Applied Mechanics and Materials Vol. 660 (2014) pp 572-577
Online available since 2014/Oct/31 at www.scientific.net
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doi:10.4028/www.scientific.net/AMM.660.572

Submitted: 23.06.2014
Revised: 07.07.2014
Accepted: 14.08.2014

IMPACTED OF VACUUM BAG WOVEN KENAF/FIBERGLASS HYBRID COMPOSITE

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Keywords: kenaf, woven fiberglass, tensile, post-Impact, hybrid

Abstract. This paper discusses the mechanical properties of woven kenaf/fiberglass hybrid composites which has been fabricating using vacuum bag technique. Kenaf fiber had chosen among others natural fibres due to its excellent mechanical properties and potential natural raw fiber to replace plastic or tobacco in manufacturing a multitude of products for the construction, automotive, textile and advanced technology sectors. This study investigates post impact tensile of kenaf hybrid composites and its surface fractured. The impact energy used consists of 4J, 6J, 8J, 12J and 16J. The specimens were clamped between two plate rings with an internal hole diameter of 18mm and impacted with hemispherical nose impactor shape with diameter size of 12.7mm. The results revealed that this kenaf hybrid composite showed significant decreasing of strength and modulus as increasing the impact energy. The damage area affected with fiber fracture occurred much later in fracture process due to high bending stresses.

Introduction

Over the last few decades, there has been a growing interest in the use of natural fibers in composite applications. These types of composite present many advantages compared to synthetic fibers such as low relative density, low cost, availability and biodegradability. Kenaf is one of the natural (plant) fibers used as reinforcement in. Kenaf (Hibiscus Cannabinus,L,family Malvacea) has been found to be an important source of fiber for composite, and other industrial applications. Kenaf is well known as cellulosic source with both economic and ecological advantages, in 3 month (after sowing the seeds), it is able to grow under a wide range of weather conditions, to a height of more than 3m and a base diameter 3-5 cm [1].

This study investigates and analyzes the mechanical properties of woven kenaf/fiberglass epoxy composite. This specimen will be tested under post impact and tensile test in order to observe the ability of this material to withstand impact and to predict its behavior under actual conditions. Impact test seems to be uncomplicated, but quantitative interpretation of the test results to derive inherent physical material parameters can be difficult and complex. Therefore impact test can also be divided into three categories which is qualitative, semi quantitative and quantitative, depending on the property measured, rather than on the method by which the impact test is performed [2]. There are many researcher has been conducted using post impact which is using knit fabric glass/epoxy composite as the specimen. When a foreign object impacts on a composite laminate, several damage modes including delamination, edge delamination, fiber splitting, fiber cracking and matrix cracking can occur in the composite laminate. These damage modes depend on the impact parameters such as the shape and mass of the impactor, impact energy and dimension of composite laminate [3].

Tensile testing, also known as tension testing, is a basic materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are usually used to select a material for an application, for quality control, and to predict how a material will respond under other types of forces. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined such as Young's modulus, Poisson's ratio, yield strength, and strain-hardening characteristics [4].

The objective of this project is to investigate the ability of woven kenaf fiberglass hybrid composite to withstand impact. Post impact test was done in order to determine the damage resistance of multidirectional and type of failure on this kenaf hybrid composite. Tensile test was then done to analyze how this material reacts to forces being applied in tension after impact.

Methodology

Material Selection

Materials used for this project were kenaf, glass fiber and epoxy. This material was fabricated by using vacuum bag technique. Kenaf were supplied by Innovative Pultration Sdn.Bhd and used without any surface treatment. While epoxy was supplied by Miracon Sdn. Bhd and woven fiberglass were supplied by Mostrong Industries Sdn.Bhd.

Material Preparation

Long kenaf was sewing manually in a woven form using special tools. It will be then laminate with 2 layers of woven fiberglass. The matrix used was epoxy and hardener with ratio of 10:3. The process was done through vacuum bag process as shown in Figure 1. This process is basically an extension of the wet lay-up process where pressure is applied to the laminate once laid-up in order to improve its consolidation. This is achieved by sealing a plastic film over the wet laid-up laminate and onto the tool. The air under the bag is extracted by a vacuum pump and thus up to one atmosphere of pressure can be applied to the laminate to consolidate it. This process requires at least one hour in the room temperature.

