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STUDIES ON THERMOKINETIC FIRE PROPERTIES OF THERMOPLASTIC BONDED PARTICLE BOARDS (WPC)

STUDIE TERMOKINETICKÝCH POŽÁRNÍCH VLASTNOSTÍ TERMOPLASTOVÝCH LEPENÝCH DŘEVOTŘÍSKOVÝCH DESEK (WPC)

Abstract

Studies on thermokinetic properties of wood derived boards with plastic additives was carried out for three types of materials: control board (a traditional particleboard), polyethylene bonded particleboard and polypropylene bonded particleboard. Method "Cone calorimeter" was used as a tool. The examined material placed horizontally with reference to radiator was subject to thermal radiation flux with intensity of 30, 50 and 70 kW/m^2. The combustion reaction was initiated by ignition. During tests, the following parameters were determined: time to ignition (TTI), heat release rate (HRR), total heat release (THR), average specific mass loss rate (MLR), average heat release rate to 180 s (from initiation), heat of combustion (HOC)

Key words: fire properties, WPC, thermoplastic bonded particle board, cone calorimeter

Abstrakt

Byly provedeny studie termokinetických vlastností desek materiálů na bázi dřeva s plastickými aditivy pro tři typy materiálů kontrolní vzorků (tradiční dřevotřísková deska), dřevotřísková deska lepená polyethylenem a dřevotřísková deska lepená polypropylenem. Jako nástroj byla použita metoda "Kónický kalorimetr". Zkoumaný materiál umístěný horizontálně vzhledem k zářiči byl vystaven toku tepelného záření s intenzitami 30, 50 a 70 kW/m^2. Spalovací reakce byla iniciována zapálením. Během testů byly stanoveny následující parametry: doba do zapálení (TTI), rychlost uvolňování tepla (HRR), celkové uvolněné teplo (THR), průměrná specifická rychlost ztráty hmoty (MLR), průměrná rychlost uvolňování tepla až 180 s (od iniciace), spalné teplo (HOC)

Klíčová slova: požární vlastnosti, WPC, termoplastová lepená dřevotřísková deska, kónický kalorimetr

Introduction

Production of wood derived boards makes a significant branch of woodworking industry. The boards are made for building purposes and used for furniture production mainly. The boards used as interior decorations, insulation, construction and lining elements must comply not only with high strength but with high fire resistance requirements also. Today, buildings and building materials must comply with high fire safety requirements. The new buildings and the existing ones must comply with the conditions as provided by fire protection regulations.

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As far as fire safety is concerned, the materials used for building industry should be characterized by low combustion heat, low smoking intensity in fire conditions and toxicity of combustion products should be leas possible. Producers of wood derived building elements do their utmost to ensure full safety by realization of the goals as mentioned above. To cope with various requirements and expectations, more and more new wood derived materials production technologies are come into being. Wood derived composites, joining wood with non wood materials, are one of the directions aimed at by woodworking industry. WPC (Wood Plastic Composites) are most widely used [1 - 9]. These are materials made on the basis of joining wood particles with thermoplastics. The WPC production market becomes more and more developing. The plastics used for this technology come from post production waste frequently. The production of WPC composites is thus quite substantial for protection of natural environment. In general it can be stated that WPC are characterized by low production costs, adequate strength and rigidity, biodegradation capacity, renewability and flexibility used during processing. WPC production process proceeds at two stages: (1) joining wood particles, thermoplastics and additional substances into uniform mixture, (2) forming a ready products from prepared mixture. The raw materials needed for WPC production are primary or recycled thermoplastics (polyethylene, polypropylene, polystyrene, polyvinyl chloride) [1 - 2]. Selection of thermoplastics depends on specific application of the product. Typical WPC is made during processes, applied in production of plastics, i.e extrusion or injection. Thermoplastics bonded particleboards can be made basing on the idea of WPC composites also. These are characterized by properties similar to WPC composites on one hand and to production of typical wood materials as far as technological process is concerned on the other.

Composite materials, joining wood particles and thermoplastics (WPC or their derivatives) have not been widely used in Poland for building yet. To make it happen so, various scope of research is needed to confirm the properties adequate to start commercial production.

Experimental Data

Traditional particleboards (glued with urea-formaldehyde resin) and single layer thermoplastic bonded particleboards, i.e. polyethylene (PE) and polypropylene (PP) have been used for experiments. The boards have been made at Department of Wood Based Panels, Faculty of Wood Technology, Warsaw University of Life Sciences - SGGW.

