Annals of Warsaw University of Life Sciences – SGGW
Forestry and Wood Technology No 75, 2011: 181-184
(Ann. WULS-SGGW, Forestry and Wood Technology 75, 2011)

Analysis of selected flammability properties of wood-polymer composites (WPC) used in noise barriers

MARCIN OSZUST[1], MARZENA PÓŁKA[2], PAWEŁ OGRODNIK[1]
[1]Department of Applied Mechanics – The Main School of Fire Service, Warsaw, Poland
[2]Department of Combustion and Fire Theory – The Main School of Fire Service, Warsaw, Poland

Abstract: *Analysis of selected flammability properties of wood-polymer composites (WPC) used in noise barriers.* In the article an analysis was carried out of selected combustible properties of WPC, designated as an input material for the production of noise barrier profiles. To analyse the combustibility of noise barriers tests were carried out related to inflammability, thermostability, calorific effect and the rate of heat release from the tested composite materials. The presented test results allowed a complementary analysis of combustible properties of the tested composites in heat and flow exposition similar to the fire environment.

Keywords: wood-polymer composites (WPC), combustibility, noise barriers.

1. INTRODUCTION

Composites are a group of materials with a combination of various raw materials thanks to which it becomes possible to obtain the selected desired properties of an element, which would have been impossible in monolithic structures [1]. The wood-polymer composites (WPC) are especially more and more frequently applied in construction industry. Those are composite materials based on polymer as a warp, in the case of which various wood fractions could be the fillers. Polymer materials used to produce WPC are available as primary granulates (PVC, PP, PE), but may also come from recycling [2]. The filler used to produce WPC may be of different origins and may be in various forms: splinters or various types of chips [3]. The wood filler, which constitutes even 70% of the composite filling, may come from waste generated during tree felling or during the consequent timber processing. Use may also be made of wood waste from such products as furniture, pallets and even crushed medium density fibreboards [4]. The introduction of wood-polymer composite as a material for the construction of large sized precast elements continues to be an innovative and developing activity. This concerns in particular precast elements with a length of up to a few metres, which are applied in noise barriers. They should also have the appropriate fire properties, thanks to which the use of such barriers while they are exposed to thermal exposures created during fires of vehicles on the road or fires of road surroundings behind the noise barrier is safe for human health and life.

Those properties, which are only partly allowed for in domestic regulations and standards [5], will be taken up in this article in a much wider way and reviewed in more detail.

2. DESCRIPTION OF RESEARCH METHOD AND SAMPLES

To determine the selected combustible properties of noise barriers, the following tests were carried out:

- Testing the ignitability with the low flame method according to the standard PN-EN-ISO 11925-2:2004 was carried out on six standardised samples with dimensions of 250mm×90mm. Two times of flame impact were applied: 15s and 30s.

- A determination was made of the combustion heat of the tested material using the Cleveland open cup method according to the standard PN-EN ISO 1716:2010. From the supplied composite mass 3 samples were taken for needs of tests with a weight of 1.0 g.
- The value of the ignition temperature was determined according to the standard PN-69/C-8922. The tested material was broken up into pieces with dimensions from 0.5mm to 1.0mm and placed in samples with a weight of 1±0.1g.
- A heat release rate analysis was carried out according to the standard ISO 5660:2002 using a cone calorimeter. For needs of a series of tests, for one material 5 samples were chosen with dimensions of 100 x 100 x 5mm that were subjected to a heat flow, the value of which amounted to 50kW/m^2.
- A thermogravimetric analysis was carried out according to guidelines contained by the standard PN-EN ISO 11358:2004 on samples of the tested material with a weight of 6.659 mg. The tests proceeded with the use of the dynamic technique at the furnace heating rate of 10°C/min, within the temperature range of 20°C - 900°C.

3. MATERIAL

The material used for tests was the wood-polymer composite (WPC) used for production of noise barriers. Those are prototype elements, which are soon to be entered onto the market. The manufacturer and supplier of samples for the needs of tests is a company called Moller Polska Sp. z o.o. with a registered seat in Zielone Błota. The proprietary name of the noise barrier is a Kinrok-Akustik panel. The polymer fabric is PVC amounting to 50%, while the filler is a beech wood flour also amounting to 50% of composite filling.

