	**31**	9.84	**44**	11.59	**53**

RESULTS AND DISCUSSION

The first step of thermal degradation investigated by TG analysis starts at 150 °C and ends at 380 °C. In this interval, the biggest weight loss of samples was 66.72%. The second step of thermal degradation starts at 380 °C and ends at 486 °C. The thermal decomposition of OSB samples took place in two stages. In the first stage, the highest rate of decomposition of OSB was at 326.7 °C, and in the second one at 450.3 °C (Figure 2).

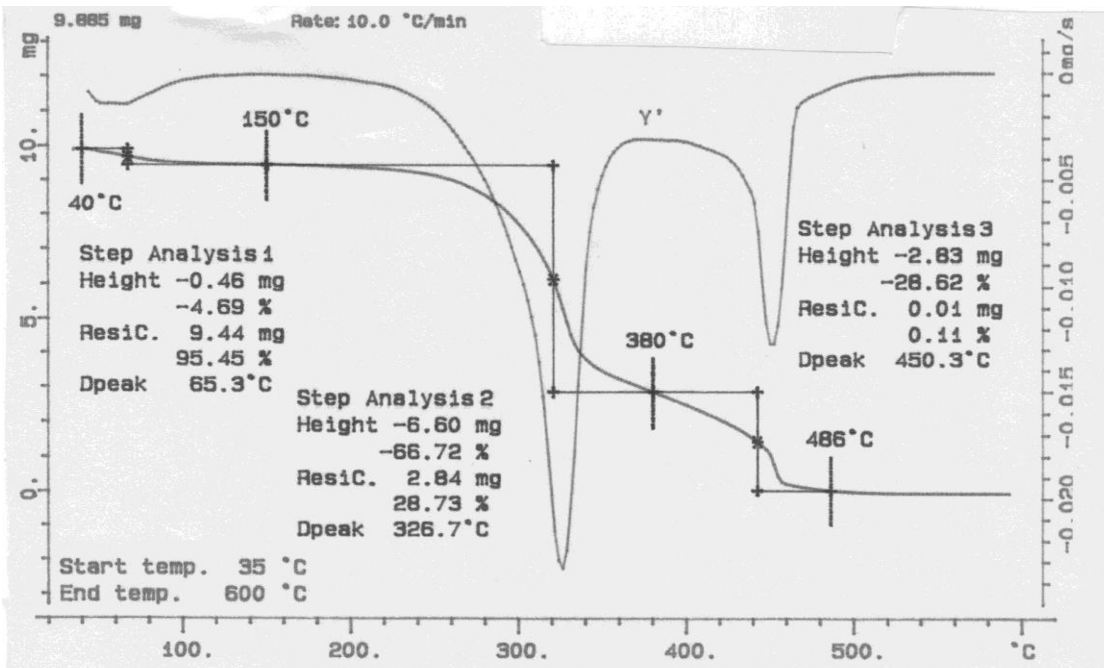

***Fig. 2** TG and DTG curves of OSB sample (heating rate 10 °C min^{-1} and flow rate of air 200 ml.min^{-1})*

The results of DSC are shown in Figure 3. The exothermic decomposition of the OSB sample at heat rate of 10 °C min^{-1} occurred from 220 °C and continued up to 560 °C. The temperature at which occurred the maximum heat release rate of OSB sample in air was 356 °C. The second peak occurred at 486.2 °C. The change in reaction enthalpy of the OSB sample was 9663.7 $J.g^{-1}$ and ΔH was 51.701 J.

