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Review on Mechanical Characteristics of Synthetic Fibers based Composite Materials

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Abstract - *Composite materials are preferred as an alternate for traditional metals due to its admirable properties like chemically inactive nature, high impact strength, high strength to weight ratio, flexural strength, tensile strength, ease of fabrication and capability of tailoring into the required shape. Synthetic material fiber composites such as Glass, Kevlar and Rubber powder composites became more attractive due to their high strength. A composite material can provide superior and unique mechanical and physical properties because it combines the most desirable properties of its constituents while suppressing their least desirable properties. In this composite materials play a key role in defence industry, automobile industry and other engineering applications as they exhibit outstanding Composites are one of the most advanced and adaptable engineering materials. Results expected that hybridization of Kevlar fiber and glass fiber improves the load carrying capability, energy absorbing and damage degree of composite laminates with a slight reduction in deflection.*

Key Words: **Glass Fiber, Kevlar Fiber, Weight ratio, Flexural Strength, Impact Strength.**

1. INTRODUCTION

A composite material is composed of at least two materials, which combine to give properties superior to those of the individual constituents. Composites are one of the most advanced and adaptable engineering materials known to everyone. Many studies were conducted to investigate the impact behavior of fiber reinforced composites due to the increasing demand of these materials in the automotive, maritime, aviation, infrastructure, military, petroleum and sport sectors.[1]Properties of composites are strongly dependent on the properties of their constituent materials, their distribution and the interaction among them. [2]The composite properties may be the volume fraction sum of the properties of the constituents or the constituents may interact in a synergistic way resulting in improved or better properties. [3]Apart from the nature of the constituent materials, the geometry of the reinforcement (shape, size and size distribution) influences the properties of the composite to a great extent.[4] The concentration distribution and orientation of the reinforcement also affect the properties.[5] The shape of the discontinuous phase (which may by spherical, cylindrical, or rectangular cross-sanctioned prisms or platelets), the size and size distribution (which controls the texture of the material) and [6]volume fraction determine the interfacial area, which plays an important role in determining the extent of the interaction between the reinforcement and the matrix. [7]Concentration, usually measured as volume or weight fraction, determines the contribution of a single constituent to the overall properties of the composites.[8] The main advantage of hybrid composites lie in the ability to combine the properties of their individual constituents, and it provides superior properties which cannot be obtained from the single fiber based polymer composites.[9] Koronis et al. carried out an ANOVA test, based on the obtained experimental data to find the significant effect of input parameters. In this composite materials play a key role in defense industry, automobile industry and other engineering applications as they exhibit outstanding Composites are one of the most advanced and adaptable engineering materials.

2. MATERIALS USED

2.1. Kevlar fiber

Kevlar is a synthetic fiber that is five times stronger than steel, weight for weight. Kevlar is very heat resistant and decomposes above 400 °C without melting. It is usually used in bullet proof vests, in extreme sports equipment, and for composite aircraft construction. It is also used as a replacement for steel cords in car tires, in fire suits and as an asbestos replacement.

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.

(a) **(b)**
Fig1. (a) Unprocessed Kevlar fiber; (b) Woven Kevlar fiber

2.2. Epoxy resin

The Epoxy 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 1158 Rajesh et al. / Materials Today: Proceedings 5 (2018) 1156–1161 shows that vapour pressure is lesser than 0.01 Pa at 20°C and specific gravity must be between 1.15-1.2 at 25°C. The boiling point and the decomposition temperature must be greater than 200 °C.

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 200°C, the flash point must be 110°C, its vapour pressure is 0.3 Pa at 20°C and its density is 1g/cm^3 at 20°C.

2.4. Glass Fiber Reinforced Polymer

Fiber-reinforced polymer (FRP) 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.

2.5. Scrap Tyres

The most preferred method for their cycling of tire rubber is by grinding It and then to convert it for various applications .The crumb rubber used in concrete or asphalt paving mixtures is in sizes ranging from 0.0075mm to 4.75mm .The steps involved in the production of crumb rubber includes herding ,separation of steel and textile, granulation and classification. The tires would be cut into larger pieces and then shredded into smaller pieces .The steel wires and the textile part would be separated after shred- ding. Mechanical grinding for granulation could be performed at ambient temperature under wet condition, a thigh temperature and at cryogenic temperature.