4. RESULTS

Results of inflammability tests with the low flame method according to the standard PN-EN-ISO 11925-2:2004 were presented in table 1 while results of tests of combustion heat determination with the Cleveland open cup method according to the standard PN-EN ISO 1716:2010 and values of ignition temperature according to the standard PN-69/C-8922 were presented in table 2.

Table 1. Results of inflammability tests according to the standard PN-EN-ISO 11925-2:2004

Ignition after 15s	Ignition after 30s	Does the peak reach 150mm and the time after which it occurs	Production of droplets	Ignition of filtering paper
No	No	No	No	No

Table 2. Results of tests of combustion heat determination by the Cleveland open cup method according to the standard PN-EN ISO 1716:2010 and the ignition temperature according to the standard PN-69/C-8922

Average value of combustion heat	Average value from 3 determinations of ignition temperature
25.50 MJ/kg	250 ^{o}C

Results of tests of the heat and smoke release rate according to the standard ISO 5660:2002 were presented in table 3 and on figure 1.

Table 3 . Thermokinetic properties of the tested material determined according to the standard ISO 5660:2002.

Thermokinetic parameters	HRRmax [kW/m^2]	HRRav [kW/m^2]	SEAav [m^2/kg]	HRR t60* [kW/m^2]	HRR t180* [kW/m^2]	HRR t300* [kW/m^2]
Heat exposure	50 kW/m^2					
Results	188	117	383	128	123	126

-* **HRR t60, HRR t180, HRR t300** – total heat release rates by the material in correctly tested time intervals: 60s, 180s and 300 s from the time of sample testing.

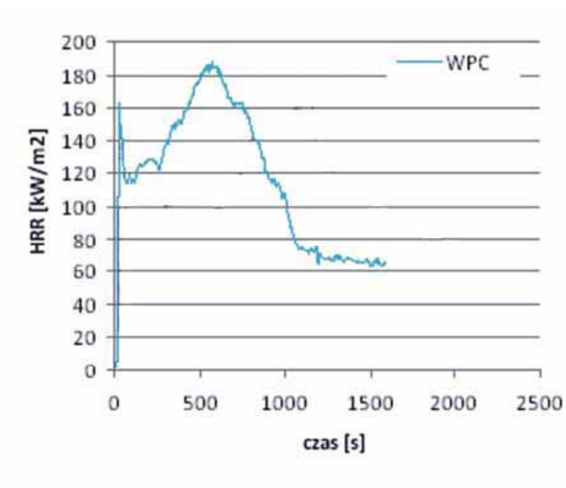

Fig. 1. Heat release rate HRR

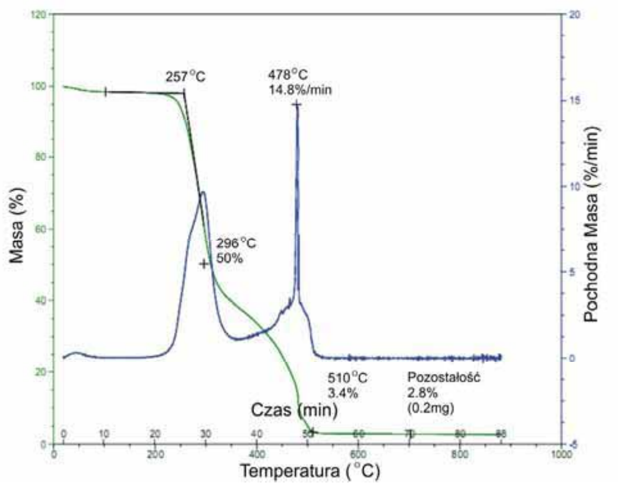

Fig. 2. TG and DTG curves.

Results of tests of thermogravimetric analyses according to the standard PN-EN ISO 11358: 2004 are presented in table 4 and on figure 2.

Table 4. Results of tests of thermogravimetric analyses for the tested material according to the standard PN-EN ISO 11358: 2004

Temperature of decomposition start	Temperature of a 50% weight loss	Temperature of the maximum rate of weight loss	Maximum rate of weight loss	Remaining that does not undergo decomposition	Temperature of the end of decomposition
257°C	296°C	478°C	14,8%/min	2,8%	510°C