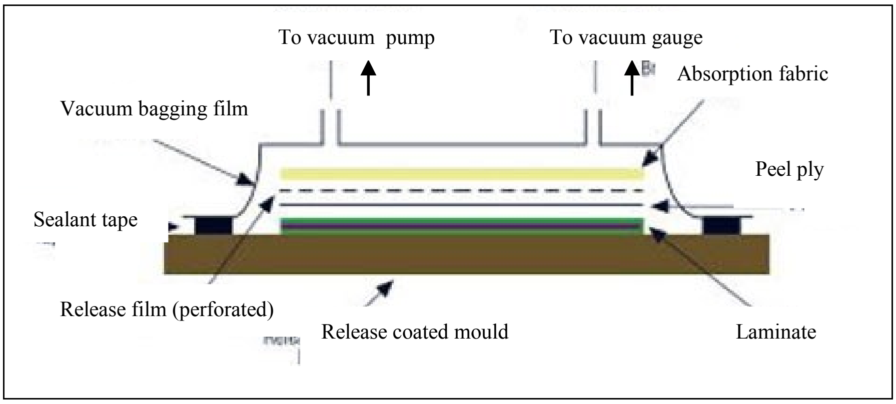


Figure 1. Vacuum bag moulding technique

Finally, after the specimen is taken out from the mould, the specimens placed at room temperature for 24 hours before cutting and further testing. The specimens that will be tested are with dimension of 200mmx20mm which are following the BS EN ISO 527:1997 standard.

Mechanical Testing

The specimens were undergone both impact and tensile test. Impact test were done at five impact energy levels which were 4J, 6J, 8J, 12J and 16J. Specimen was clamped between two plate rings with an internal hole diameter of 18mm and impacted using an impactor with a hemispherical nose diameter 12.7mm. Then, impacted specimens will tested through tensile test. Tensile testing machine operating at a crosshead speed of 1mm/min with 25 mm extensometer attached to the specimen. Surface fracture of all impacted specimen were examined and observed before conducted tensile testing.

Result and Discussion

The performance of materials is always presented in terms of their mechanical characteristics, such as tensile properties. These characteristics are important in order to predict or determine material ability, especially under extreme and critical conditions, which are directly connected with engineering performance.

Figure 2 shows the trend graph of load (N) versus extension (mm) for non-impacted woven kenaf fiberglass hybrid composites. It can be seen that load is directly proportional to the extension until fracture. From the graph, the initial curve was not smooth to represent the slope due to gripping error in the machine at the beginning stage of testing. However, the curve exhibited smoothly as loading progress until failure. All the mechanical properties have been recorded as shown in Figure 3 and Figure 4. The results obtained, have proved that this hybrid composite exhibits higher strength values in terms of tensile properties as compared to the non-woven kenaf fiberglass under the same specimen preparation (vacuum bag moulding).

