Mechanical and Metallurgical Properties of Hybrid Composite Material

V. Karthi, K. Marimuthu, G. Boopathy, and N. Ramanan

Abstract Tremendous growth has been incorporated in the field of composite materials in the current scenario where the engineering applications are highly demandable. Currently composites are being used to replace conventional metallic materials in a wide range of industries including aerospace, defense, aircraft, and textile which require structural materials with high strength-to-weight and stiffness-to-weight ratios. Also natural fiber composites are currently replacing synthetic fiber composites of different applications in various engineering industries due to their low cost and eco-friendly in nature. In this work, twisted kenaf, and twisted kevlar (aramid fibers) have combined together to enhance the mechanical properties and also to improve high impact resistance with less contribution of kevlar which is very high in cost categorized next to carbon fibers. Here, the hybrid composites (natural and aramid) are done by using hand layup method, and various mechanical properties have been investigated. Also, the morphological analysis is done to observe the internal structure of the tested composite. It is observed that hybrid composite has high strength with minimum contribution of kevlar fibers.

Keywords Eco-friendly fiber · Hybrid composite · Fracture surfaces · Hand layup method

1 Introduction

In recent days, technology needs a high demand toward the growth of future generations. Hence, in order to produce a good product which needs to satisfy the customers, it should be developed at an economical way, high quality with minimum possible

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time challenging among the competitors. Natural fiber-based polymer composites are the most which show potential option to synthetic fiber and powerful polymer composites. It enhances the awareness of eco-friendly material and makes it crucial to utilize natural fiber as a potential reinforcement in polymer composites. Natural fibers are plentifully existing, biodegradable, and recyclable, which makes them conventional in the automobiles industries. The major negative aspect of testing is stretched time, manufacturing cost is high, mistakenness, machine error, and today, most bio composite researchers are moving toward computational methods to model the NFRPC to simulate the mechanical and thermal properties. A study based on the tensile properties of flax/basalt hybrid composites with loading conditions were performed which indicated that the tensile properties of composites decreases with increasing aging conditions [1]. They reported that the tensile properties of composites decreased with increasing aging conditions [2]. The rigidity and modulus diminished because of embrittlement of the matrix materials. Comparative attributes were observed for sisal-fiber-reinforced PP composites [3, 4]. The affiliation between the cross-section of the natural fiber and the tensile properties were studied. They modeled and evaluated the tensile performance of hemp fiber with dissimilar elliptical cross-sections. The results appeared that the tensile properties have a physically powerful manipulate on the degree of ellipticity. The microfibril angle and the viscoelastic properties played a very important role in the geometry of the natural fiber [5]. As basalt is eco-friendly, chemically inert, highly resistant to corrosion, and very low thermal conductivity, it makes it superior to choose than any other reinforcement available today.

2 Materials and Methods

The aramid fiber is a superior material in all fields. With the ultimate mechanical properties, particularly high strength-to-weight ratio, low density, and heat resistance, aramid fiber is utilized as perfect reinforcement for polymer-based composites [6]. It has been widely used in various civilian and military fields, including aramid/rubber for tire cord and automobile rubber hose [7].

3 Hand Layup Method

In hand layup method, resins are impregnated into fabrics by manual feed which is mainly of roving form. The fibers and resins are impinged on the surface with the help of the rollers which has been fed into the mold. Then, the fibers are made free under standard atmospheric conditions. This method is very simple and easy, but it requires high skill to fabricate the composite. The fibers used are twisted kevlar, twisted kenaf, in addition to that glass-reinforced polymer fiber. Aramid fibers are laid at the top and bottom most of the composite laminate for better-finishing purpose.

Three different categories with three samples have been fabricated using hand layup method. All the fibers are laid in normal direction and kept in dry condition before it is fed to the laminate. Initially, the releasing agent is applied over the surface in order to remove the laminate easily. After applied, a thin layer of resin is applied, and then, the glass fiber is laid on the surface. A weight of 5 kg is placed over the aramid fiber to remove air bubbles if any, and it is kept undisturbed for about 3 h. Also, fibers are also dried in the normal condition to make the fibers moisture-free. After 3 h, the laminate was removed from the die material and used in various tests for engineering applications.