5. DISCUSSION OF RESULTS

- During tests of the ignitability by the low flame method, samples of the tested material were not ignited in contact with the flame. After removal of the flame samples proved to have been carbonised to a depth of ca. 1cm in the case of flame impact of 15s and 3cm for the flame influence time of 30s, at surface exposition, with small smoke quantities generated.
- During testing with the use of a cone calorimeter, two HRR peaks may be observed on the diagram, which form the so-called “saddle” between those peaks. This phenomenon is characteristic for a process in which on the composite surface a carbonised layer is formed that forms a barrier for heat and oxidiser.
- On the basis of thermogravimetric curves it was found that phase 1 of material decomposition commences at a temperature of 257^{O}C and that the biggest weight loss occurs in it. The sample looses a half of its weight at a temperature of 296^{O}C. In stage 1 of the transformation the smallest rate of weight loss may be observed as compared to stage 2 of the transformation, in which it reaches the maximum value equal to 14.8%/min. The thermal decomposition of the WPC materials ends at a temperature of 510^{O}C.

6. RESULTS

The conducted tests allow the presumption that the tested material does not spread fire from a low flame. It forms a carbonised layer on the sample surface, which acts as a barrier for the external heat flow, oxygen and products of thermal decomposition and combustion. Given the value of combustion heat it was by approx. 20-30% higher than the value of the combustion heat for typical wood samples. The cause of an increase in the combustion heat value for WPC is the admixture of a polymer fabric. The value of ignition temperature is typical for wood and similar wood-based materials, for which the value of ignition temperature ranges between 250 – 280^{O}C. Given the value of the heat release rate from WPC contained in the noise barriers at an external heat exposure of 50kW/m^2 and the time until ignition it may be presumed that the combustible gas phase undergoes relatively quickly to piloted ignition (3s). This shows that in thermal expositions that characterise the incipient stage of a fire, the tested composite material relatively easily undergoes initiation of the combustion reaction, but also form a carbonised coat on the sample surface within a short time, which cracks as an effect of the intensity of the decomposition and combustion process, increasing the rate of released heat (maximum on the HRR curve). The maximum heat release rate from the tested material is more or less similar to the value of wood-based materials. However, the amount of generated smoke (the value of SEA_{av}) as compared to other polymer composites is on a relatively low level. The thermal stability of WPC proves that the tested material had many more features of a wood-based material.

REFERENCES:

1. BORYNIEC S., PRZYGOCKI W., 1999: Procesy spalania polimerów. Cz III. Opóźnianie spalania materiałów polimerowych, Polimery nr 10, 656-665.
2. ZAJCHOWSKI S., TOMASZEWSKA J., 2008: Kompozyty polimerowo-drzewne, Teka Kom. Bud. Ekspl. Masz. Elektrotech. Bud.- OL PAN, 183-188.
3. BLEDZKI A.K., LETMAN M., TANCZOS I., PUTZ R., 2006: Acetylation and coupling agent effect of wood fibre on the physical and mechanical properties of WPC, 6th Global Wood and Natural Fibre Composites Symposium, Kassel.
4. GOZDECKI C., KOCISZEWSKI M., ZAJCHOWSKI S., PATUSZYŃSKI K., 2005: Wood-based panels as a filler of wood-plastic composites, Ann. Warsaw Agric. Univ., Forestry and Wood Technology nr 56, 255.
5. PN-EN 1794-2:2005 Drogowe urządzenia przeciwhałasowe. Wymagania pozaakustyczne. Część 2: Ogólne bezpieczeństwo i wymagania ekologiczne.

Streszczenie: *Analiza wybranych właściwości palnych kompozytów drewno-polimer (WPC) używanych na ekrany akustyczne.* W artykule przeprowadzono analizę wybranych parametrów palnych kompozytu WPC, przeznaczonego, jako materiał wyjściowy do wytwarzania profili ekranów akustycznych. W celu dokonania analizy palności ekranów akustycznych przeprowadzono badania dotyczące zapalności, termostabilności, wydajności cieplnej i szybkości wydzielania się ciepła z badanych kompozytów. Przedstawione wyniki badań pozwoliły na komplementarną analizę właściwości palnych badanych kompozytów w ekspozycji cieplno - przepływowych zbliżonych do środowiska pożaru.

Corresponding authors:

Marcin Oszust, Paweł Ogrodnik
The Main School of Fire Service, Department of Applied Mechanics
ul.Słowackiego 52/54, 01-629 Warsaw
E-mail address: mechanika@sgsp.edu.pl

Marzena Półka
The Main School of Fire Service, Department of Combustion and Fire Theory
ul.Słowackiego 52/54, 01-629 Warsaw
E-mail address: mpolka@sgsp.edu.pl