POTENTIAL APPLICATIONS OF BASALT FIBER COMPOSITES IN PASSIVE FIRE PROTECTION

P. Sántha[a], P. Tamás-Bényei[a,b]

[a] *Department of Polymer Engineering, Budapest University of Technology and Economics, Muegyetem rkp. 3., 1111, Budapest, Hungary*
Email: pter.sntha@gmail.com .

[b] *MTA–BME Research Group for Composite Science and Technology, Muegyetem rkp. 3., 1111, Budapest, Hungary*
Email: tamasp@pt.bme.hu .

Main message:
In this present study we have investigated the flame and heat resistance of basalt fiber reinforced polymer (BFRP) composite materials. Mono and hybrid composite plates were produced from several forms of basalt fiber (milled, chopped fiber, woven fabric) and epoxy resin. The effect of surface treatment was also investigated in the mechanical and thermal testing of the BFRPs. The fire behavior of composites was evaluated by horizontal burning test and thermo-camera assisted jet fire test.

Keywords: basalt fiber, epoxy resin, passive fire protection, mechanical testing

Introduction
Basalt fibers are produced from the common volcanic basalt rock which is available all around the globe. These fibers have drawn attention due to their natural origin and special properties, such as corrosion and oxidation resistance, chemical and thermal stability [1]. Similar chemical composition to widespread glass fibers produces high strength and stiffness [2]. With the rise of concerns for environmental measures basalt fibers offer a sustainable solution at a moderate cost.

Experimental
Firstly, some of the woven fabric and milled fibers were treated with a silane coupling agent. The composite plates were produced with hand layup and compression molding. Hybrid plates were laminated using woven and milled fibers. After post-curing the specimens were prepared by a diamond blade saw. Mechanical properties of the composite materials were measured with three point bending test according to the EN ISO 14125:2011 [3] standard. Thermal behavior of the BFRP specimens was measured with thermo gravimetry analysis (TGA) using nitrogen atmosphere. The burning rate of the samples was determined by a horizontal burning test, similar to the UL-94 [4] standard. The flame spread characteristics of the materials were tested with infrared thermographic (IRT) camera assisted jet fire tests. In this laboratory scale test the specimens were impinged by the flames normal to the surface. The surface temperatures of the unpenetrated side of the specimens were measured by the thermographic camera. The videos and thermal images captured with the IRT-camera were furtherly processed with a self-developed image processing software.

Results and Discussion
The application of basalt fibers in the fire retardancy of composite materials have been assessed. Mechanical testing results show that continuous basalt fibers provide excellent flexural strength and moduli for composite materials. In the case of silane surface treatment is applied to the fibers the mechanical properties mentioned before could be improved further. The mechanical strength of BFRP compared to E-glass fiber reinforced composites [5] proved to be superior. On the one hand presence of milled fibers between the layers in hybrid laminates decrease the flexural strength and moduli, on the other hand it improved the fire behavior.

Thermogravimetry analysis showed that basalt fibers have great thermal stability. The lowest burning rate was performed by the milled fibers, highest by the continuous fibers during the horizontal burning tests. This phenomenon could be explained by the so-called wick effect which is common among woven fabric reinforcement structures. The burning rate could be reduced by applying milled fibers between the fabric layers. Hybrid structures provide slower flame spread. Surface treatment decreased the burning rate in the case of woven fabric laminates but did not have this favorable effect on the hybrid reinforcement structures. Thermo-camera monitored jet fire tests showed that milled and chopped fibers provide excellent protection against fire impingement. While the resistance to heat improved with the amount of milled basalt fibers, the chopped fibers performed similar results regardless the fiber content. Hybrid structure provided better fire resistance than the woven fabrics.

In summary basalt fiber reinforced composites in addition to the great mechanical properties provide excellent fire resistance for structural components. Whereas BFRP components are spreading in the construction industry, further fire and elevated temperature mechanical tests could be carried out on the BFRP composite materials considering the relevant standards, such as the local ÉMI (non-profit organization for construction quality control and innovation) standards. Jet fire test could be done on bigger sized specimens to prevent the flames to bypassing the edges of the plates. Although the TGA proved that basalt fibers do not degrade at high temperatures, the mechanical properties dependency on temperature could provide further insight on the thermo stability of BFRPs. Standardized UL-94 horizontal burning tests could help to classify the flame resistance of BFRPs in comparison to other composite materials.

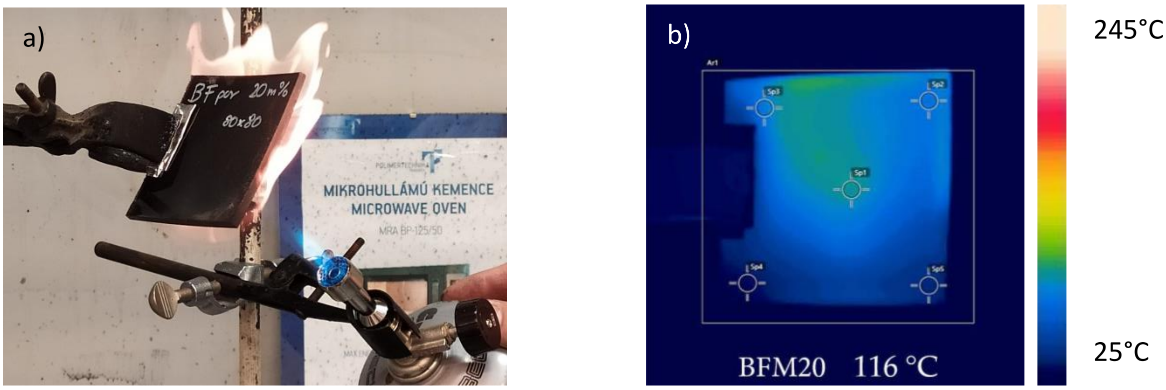

FIGURE 1. a) Jet fire testing of BFM20 specimen b) thermal image of the jet fire testing of BFM20

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