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Investigation of Tensile Behavior of Kevlar Composite*

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Abstract

Now-a-day technology demands new innovative materials for making more reliable and smart components. With those aspects, composite materials list as top among the new engineering materials that finds application in all fields of engineering and technology. This paper aims to investigate the tensile property of a Kevlar composite prepared by hand layup method which has four layers of Kevlar laminate. Morphological analysis was performed using Scanning Electron Microscope to observe the internal structure of composite fibres after testing. The result showed that Kevlar has good tensile strength and hence can be a good alternative conventional material for many applications in engineering industries.

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Keywords: Kevlar; Hand lay-up method; Tensile testing; SEM.

1.0 Introduction

1.1. Kevlar and its structure

Kevlar is a para aramid synthetic fiber which has good tensile modulus, high strength to weight ratio, and high energy absorption capacity. It also has good ballistic impact resistance specially designed for defence applications.

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Channa basava raju et al[1] evaluated the tensile and flexural properties of glass, graphite and Kevlar fiber and the behavior of various orientations of fibers with respect to the thickness has been studied and the result shows that the improved mechanical properties by using vacuum bag molding process. Zhu et al[2,3] worked on Kevlar 49 fabrics with different gage lengths has been carried out with mechanical properties like young's modulus, strain, tensile strength and toughness comparing both dynamic and quasi static loading conditions. The result shows that the strain rates are reasonably plotted with the help of weibull distribution curves. Experimentally investigated the Kevlar composite subjected to ballistic impact test and showed the improved results on multi layer fabrics with various configurations. The results are then compared between the simulations and the experimental data. Mittelman and Roman [4] Investigated mechanical behaviour of unidirectional Kevlar/epoxy composites subjected to tensile strength and various failure modes have been investigated with minimum deviations occurred are studied. Sapuana et al [5] investigated the mechanical and chemical properties of Kevlar/kenaf composites considering the layer sequences and the results shows the significant tensile property with three layers of composite combination and analysis has been done and studied. Kulkarni et al[6,7] experimentally determined the effect of fiber properties, matrix properties, interface properties and also shows that the significant properties on the increase in strength with internal instability.sem analysis has been incorporated to determine the internal structure of the fibre. Impact behaviour of the fiber has also been studied with carbon fibre combination. Reis et al [8] studied the effect of Kevlar with Nano clay properties has been studied and the results shows the best performance when it is subjected to elastic and threshold properties with increase in benefits with marginal benefits. Sarawut Rimdusit et al [9] fabricated the Kevlar fiber as the reinforcement and the combination of polycarbonate (PC) and acrylonitrile-butadiene-styrene (ABS) as the matrix, evaluated the tensile and flexural strength using universal testing machine. The result shows that the significant results of both flexural modulus and tensile strength with the increase content of matrix and also SEM analysis has been incorporated and results shows satisfactory. Vijaya Ramnath et al[10,11,12] experimentally proved the natural fibers subjected to all kinds of mechanical testing has been done and also the morphological analysis has been analysed in order to determine the internal structure of all natural and aramid fibers. Rajesh et al [13, 14] investigated the effect on various cut out shapes on various fiber and showed the improved mechanical properties and also shows improved properties such as impact and hardness properties of a Kevlar composites. Srinivasan et al [15, 16] investigated mechanical properties of flax with banana and kenaf composites and found that hybrid composite have good mechanical and thermal behaviour than mono fiber composites.

2.0 Materials used

2.1. Kevlar fibres

The figure 1 (a) shows the fiber in unprocessed manner and figure 1 (b) shows the fiber in woven roving mat chopped in either direction.

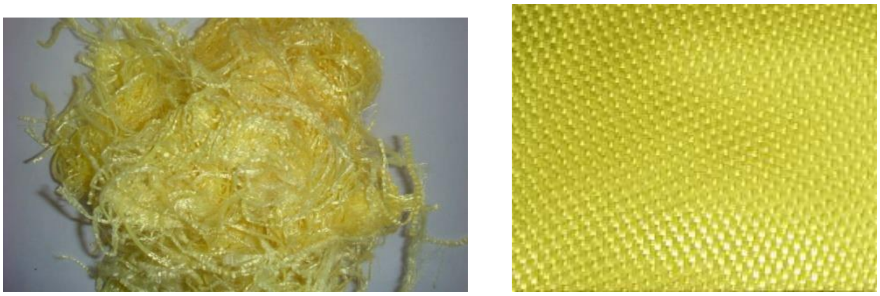

Figure 1. (a) Unprocessed Kevlar fibre; (b) Woven Kevlar fiber

2.2. Epoxy resin

The Epoxide resin used in our work is Araldite LY556.The various physical and chemical properties of araldite LY556 are as follows. It is clear in colour with slight odour; it is of liquid state and insoluble in water. The vapour pressure is lesser than 0.01 Pa at 20ºC and specific gravity must be between 1.15-1.2 at 25ºC. The boiling point and the decomposition temperature must be greater than 200ºC.

