

INVESTIGATION OF TENSILE STRENGTH AND ELONGATION PROPERTIES OF BASALT FIBER-PUMICE REINFORCED POLYPROPYLENE COMPOSITES

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Abstract: Basalt fibre is obtained from volcanic basalt rocks. The manufacture of basalt fiber requires the melting of the basalt rock to about 1400°C. Its chemical structure is nearly related to glass fiber. It has slightly better mechanical properties than glass fiber. Basalt fiber has great potential application to composite manufacturing. In this study, multiaxial fabrics were produced from basalt filaments. Multiaxial basalt fabric and pumice stones were used as reinforcement material for the production of the composite structures. Polypropylene was used as resin. Finally multiaxial basalt fabric-pumice stone reinforced polypropylene composites were produced by using hot press compression machine. Then modulus of elasticity, tensile strength and elongation properties of the thermoplastic composites were investigated.

Keywords: Basalt fibre, composite, polypropylene, pumice

Introduction

Production and using of fiber reinforced composite structures is very attractive and developing subject for few years. Fiber reinforced composite structures have very important advantages such as low weight, low cost, high strength, resistance to flame and corrosion, etc. Due to their advantages, fiber reinforced composites are used instead of conventional structural parts especially in construction, automotive and industrial applications. Basalt fiber is a newly developed inorganic fiber which produced from molten volcanic basalt rocks (Shi, 2015). It is similar to carbon fiber and glass fiber, having better mechanical properties than glass fiber, but it is significantly cheaper than carbon fiber and little more expensive than glass fiber. Its chemical structure is nearly related to glass fiber. The most important components of basalt fiber are SiO₂, Al₂O₃, CaO, MgO, Fe₂O₃ and FeO. The manufacture of basalt fiber requires the melting of the basalt rock to about 1400°C. They are not required any additional additives during the production process, so their production cost is low. The molten rock is then extruded through small nozzles to produce continuous filaments of basalt fiber. The fibers typically have a filament diameter between 9 and 13 micrometres. Compared with glass fiber, basalt fibers are more resistant to strong alkali and less resistant to strong acids. Basalt fibers can be used over a wide range of temperature, from 200°C to 600°C. They are resistant to high temperatures. Basalt fiber has great potential to be used in composite structures. The basalt filaments are more ductile than glass and carbon fibers (Sun, 2010; Deak, 2009; Militky, 1996; Czigány, 2007; Sim, 2005).

Materials and Methods

Materials

In this study basalt filaments (400 Tex) were used for the reinforcement of the composites. In order to use basalt filaments in composite structures, multiaxial fabrics were produced. Multiaxial fabrics were manufactured by using basalt filaments in 0°, 90°, and ±45°. Photo of the multiaxial fabric is given in Figure1. Also pumice stones were used as filling material. Used pumice stones were in 3 different sizes. Particle sizes of the pumice stones were 0-1 mm, 1-2.5 mm and 2.5-4 mm.

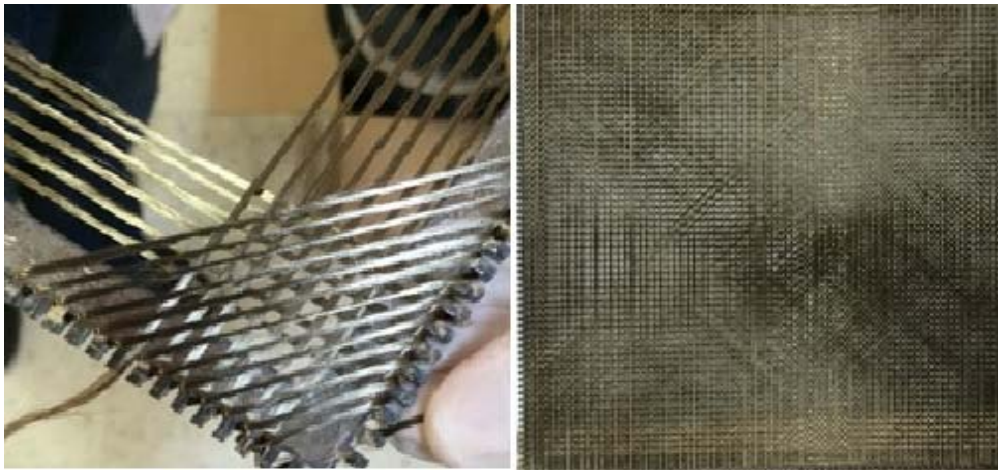


Figure 1. Produced Multiaxial Basalt Fabrics

Production of Composite Structures

Multiaxial basalt filament- pumice stone reinforced polypropylene composites were produced by using hot press compression machine. Production of the composites were performed under 200 °C and 100 bar pressure. Polypropylene resin was used in granule form. Properties of the produced thermoplastic composites are given in Table 1. Photo of the hot press compression machine and produced composite structure are given in Figure 2.