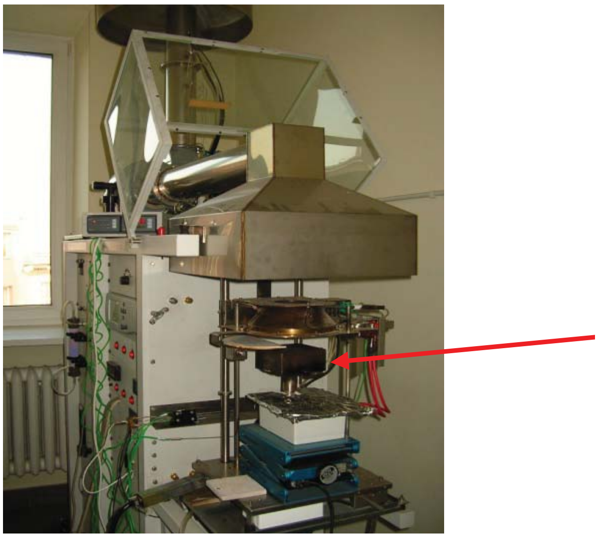
The PE and PP bonded particleboards were made with weight ratio of 30 % thermoplastics and 70 % pine chips, generated in industrial conditions of particleboard factory. Mixing of the components (thermoplastic + wood chips) and formation of the boards was made manually with the use of a special mould. Compression was carried out by one shelf press, maintaining the following parameters:

1. pressing time: 10 min.
2. pressing unit pressure: 2.5 MPa
3. pressing temperature: 190 degrees C
4. cooling time (in a cold mould with assumed unit pressure): 10 min.

The boards were conditioned after manufacturing, in laboratory conditions, for 7 days and then samples for further examinations were taken.

Experimental test were conducted accordance with ISO 5660-1 [10] (Fig. 1 and 2) in the Institute of Combustion and Fire Theory of the Main School of Fire Service in Warsaw.

During tests, the following parameters were determined: time to ignition (TTI), heat release rate (HRR), total heat release (THR), average specific mass loss rate (MLR), average heat release rate to 180 s (from initiation), heat of combustion (HOC).



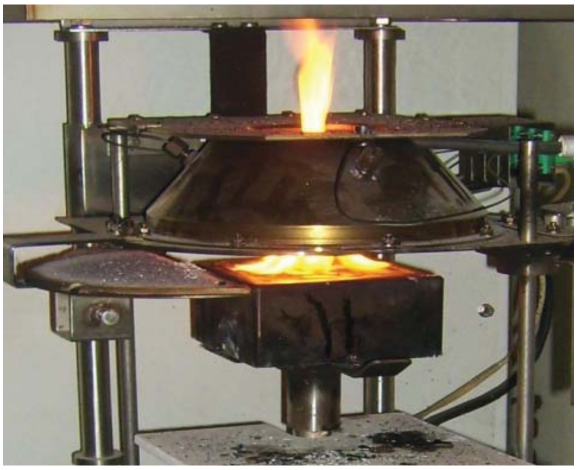


***Fig.1:** Cone calorimeter*

***Fig.2:** The frame with burning of sample*

The tests were conducted in accordance ISO 5660-1 on samples with dimensions of 100 mm x 100 mm x 10 mm (100 mm x 100 mm x 18 mm The tested material was mounted on a metal frame. The samples were affected by the external heat flux (infrared radiator) of 30, 50 i 70 kW/m with spark igniter.

Results

The results are presented in fig. 3 - 8 and tab. 1.