4 Tensile Test

Material strength can be found by testing the material in tension or compression. Standard dog-bone-shaped specimens (pure nylon and nylon composites of 10% aramid fiber content) were according to the ASTM D638 specifications for tensile testing (reinforced and unreinforced plastics). Each specimen having 30 mm width and 280 mm gauge length, The specimen is loaded in computer-controlled universal testing machine (ASE—UTN 10) until the failure of the specimen occurs. Tests are conducted on composites of different combinations of reinforcing materials, and ultimate tensile strength and ductility are measured. Simultaneous readings of load and elongation are taken at uniform intervals of a load. A tensile test is carried out at room temperature. Uni-axial tensile test is conducted on the constructed specimen to obtain information regarding the behavior of a given material under gradually increasing stress-strain conditions. The tensile stress test results give the elasticity limit of the polymer composite fiber.

The tensile test result is shown in Fig. 1. The fiber ratio differs by 30–50% in laminate plates. But, the ultimate tensile strength result shown in the 30% fiber has maximum strength. When the fiber ratio increases, the material UTS will also be increased. In the case of negative result then it will be due to the reason that fiber ration increases correspondingly the material thickness will increase. Hence,

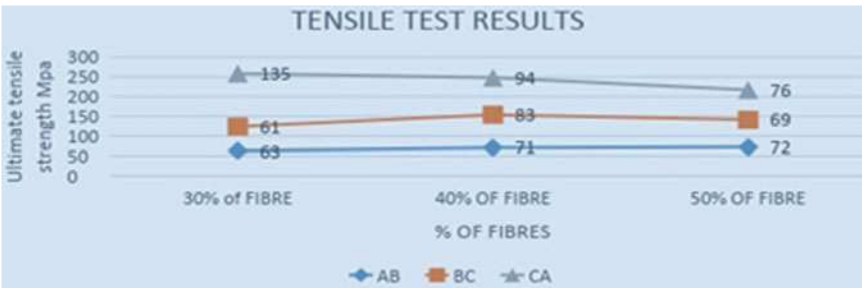

Fig. 1 Tensile test result

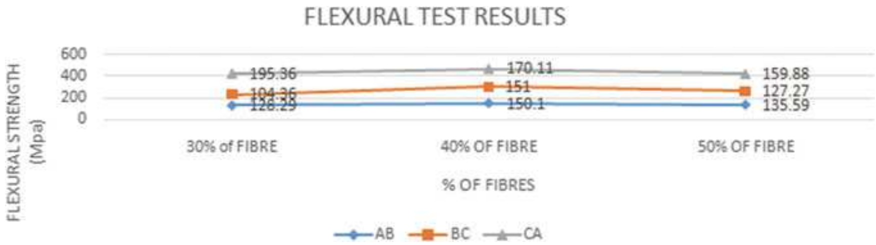

Fig. 2 Flexural test result

the failure will occur suddenly. The reason is that material failure has higher fiber percentage level.

5 Flexural Strength

Material strength can be found by testing the material in tension or compression. Test specimens are equipped according to ASTM D315 standard, each specimen having 30 mm width and 280 mm gauge span. The specimen is set up in computer-controlled universal testing machine (ASE—UTN 10) until the collapse of the specimen occurs. Tests are conducted on composites of different combinations of reinforcing materials, and ultimate tensile strength and ductility are measured. Simultaneous readings of load and elongation are taken at uniform intervals of the load. The tensile test is carried out at room temperature. The uni-axial tensile test is conducted on the fabricated specimen to obtain information regarding the behavior of a given material under gradually increasing stress–strain conditions (Fig. 2).

The flexural test result is shown in Fig. 1. The fiber ratio differs by 30–50% in laminate plates. But, the ultimate tensile strength result shown in the 30% fiber has maximum strength. When the fiber ratio increases, the material's UTS will also be increased. In the case, the negative result will be came due to the reason is the fiber ration increase corresponding the material thickness will be increase. Hence, the failure will occur suddenly. The reason is that material failure has higher fiber percentage level.