Figure 2. Hot press compression machine and cross sectional view of the composites

Table 1: Properties of the Produced Basalt Filament-Pumice Reinforced Polypropylene Composites

Composites	Ratio of Polypropylene (%)	Ratio of Pumice Stone (%)	Ratio of Basalt Fibre (%)	Pumice Particle Size (mm)
C 1	72	-	28	-
C 2	56	18	26	2.5-4
C 3	56	18	26	1-1.5
C 4	56	18	26	0-1

Results and Discussion

Tensile Strength and Elongation Analysis

Elasticity modulus, tensile strength and elongation at break properties of the multiaxial basalt filament-pumice stone reinforced polypropylene composites were investigated by using Zwick Z010 testing instrument. Tensile strength and elongation analyses of the composites were performed according to ASTM D 3039/D3039M-07 standard.

Elasticity modulus, tensile strength and elongation at break properties of the thermoplastic composites are given in Figures 3, 4 and 5 respectively.

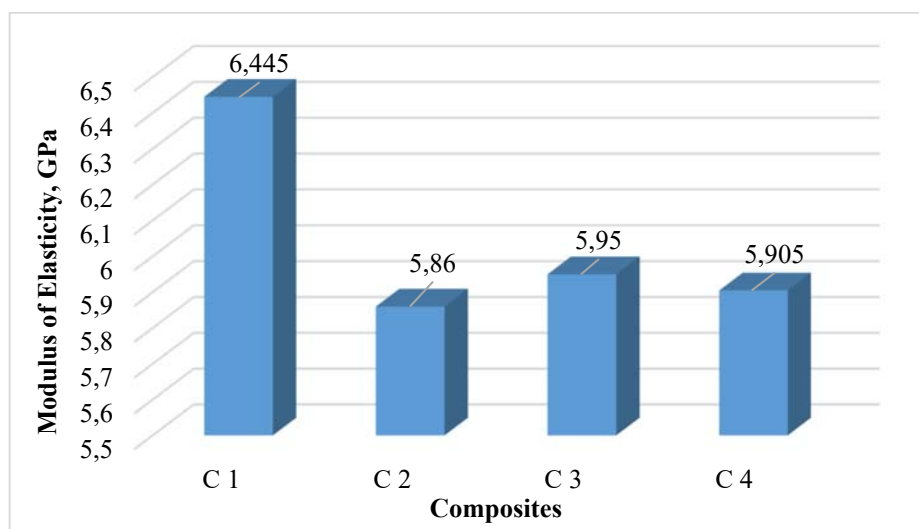


Figure 3. Elasticity modulus properties of the produced composites

Addition of pumice stones decreased the modulus of elasticity properties of the composites. The highest elasticity of modulus properties were obtained by using 1-2.5 mm pumice stones. 2.5-4 mm pumice stone added composites have the lowest elasticity of modulus properties.

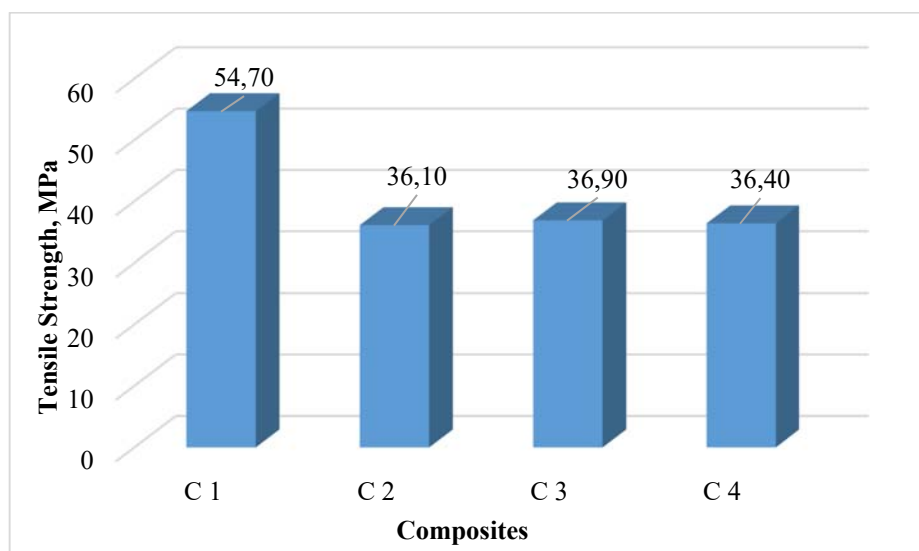


Figure 4. Tensile strength properties of the produced composites

Addition of pumice stones decreased the tensile strength properties of the composites. The highest tensile strength properties were obtained by using 1-2.5 mm pumice stones. 2.5-4 mm pumice stone added composites have the lowest tensile strength properties.

