International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

Study of Tensile Behaviour by Variation of Kevlar to the Jute Fibre Epoxy Hybrid Composites

Bhanupratap R[1]
Research Scholar,
Dept of Mech Engg
University Visveshvaraya College of Engineering
Bengaluru, India

H C Chittappa[2]
Associate Professor,
Dept of Mech Engg
University Visveshvaraya College of Engineering
Bengaluru, India

***Abstract*— Hybrid composites are occupying the place of conventional materials by meeting the requirements of the industries, aerospace, mechanical, space, construction, and biomedical applications. But the desire of achieving the higher modulus to density ratio always remains starved as it requires the maximum output in minimal consumption with better life expectency to find the economical means of utilising the technology for different applications. Here an attempt is made to study, observe and compare to know the tensile behaviour of the hybrid polymer composite material. From the result, increased layer of kevlar to the jute fibre shows improvement in the tensile strength and tensile modulus.**

Keywords—Jute; kevlar; epoxy, hybrid composite, laminate, hand lay up technique

I. INTRODUCTION

In order to conserve natural resources and economize energy, weight reduction has been the main focus of automobile manufacturers in the present scenario. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes. The introduction of composite materials made it possible to reduce the weight of component without any reduction on load carrying capacity and stiffness. The composite materials have more elastic strain energy storage capacity and high strength to weight ratio. The composite material offer opportunities for substantial weight saving but not always are cost-effective over their steel counter parts [1]. Composite materials are new generation materials to meet the demands of rapid growth of technological changes in the industry. Composite materials are engineering materials made from two or more constituents materials that remain seperate and distinct on macroscopic level while forming a single component. It consists of short and soft collagen fibres embedded in a mineral matrix called apatite[2]. Hybrid compposites contains more than one type of fibre in a single matrix material. In principle, several different types of fibres may be incorporated to become hybrid material, but it is more likely that a combination of only two types of fibres is more beneficial. They have been developed a logical sequel to conventional composites containing one fibre. Hybrid composites have unique features that can be used to meet various design requirements in a more economical way than conventional composites. This is because expensive fibres like graphite and boron can be partially replaced by less expensive fibre like kevlar[3].

Natural fibres include those produced by plants, animals and geological process. They are biodegradable over time. Vegetable fibres are generally based on arrangements of cellulose, often with lignin. Examples are jute, cotton, flax etc. Animal fibres consists of particularly proteins. Some of the instances are silkworm, spider silk etc. Mineral fibres include the asbestos which is the only natural ocuring long mineral fibre[4]. Synthetic fibres come from synthetic materials such as petrochemicals but some types of synthetic fibres are manufactured from natural cellulose[4]. Hybrid composites normally contain high modulus, high strength etc. The intrinsic mechanical properties of both reinforcement material gives raise to unique structural materials in terms of toughness and strength[4]. A laminate is a material that can be constructed by uniting two or more layers of materials together. A laminate is the stock of lamina orientation in a specific manner to achieve a desired result. Individual lamina are bonded together by a curing procedure that depends on the material system used. The mechanical response of the laminate is different from that of the individual lamina that is formed. The laminates response depends on the preperties of each lamina as well as the order in which the lamina are stocked. Laminated composite consist of layers of atleast two different materials that are bonded together. If layers of such composite are stacked and bonded together in such a way that successive layers have their fibres alligned in different directions, the composite on the whole will have high strength and iniform properties in all directions[4]. The tensile, flexural and impact properties of pineapple leaf fibre and sisal reinforced polyester composites are improved by the incorporation of small amount of glass fibres in these composites showing positive hybrid effect[5]. The properties of natural fibre reinforced composites can be enhanced by combining it with synthetic fibre and making it hybrid polymer composite. The bamboo- glass fibre reinforced polymer composite showed better mechanical properties like hydro thermal aging and tensile strength[6]. The epoxy resin reinforced with glass fibre and bamboo leaf derived SiC improves tensile and flexural strength of the composite[7]. The jute and E glass reinforced polyester composite showed an considerable improvement by incorporating the E glass as extreme glass plies[8]. Very less research have been conducted in the field of kevlar and natural fibre