6 Morphological Analysis

Morphological analysis has been done on the tested specimens using scanning electron microscope with varying magnification factors for better visibility of the fibers in the composite laminate. The sample has been dried completely, and then, gold coating is done on the sample with appropriate device. Then, the ultraviolet rays have been passed through the laminate and were inspected and observed by scanning

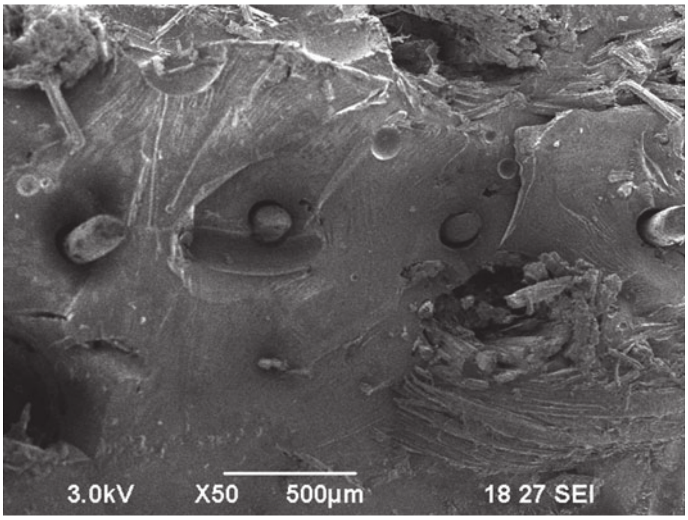

Fig. 3 Tensile fracture

electron microscope. The twisted fibers are elongated to some extent, and each of the fibers is distinctly identified due to the application of tensile load as shown in Fig. 3. Due to the elongation effect, fibers have not been affected much which leads to ductility failure. The bond between the reinforcement and the matrix medium is clearly seen.

The images 4 and 5 are shown in a fracture surface of the SEM images. Figure 3 shows a tensile fracture image. The image shows voids that occur due to the exothermic heat formation. But, the result has been shown in higher tensile strength. The voids also control the limit. Figure 4 shows the flexural fracture images. The flexural fracture test shown in the normal fiber fracture contains no voids or porosity. Hence, the images show the better strength of the laminates.

7 Conclusions

The results of various mechanical tests have been done. In this research work, twisted fibers, namely kevlar, kenaf were fabricated by using hand layup method along with kevlar-fiber-reinforced polymer composites on either side of the composite laminate for better results. Three different categories were prepared with three samples each for better analysis of results. The tests, such as tensile test and flexural test, have been conducted to determine the mechanical properties of the hybrid composites. The morphological analysis has been done to see the internal structure of the hybrid composite, and the interpretations have been discussed in detail for each test.

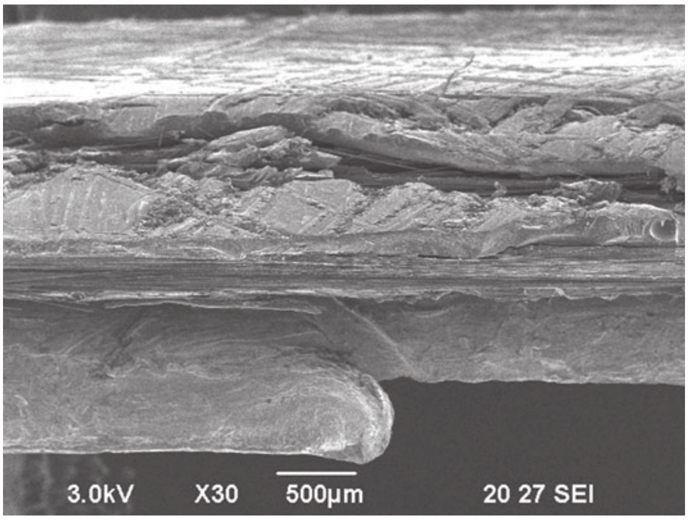

Fig. 4 Fletural fracture

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