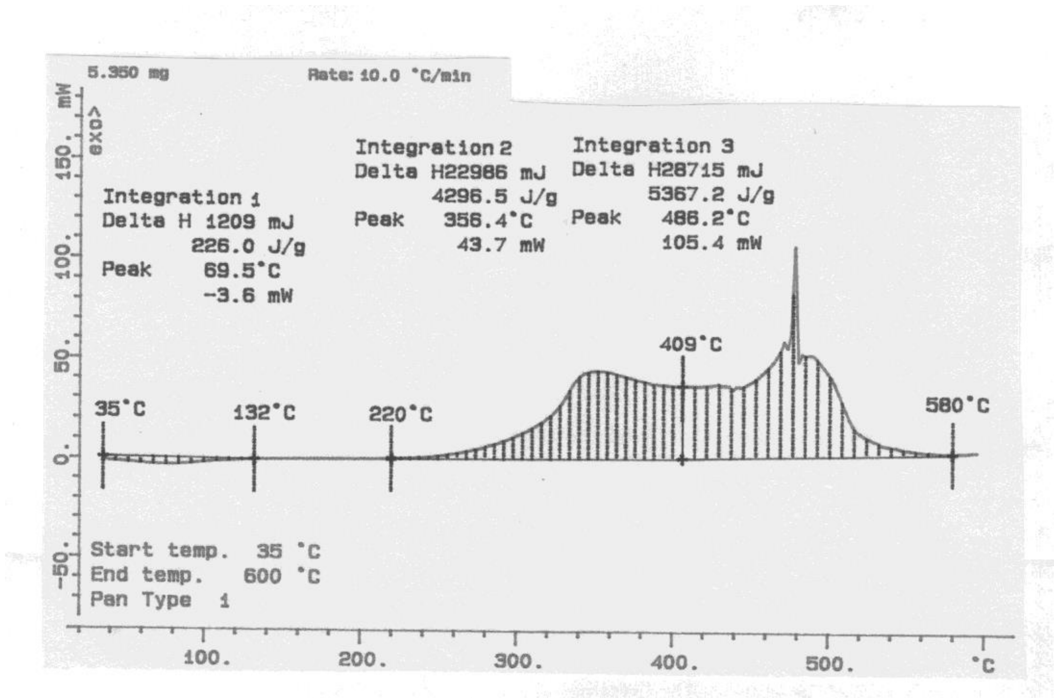

Fig. 3 *DSC curve of thermal decomposition of OSB in dynamic air flow*

The effect of the heat flux on the self-ignition of the OSB by using method of VERP

For each heat flux 31 $kW.m^{-2}$, 44 $kW.m^{-2}$ and 53 $kW.m^{-2}$ were conducted seven measurements for determining the time to flaming ignition of OSB samples by thickness of 8 mm, 14 mm and 25 mm. The distance from the surface of the electrically heated radiator to the specimen surface was constant 50 mm. It was found that when heat flux 31 $kW.m^{-2}$ is applied to the samples surfaces, there is no flame combustion within less than 10 minutes. With such mode, the thermal load generates on the surfaces enriched carbon layer. Also, when using OSB samples with a thickness of 8 mm, 14 mm and 25 mm, heat flux was insufficient to ignite the samples and there was observed only process of smouldering. On the surface, a continuous carbon layer was formed.

In the following experiment, we increased the intensity of the heat flux to 44 $kW.m^{-2}$. All samples at heat flux 44 $kW.m^{-2}$ were ignited and flame combustion occurred during experiments. Average time to ignition for 8 mm thick sample was 68 seconds, for 14 mm thick sample the time to ignition dropped to 54 seconds. Figure 4 show the burning mode for the selected heat flux 44 $kW.m^{-2}$. Using the heat flux of 44 $kW.m^{-2}$ the sample of 25 mm thickness has the time to self-ignition 58 seconds. The OSB samples exhibit a strong surface degradation with formation of a carbon layer on the surface. In the first stage, the degradation is caused by the flame combustion, while in the second phase by decomposition during flameless combustion (Figure 4).

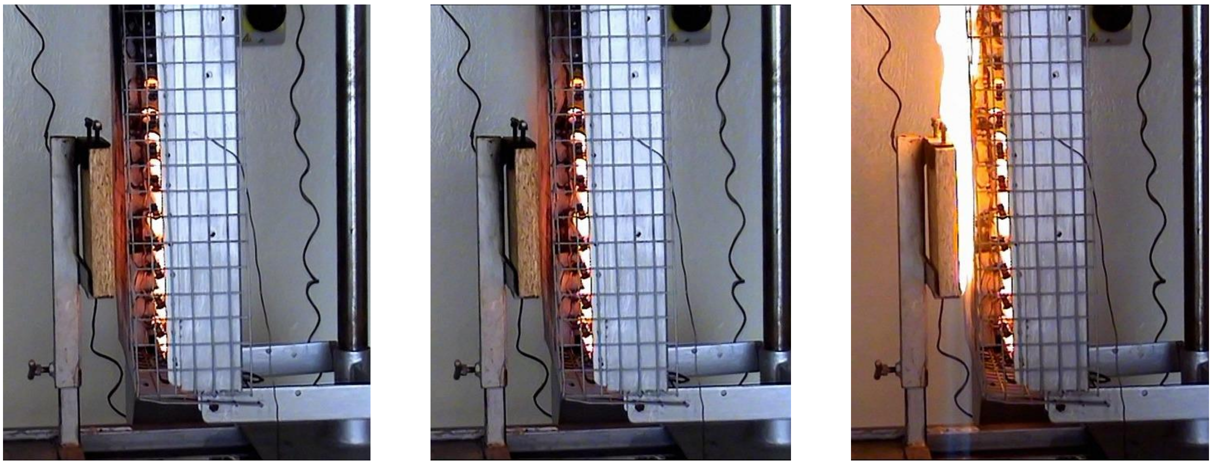

Fig. 4 *Ignitability experiment of 25 mm thick OSB board under 44 kW.m^{-2} heat flux*

At the heat flux 53 kW.m^{-2} during the experiment, each sample was self-ignited. Figure 5 show the burning mode for the selected heat flux of 53 kW.m^{-2}.