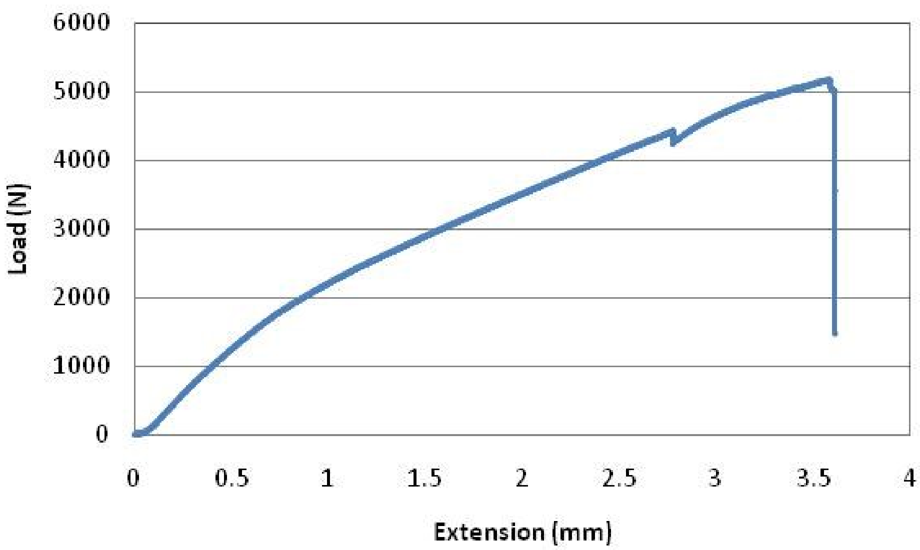


Figure 2. Graph of Load (N) against Extension (mm)

Table 1 shows both faces (impacted and distal) of all impacted specimens before gone through tensile testing. The impact test was design with two clamps with diameter hole much smaller than the width of specimen in order to assure that the impact did not result in the full penetration and to control the damage area even at highest energy applied. Each of the specimen were endured five different impact energy from 4J until 16J. The damage zone (white region) were increase from lower impact energy to higher impact energy.

Close examination of the fracture surfaces of impacted specimens reveals that within the short period of impacting a crack grows at both side of the specimens. The cracks grows more rapidly from 12J to 16J compare to the others. The distal side of the impacted composite was subjected to bending stress. Fibre fracture occurred much later in the fracture process on the non-impacted face due to the high bending stresses. Based on the phenomena ,the fracture process could be depending on the fibre strength [6]. At suitable volume fractions of fibres and matrix, this hybrid composites sufficiently restrained and the stress is more evenly distributed. This will results in reinforcing effects outweighing the effects of the stress concentrations and outcome in increase of impact energy [7].

Table 1. Surface of impacted and distal faces of the specimens

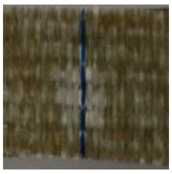
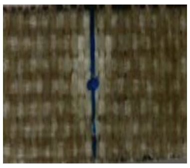
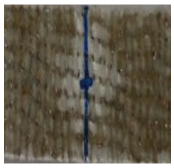
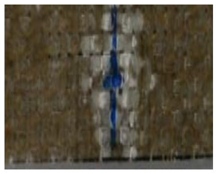
Impact Energy	4J	6J	8J	12J	16J
Impacted Faces					
Distal Faces					

Figure 3 and Figure 4 shows the tensile stress and young modulus of the specimen against respective energy level. The tensile stress and modulus were decreasing as the energy level increase. This phenomenon can be proved by impacted surfaces in each specimen shown in Table 1. It indicates that visible damage on the impacted surface clearly grown between 12J and 16 J, and with great evidence, between this energy level, it give a very high different tensile stress (MPa) and modulus (GPa) than 4J, 6J and 8J.

It suggests that the evolution of damage with impact energy in these materials appears to be gradual, a small increase of impact energy resulting obviously in further degradation, but not in an abrupt change of fragmentation characteristics. This involves the formation at rear of an elongated crack, corresponding approximately to the dimension of the impactor, which then propagates along different directions, being diverted quite unpredictably by the random orientation of reinforcement fibres [8]. It is of crucial importance to pinpoint the force at which the crack growth initiates, in order to determine the fracture resistance of the specimen. Unfortunately, under even moderately high impact rates the forces acting on the specimen at the tip of the initial crack can be measured directly only by using techniques rather sophisticated such as caustics [9]. According to the results obtained in this study, kenaf fiber has appropriate properties to be used, in engineering, as fiber in fiber reinforced polymer composite sector.