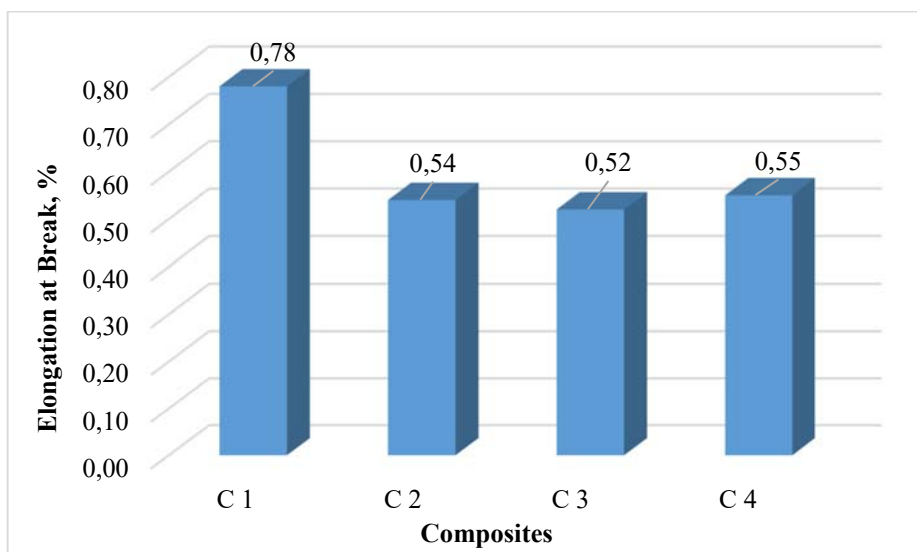


Figure 5. Elongation at break properties of the produced composites

Addition of pumice stones decreased the elongation at break properties of the composites. The effect of the pumice stone sizes on the elongation at break properties of the composites is negligible.

Morphology of the composite structures

Morphology of the produced multiaxial basalt filament-pumice reinforced polypropylene composite structures were analysed by using JEOL JSM-5410 LV Scanning Electron Microscope. SEM micrographs of the composites are given in Figure 6.

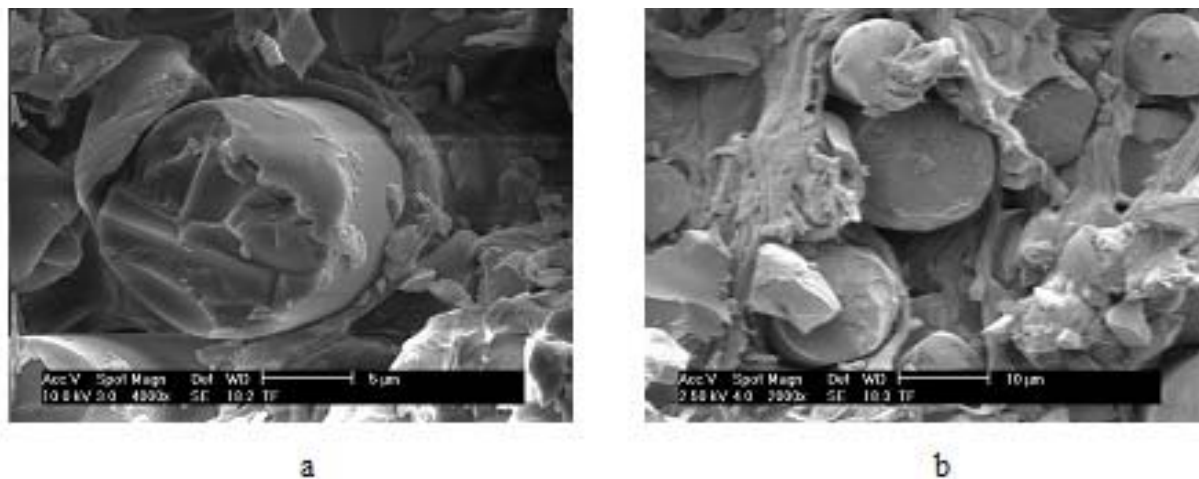


Figure 6. SEM Micrographs of the a)Multiaxial basalt filament reinforced composite b)Multiaxial basalt filament-pumice stone reinforced composite

It is seen from the Figure 6, good adhesion occurred between the basalt fibre and polypropylene resin, it is also observed that pumice stones were slightly bonded to the polypropylene resin.

Conclusion

In general, addition of pumice stones decreased the modulus of elasticity, tensile strength and elongation at break properties of the composites. Better modulus of elasticity and tensile strength properties were obtained by using 1-1.5 mm pumice stones. It is seen that pumice stone size is effective on modulus of elasticity and tensile strength properties of the composites. And good adhesion was occurred between the basalt fiber-polypropylene resin and

pumice stones – polypropylene resin. As a result, pumice stones can be added to the fiber reinforced composite structures as filler to obtain moderate tensile and improved insulation properties.

Acknowledgements

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