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Analysis of Basalt and Thermoplastic Hybrid Composites ⋆

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Abstract

This study focusses on investigations based experiments which are carried out to check the mechanical & thermal properties of woven epoxy composite laminates from Basalt/PP, Basalt/PET fibers and vice versa. Fabricated composite samples are subjected to mechanical and thermal characterization. The results reveal that, there is noticeable improvement in mechanical properties with the change of weaves in basalt hybridized composites. Interfacial linkages/bond between fibers and resin cause a significant modulus increase in composites. Thermal behavior of fiber and composite was observed by Thermal Gravimetric Analysis and Differential Scanning Calorimetric. Thermal properties are also affected by hybridization. Thermal conductivity is strongly affected by resin properties. A demonstration of ruptured surface was done by Fractography. The results show that hybridized basalt in different composites leads to a significant improvement in the dynamic and static mechanical properties of composites. Fiber type, weave structure, and resin properties greatly affect the mechanical properties of composites made with hybrid basalt fabrics.

Keywords: hybrid woven Basalt composites; Polyester; Polypropylene; flexural modulus

1 Introduction

The textiles are core ingredient of human life since ancient times. Use of fabrics ranges from clothing to industrial application based on the raw material for specific use. The development of different set of materials has spread its uses beyond expectations. Hi-tech composite reinforcing materials have become an integral part of many applications, e.g. IT, Electronics, Automotive, Sports, Health care, Energy generation, Energy storage etc. Fibers are used in different polymer

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matrices for enhancement of features like strength and rigidity. In aerospace and defense industries, there is a demand for materials with higher strength and lower weight. Thus fiber reinforced composites became an obvious choice. As the demand for fiber reinforced composites increased for specific applications, a number of new fiber/resin systems were on offer or the designers. A hybrid composite is formed by a combination of two or more types of fibers in a matrix [1-3]. Hybrid composites give the privilege to create a material bearing desirable properties among the combination of fibers, that is more cost effective and we can mitigate the non-desirable properties from the combination. It can help to tailor the requirement for specific materials. In comparison with conventional composites, hybrid composites exhibit balanced strength and stiffness, improved fatigue resistance, improved fracture toughness, impact resistance, reduced notch sensitivity, and reduced weight and/or cost [4-5]. The fibers are bound in a variety of ways including weaving, stitching and knitting. Better dimensional stability is exhibited by woven fabric composites when they are exposed to a large range of temperatures.

Glass fiber-reinforced composites were widely used to fabricate various applications in recent times but the aim to produce more environment friendly composites is leading to reduction of glass fiber use [6-8]. Basalt fiber has evolved as a replacement of glass fiber due to its environment friendly natural origin. Basalt rock is famous for its properties like strength, thermal properties and durability since long time. Basalt is known to possess better tensile strength in comparison with E-glass fibers. The recycling of basalt fiber can be done in much better environment friendly way than glass fibers. When a resin with basalt fibers is recycled, same material of basalt powder is obtained so it is classified under sustainable material category.

Conventional reinforced composites are always problematic at the end of their service life during recycling. Due to environmental and legal issues, recycling process has become an increasingly difficult issue. The solution to the issues related to recycling was answered by use of green matrix based renewable resource or green composite which are generally formulated by embedding the fibers into bed of bio-polymers that can integrate more readily into natural biodegradation cycles, for example by CO_2-neutral incineration, which includes recovery of energy, or by composting.

We have a twofold aim of our research which is, to enhance use of green composites by adding natural basalt fibers in biodegradable polymeric resins and, to develop hybrid composites with most commonly used fiber i.e. polyester and polypropylene. Basalt woven hybrid composites are developed. The investigation study is devoted to the role of different yarns in composites with their capabilities and properties. PET and PP yarns are used to form hybrid composites along with basalt yarn, and the mechanical properties of the composites have been scrutinized for functioning of fiber composition and weave. Another aim of this work is studying thermal properties of composites.

2 Material and Methods

2.1 Materials

Basalt (B) is known fiber that is extracted from rocks bearing excellent thermal resistance. Polyester (PET) and Polypropylene (PP) are thermoplastic polymeric materials. The polyester (PET) and polypropylene (PP) yarns are commercially available yarns in market. The source of basalt yarn was, Kamenny Vek (KV). The supplier of Hardener and bio epoxy resin was Spolek,