2.3. Hardener

Hardener (HY 951) is employed to improve the interfacial adhesion and impart strength to the composite. The various physical and chemical properties of hardener HY951 is of liquid state with ammonia odour, it is colourless in nature and its pH value is 13. The boiling point and the thermal decomposition temperature must be greater than 200ºC, the flash point must be 110ºC, its vapour pressure is 0.3 Pa at 20ºC and its density is 1g/cm^3 at 20ºC.

2.4. Glass Fiber Reinforced Polymer

Fiber-reinforced plastic (FRP) (also -reinforced polymer) is a composite material made of a polymer matrix reinforced with fibers. The fibers are usually glass, carbon, basalt or aramid, although other fibers such as paper or wood or asbestos have been sometimes used. The polymer is usually an epoxy, vinyl ester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use. FRPs are commonly used in the aerospace, military, automotive, marine, and construction industries. The reinforcement used here is glass and hence gets its name as glass fiber reinforced polymer.

3.0 Fabrication

Hand Layup Method is used to fabricate the Kevlar composites which are a simple method for composite production.

3.1. Experimental Setup

Resins are impregnated by hand into fibres which are in the form of woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. Laminates are left to cure under standard atmospheric conditions.

Steps followed in the hand lay-up process for Kevlar Composite:

- The Kevlar composite which is available as a sheet of required dimensions is spread out dried to remove the moisture content present if any.

Figure 2. (a) Cut Kevlar sheets; (b) Fabrication of Kevlar Specimen

- The fabrication is done over flat surface like a flat plate or a tile. The flat surface is cleaned thoroughly to remove any dust particles which might create some defects in the specimen like void and air-bubbles.
- The epoxy resin of LY556 grade and an Araldite HY951 hardener is used .Now the Kevlar fiber is placed over the plate and an epoxy resin with a hardener is rolled over the fibre, this forms the first layer.
- The structural arrangement is such that the composite specimen consists of four layers of Kevlar with an epoxy resin matrix between each layer such that each layer are arranged in perpendicular orientation as shown in figure 2(a) and 2(b).
- A proper resin-hardener mixture is applied between these layers for perfect adhesion. The resin and hardener is mixed at ratio of 10:1.
- The material is dried out under sunlight for 24 hours to form a Kevlar fibre reinforced composite with an epoxy resin matrix.
- A suitable weight say 20kg is placed over the fibre arrangement for better adhesion as shown in figure 3.

Figure 3. Weights placed on the Specimen

- After proper drying of the specimen under a load. The rectangular composite specimen with Kevlar matrix arrangement and epoxy reinforcement is obtained as shown in the figures 4(a) and 4(b) respectively.

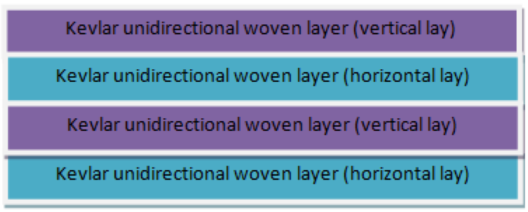

Figure 4. (a) Arrangement of Kevlar Composites; (b) Completed Kevlar composite

4.0 Testing of Composites

4.1. Tensile Testing

Tensile testing utilizes the classical coupon test geometry as shown below and consists of two regions: a central region called the gauge length, within which failure is expected to occur, and the two end regions which are clamped into a grip mechanism connected to a test machine.

5.0 Results and discussions

Under tensile loading conditions cited above the tensile test specimen of Kevlar based composite breaks at 6.3 kN with yield stress 143 N/mm^2 and ultimate strength of 163 N/mm^2.

6.0 Morphological Analysis

Morphological analysis is done to study the internal structure of the tested composite. It is seen from the below figure that after the tensile stress is applied to the specimen, the s crack out first and then the adhesion between the matrix and the s starts breaking. Since, Kevlar fibre has got a good strength that has broken collectively after the application of the tensile stress. Figure.5 shows the void present in the specimen like Air Bubbles and this can be rectified by proper hand lay method.

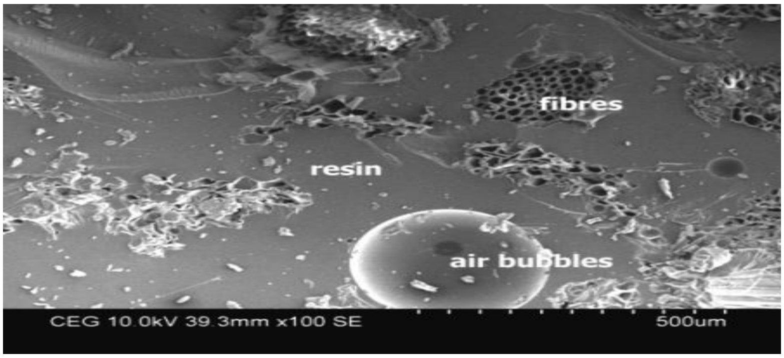

Figure 5. SEM Image after tensile test

7.0 Conclusions

Four layers of Kevlar has been fabricated using hand layup method. This shows the significant results in tensile properties. The following conclusion has been made as follows.

1. The maximum break load occurs at 6.3kN.
2. The value of yield stress as 143N/mm^2.
3. The ultimate strength being 163N/mm^2.

From the above results, it has been observed that is possesses good mechanical properties and it can be implemented in defence applications.

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