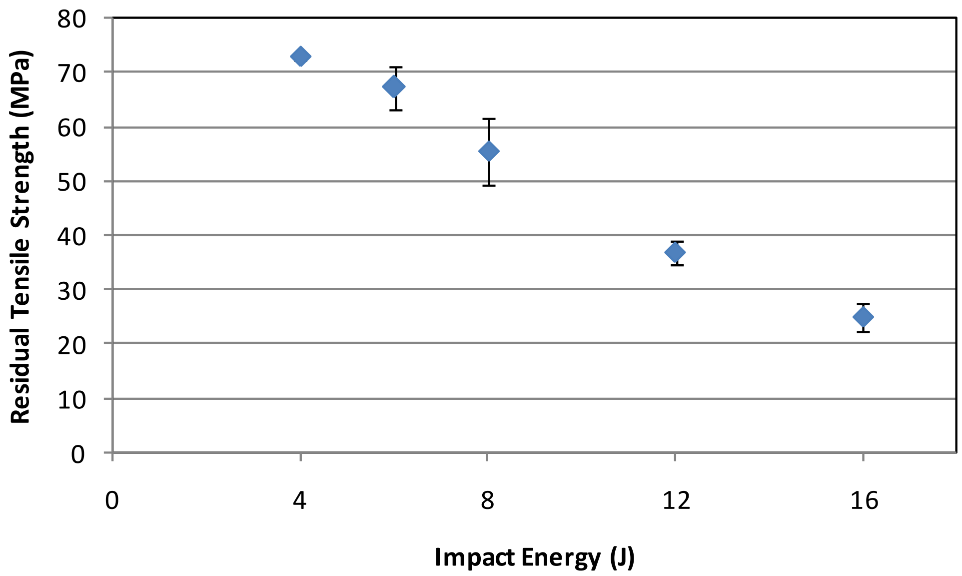


Figure 3. Tensile Stress (MPa) against Impact Energy (J)

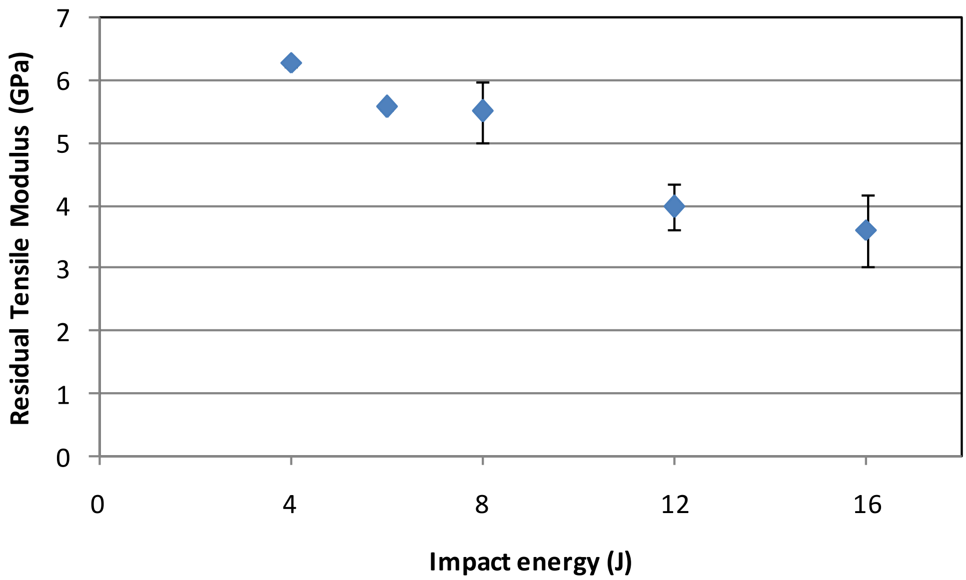


Figure 4. Young Modulus (GPa) against Impact Energy (J)

Conclusion

Woven kenaf fiberglass hybrid composite were successfully fabricated using the vacuum bag moulding technique. The strength and the ability of woven kenaf fiberglass to withstand the impact were investigated. As expected, the increasing amount of impact energy apply to material give decreasing number of residual tensile strength and modulus. Higher impact energy were also give larger crack or damage zone compared to the lower impact energy. The observation of damage which is a quite novel feature in composites including natural fibers, shows a typical non-uniform behavior around the impact area.

Acknowledgement

Thanks Allah for His mercy. Thanks to Ministry of Higher Education (MOHE) of Malaysia for the financial support through RIF grant awards 600-RMI/DANA 5/3 RIF (93/2012), (600-RMI/DANA 5/3RIF (390/2012) and MyBrain PhD, and also to Research Management Institute (RMI) of Universiti Teknologi Mara, Malaysia for facilitating this project.

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