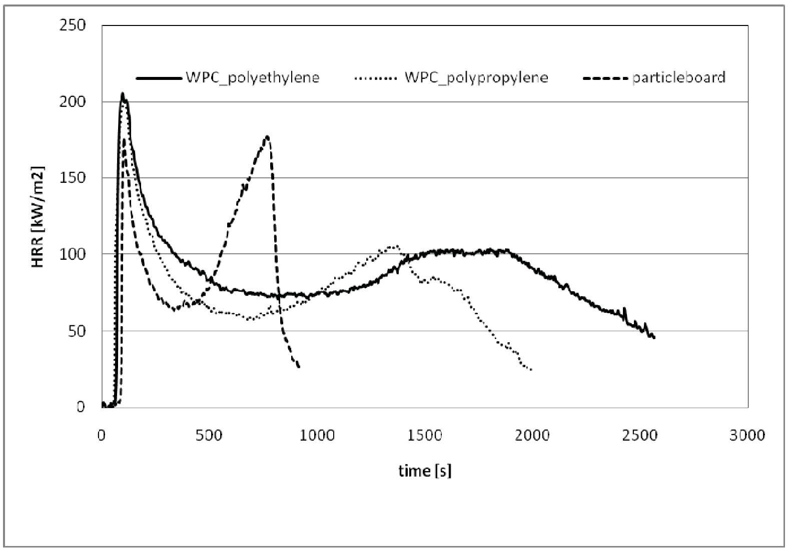


***Fig. 3:** Heat Release Rate of WPC; external heat flux 30 kW/m²*

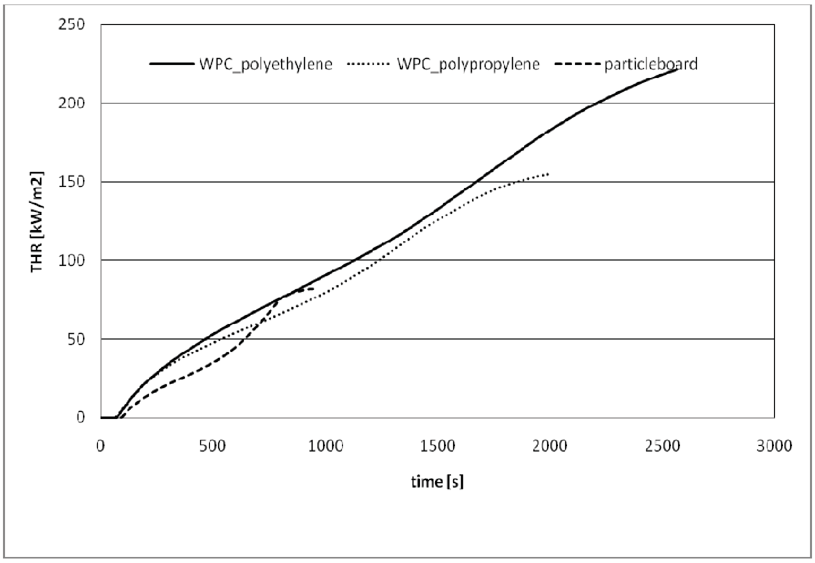


Fig. 4: *Total Heat Release Rate of WPC; external heat flux 30 kW/m²*

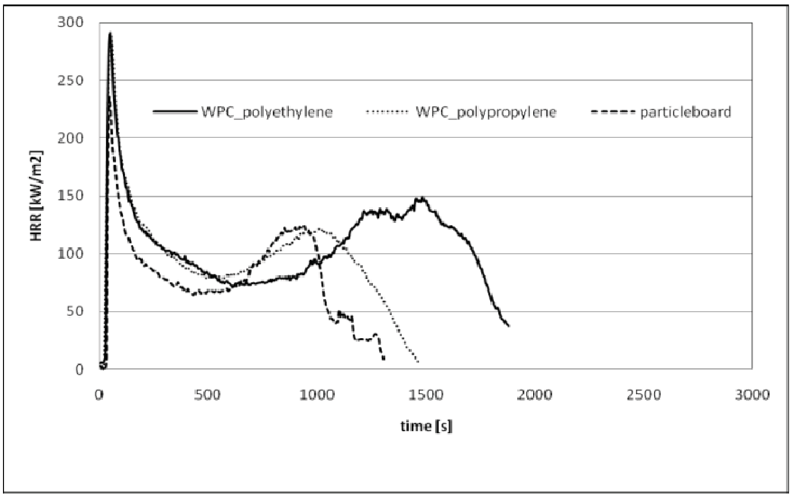


Fig. 5: *Heat Release Rate of WPC; external heat flux 50 kW/m²*

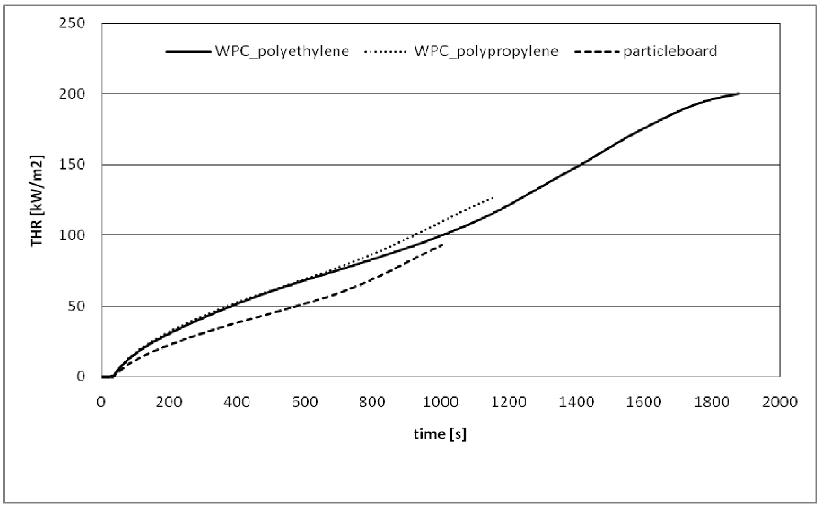


Fig. 6: *Total Heat Release Rate of WPC; external heat flux 50 kW/m²*

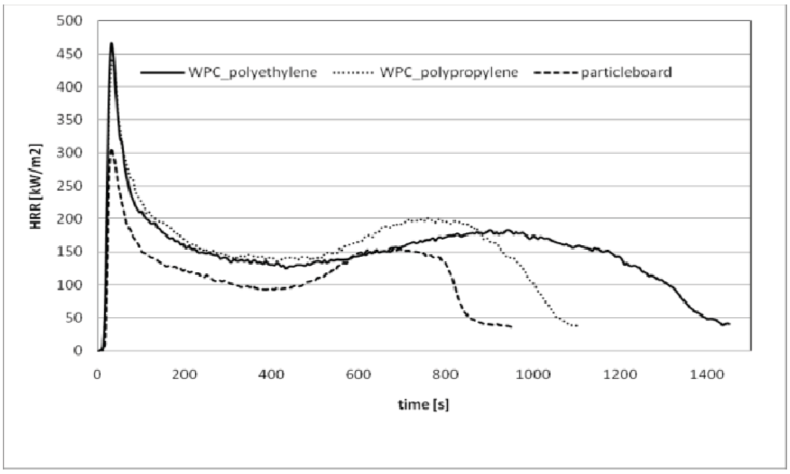


Fig. 7: *Heat Release Rate for WPC; external heat flux 70 kW/m*^{2}

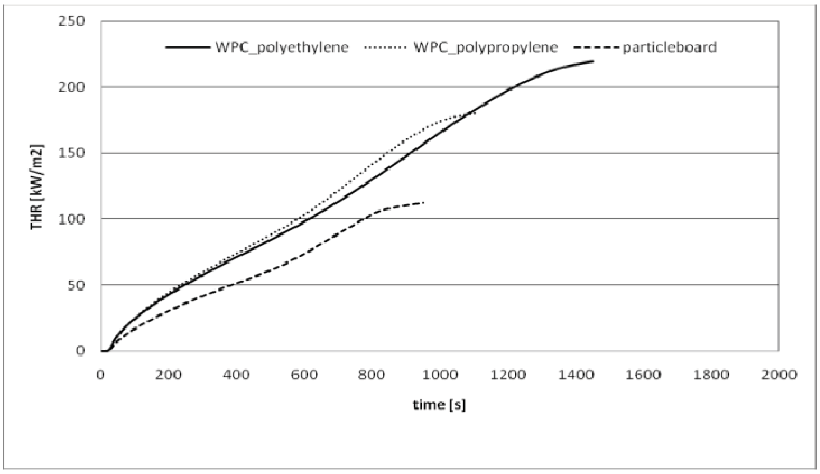


Fig. 8: *Total Heat Release Rate for WPC; external heat flux 70 kW/m*^{2}

Conclusions

From the above plots and table, the following conclusions could be drawn:

1. During tests it has been observed that the traditional particle boards are ignited and sustain flames after a longer period in comparison with the WPC materials. It is especially noticeable for exposures to the radiative heat flux of 30 kW/m2.
2. The analysis of HRR history (fig. 3-8) indicates that independently from the sample tested, there are two maximum peaks on the plot. The time to reach first peak is generally similar for all tested materials.
3. Materials with synthetic additions are showing higher HRR values when compared to traditional particle boards regardless to the level of the radiative heat flux applied.