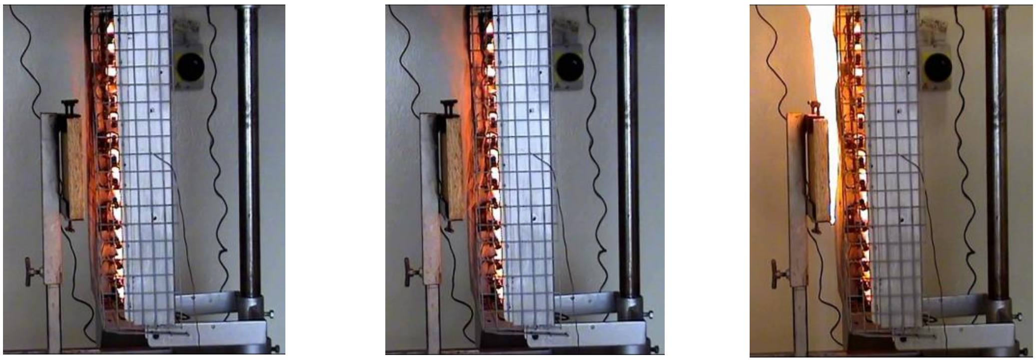

Fig. 5 *Ignitability experiment of 25 mm thick OSB board under 53 kW.m^{-2} heat flux*

Average time to self-ignition of 8 mm 0SB board at heat flux 53 kW.m^{-2} was 38 s. Bigger difference was even measured between the 14 mm (time to self-ignition 41 s) and 25 mm samples (time to self-ignition 54 s). We can assume that the samples thickness has influence on the time to self-ignition. Figure 5 shows the OSB board samples thickness of 25 mm exposed to the heat flux of 53 kW.m^{-2} until flame combustion was on.

In conclusion, we can say that the time to ignition and fire behaviour of samples are influenced by their thickness; however, the value of the heat flux is crucial (Figure 6). The three stages of combustion process, pyrolysis, burning and char oxidation, are closely interrelated.

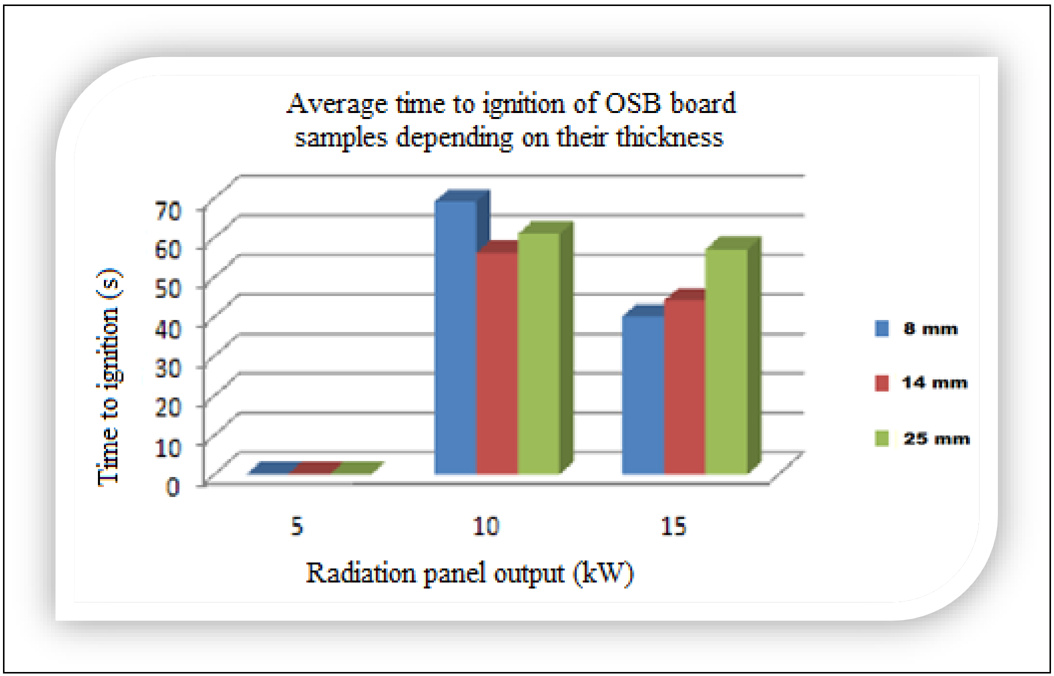

Fig. 6 *Average time to ignition of the OSB board samples depending on their thickness*

CONCLUSION

The studies clearly indicate that the time of self-ignition of the OSB specimens strongly depends on the heat flux density and the orientation of the sample. Results achieved using the VERP methods are very useful in the fire hazard analysis. Therefore, further research on the ignition parameter, the type of radiator, the presence of the pilot flame, and the time of thermal load would be a useful continuation for clarifying the burning process in the initiation phase of fire.

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ORCID:

Karol Balog 0000-0002-0804-8338