INVESTIGATION OF MINERAL FIBER REINFORCED POLYPROPYLENE MATRIX COMPOSITES

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INTRODUCTION

The most common composite reinforcing material today is glassfiber, its production gives approximately 85% of all composite reinforcing fibers. Glass fibers combine good mechanical properties and properly feasible interface coupling with relatively low price. More demanding applications require carbon fibers, though these have essentiality higher price and it is more difficult to assure the satisfactory interfacial adhesion. Due to the market competition and growing economic and environmental demands, many new fibers come into consideration as potential composite reinforcements. Basalt fibers are such new reinforcing materials [1]. Basalt is a common volcanic rock that can be found virtually in every country around the globe. Its most important components are SiO_2, Al_2O_3, CaO, MgO, Fe_2O_3 and FeO. Its chemical composition is strongly related to glass. It is molten between 1350 and 1700 ºC and when cooled rapidly it solidifies in a glass-like amorphous state. Slower cooling results in a partially crystalline structure. Its average density is 2.7 g/cm^3. It can be used between -200 and 600 ºC without the significant loss of mechanical properties. Basalt fiber are good electric insulators, not sensitive to moisture, biologically inactive and environmentally friendly. Basalt fibers can be divided into two groups: short basalt fibers made by melt spinning (e.g. Junkers method) and continuous basalt fibers made by spinneret method [2]. The different oxides compose a large crosslinked molecule with primer bondings, therefore basalt – similarly to glass – can be regarded as a special kind of polymer. Basalt fibers are more resistant to strong alkalis than glass fibers, but glass can better withstand acids. Basalt fibers can be made mostly from basalt with a SiO_2 content over 46%, high Al_2O_3 and MgO content and high melt viscosity. The idea of using basalt fiber as composite reinforcement has first raised in the former Soviet Union. Today the most notable production companies of continuous basalt fibers are Kamenny Vek (Dubna, Russia) and Technobasalt (Kyiv, Ukraine). Basalt fibers are produced in one step, directly from crushed basalt stone. Some melt spinning technologies (e.g. the duplex and Junkers method) are suitable for producing cheap, short basalt fibers, but such fibers have relatively poor and uneven mechanical properties. In melt spinning technologies the molten basalt rock is poured onto an ensemble of rotating steel cylinders. As the melt is blown off from the cylinders by air jets, fibers are formed in the air blast and solidify quickly in a glass-like amorphous phase. Continuous basalt fibers are made by spinneret method, similarly to glass fibers. Continuous basalt fibers are more expensive than short basalt fibers, but they show excellent mechanical properties, and more suitable as reinforcement for polymer matrix [3].

The aim of this study is the comprehensive comparison of short basalt fibers with continuous basalt fibers and other artificial fibers.

EXPERIMENTAL

We applied basalt, glass and carbon fibers and determined the mechanical properties of composites with different fiber contents and we assessed the damaging process using acoustic emission techniques. The matrix material of composites was polypropylene (PP) available in the form of fibers as the technology required. Short basalt fibers used in our experiments were produced with Junkers type fibrising technology in Hungary. Continuous basalt fibers were produced in Russia and in Ukraine. Glass and carbon fibers used in the greatest volume nowadays also were applied in the production of composites. The length of applied fibers was uniformly 60 mm. The composites were produced in a pressing technique from a pre-product that contained PP that served as the matrix later on and the reinforcing fibers, and fibers as well. The oriented, homogenous distribution of fibers in the pre-product was achieved by carding with a multi-cylinder carding machine. A thick, mat-like, multi-layered material was created by layering from the sliver that came from the carding machine. Then this sliver was needle punched and as a result became thinner and it contained less air inclusions [4]. 3 mm thick pure PP and composite plates were produced from the materials prepared in the way mentioned above with pressing at the temperature of 200 ºC.

The specimens were subjected to static and dynamic loading. It was found that the properties of continuous basalt fiber reinforced composites are competitive to the glass fiber reinforced composites. The results have been supported by light and scanning electron micrographs.

SUMMARY

The main purpose of this study was the development, analysis and testing of thermoplastic PP matrix basalt fiber reinforced composites. The research concerning the utilization of basalt fibers for the plastics industry is becoming fairly expansive and basalt fibers are becoming more and more accepted in the industry primarily as a replacement of glass fibers. We pointed out that basalt fibres made by melting and fiberising basalt rock are suitable for reinforcing polymer composites, thanks to its excellent mechanical properties, chemical and biological resistance and incombustibility. We produced basalt, glass and carbon fiber reinforced PP matrix composites by mixing, carding, needle punching and pressing the components and we proved that the new composites are appropriate to be used as engineering material. The acoustic emission studies demonstrated correlation between the physical parameters of sonic waves and mechanical properties of composites.

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