4. Analysing the duration of the flaming combustion it can be stated that the combustion was sustained for longer periods in case of WPC materials.
5. The average heat of combustion in case of WPC samples was higher by 60 - 100 % when compared to the traditional particle board.
6. The highest amount of the total heat released was observed for samples with addition of PE regardless of the radiative heat flux applied.

Table 1: *Average values of thermokinetic parameters for research materials according to cone calorimeter tests*

Parameter	Unit	Material		
External Heat of Flux 30 kW/m²				
		Control particle-board	**PE/wood**	**PP/wood**
Time to ignition (TTI)	s	85	62	52
Average mass loss rate (MLR)	g/sm²	9,76	4,99	5,40
Average HRR T 180	kW/m²	104,50	157,11	147,46
Average Heat of Combustion (HOC)	MJ/kg	10,75	18,55	16,02
External Heat of Flux 50 kW/m²				
Time to ignition (TTI)	s	27	22	18
Average mass loss rate (MLR)	g/sm²	8,77	6,01	7,65
Average HRR T 180	kW/m²	130,75	173,47	191,30
Average Heat of Combustion (HOC)	MJ/kg	11,63	18,88	18,99
External Heat of Flux 70 kW/m²				
Time to ignition (TTI)	s	10	10	10
Average specific mass loss rate (MLR)	g/sm²	12,26	8,57	10,08
Average HRR T 180	kW/m²	168,03	230,83	239,84
Average Heat of Combustion (HOC)	MJ/kg	11,04	19,95	17,88

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