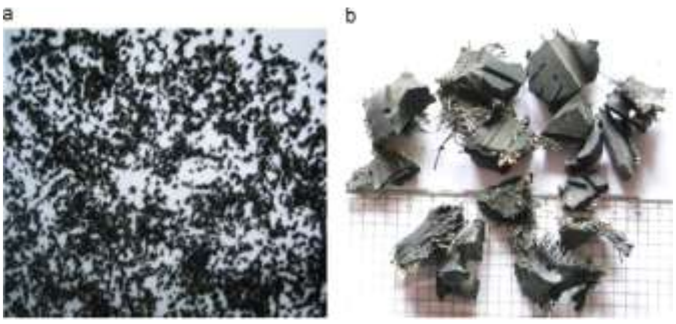

Fig.2. (a)Ground Rubber.(b)Crushed Rubber(waste tire chips)

3. 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.

Fig.3.layup the materials

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.
- 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
- 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 kept over the fibre arrangement for better adhesion

4. TESTING METHODS

4.1. Tensile test

Tensile test was conducted as per ASTM D 3039 standards .The specimens for tensile testing were cut from the laminated composites using band saw with a sample size of120 mm × 20 mm × 3 mm. Accurate surface finishing could be obtained using emery paper. Tensile strength and modulus were measured by using an INSTRON 5566 Universal Testing machine. The magnitude of load and the rate of loading were10 kN and 5 mm/min. Five identical samples were tested for each layering sequence and the average results will be generated.

4.2. Flexural test

The flexural test was carried out according to ASTM D 790 with a specimen size of 120 mm × 20 mm × 3 mm through three point bending test using an INSTRON 5566 Universal Testing machine (UTM). The standard span to depth ratio of 16:1was considered. The magnitude of load and the rate of loading were 10 kN and 2 mm/min. Five identical samples were tested for each layering sequence and the average results will be generated.

4.3. Impact test

The Izod impact test was conducted as per ASTM D 256 standards by using Go tech GT-7045-MD model impact tester. Five identical samples with dimensions of 70 mm × 15 mm × 3 mm were tested for each layering sequence and the average results will be generated.

5. COMPARISON CHART

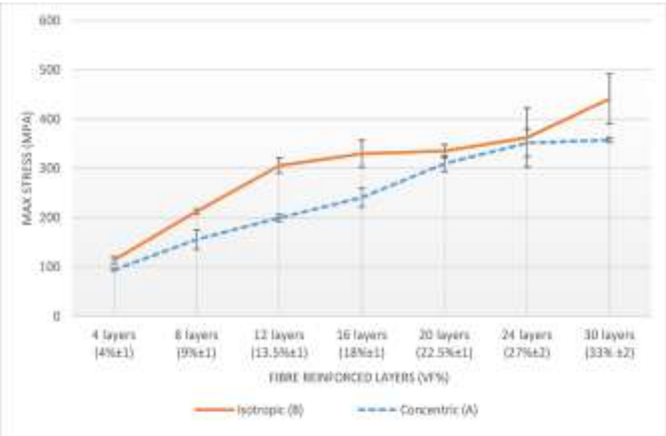

Fig .4. *Evaluation of glass volume fractions on tensile strength, as well as a comparison between strengths of Pattern 'A' and 'B' specimen. The increase in strength with increased fiber content is initially linear for both patterns, with Pattern B reaching a maximum efficiency between 12 and 16 layers. After this point the addition of further fiber up to the 33% studied was found to yield a further increase of just 31%.*

6. CONCLUSION

A critical review of characterization of Kevlar fibers and its composites are presented in the literature. The work done by many researchers have been reported. The Kevlar fiber and its composites possessed very high ratio of tensile to compression strength because of the highly anisotropic nature of the Kevlar fibers. The compressive strength of the Kevlar composites was improved by the Kevlar fiber treatment and the hybridization with other synthetic fibers like glass and carbon. This not only improved the compressive strength, but also improved the interfacial fiber-matrix adhesion, which resulted in a better flexural, modulus and the thermal properties of the Kevlar composites. It is usually used in Ballistic protective applications such as bullet proof vests and Protective apparel such as gloves, motorcycle protective clothing and hunting gaiters, chaps and pants.

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