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reinforced composite materials[9]. Panthapullakkal and Sain studied the mechnical and thermal properties of heml/glass polypropylene composite materials. They have observed that the use of hybrid composites enhance the tensile, flexural and impact properties. In addition they have observed that the addition of glass fibre into hemp-PP composites resulted in improved thermal properties as well as the water resistance of the composites[13]. Idicula et al[14] has studied the thermophysical properties of natural fibre reinforced composites . they have indicated that the natural fibre with glass allows a significantly better heat transfer ability for the composites.As a whole, in this study the bidirectional fibre mat i.e jute and kevlar is used for the preparation of the hybrid composites.

The purpose of this study is to investigate the potential utilisation of kevlar to the jute in epoxy matrix composites and the effect of kevlar fibre to the jute content on the physical and mechanical behaviour of the composites will also be investigated.

II. MATERIALS

In this study, the natural fibre jute and the kevlar are incorporated with epoxy resin.

A) Epoxy

Epoxy resins are the mostly used resins. They are a low molecular weight organic liquids which contains epoxide groups. Epoxide has two members in its ring they are carbon and oxygen atoms. The reactions of epichlorohydrin eith aromatic amines or phenols amines make most epoxies. Filler, hardeners and plasticisers are also added to produce epoxies with a wide range of properties of impact, viscosity, degradation etc. Although epoxy is a costlier one than other polymer matrices, Polymer matrix compositess is mostly used. More than two thirds of the polymer matrices which is usedns is epoxy based type. Its chemical name is Diglycidyl ether of bisphenol and the type used is Araldite LY556[10].

Table 1: Properties of epoxy

Description	Properties
Specific gravity	1.2
Tensile strength	35-130 MPa
Poisson's ratio	0.37
Compressive strength	100-200 MPa
Elongation	1-8.5%
Co-efficient of thermal expansion	45-70*10^{-6}/^{0}C
Water absorption	0.1-0.4%

B) Catalyst

Hardner such as organic peroxide or similar compound which is mixed with accelerator initiates the polymerisation process of the resins. Catalyst is available as a liquid. Its chemical name is Trietha Tetra-amine and the type used is Aradur- HY951

C) Jute fibre

Jute is a soft, long, shiny plant fibre that can be spun into course, strong threads. Jute fibre is 100% bio-degradable, recyclable and thus environment friendly. Jute does not generate toxic gases when burnt. Jute is a versatile fibre. A key feature of the jute is its ability to be used either independently or in blended form with a range of other fibres and materials[10].

Table 2: Properties of jute fibre

Description	Properties
Specific gravity	1460 kg/m^3
Tensile strength	400-800 MPa
Elongation at break in %	1.7-1.8%
Youngs Modulus	7.6 MPa
Stiffness	10-30KN/mm^2
Water absorption	13 %
Countries availabilty	India, Egypt, Guyana etc

*D) **Kevlar fibre***

Kevlar fibre reinforced composite materials are increasingly popular over the years. Its application is considerably vast due to its excellent mechanical properties, lighter weight, unique flexibility, corrosion resistant, ease of fabrication etc compared to other conventional metallic materials. Kevlar fibre possess very unique properties. It can be viewed as nylon with extra benzene rings in the polymer chain for increasing its stiffness. It is mainly popular for its applications in industrial and advanced technologies like ballistic armor, helicopter blades, pneumatic devices, sporting goods etc. Compared to other synthetic fibres, it possess significantly lower fibre elongation and higher tensile strength and modulus[11]

Table 3: Properties of kevlar fibre

Description	Properties
Density	1.45 g/cm^3
Filament diameter	12
Tensile strength	3176 MPa
Tensile modulus	135 GPa
Elongation	2.8 %
Tenacity	20-26 N
Sizing	Epoxy compatible

III. FABRICATION PROCESS

For fabrication of composite, the bi-directional fibre fabric of kevlar and jute fibre are incorporated into epoxy resin LY556 and hardener HY 951 by hand lay up method. In this method, before laying up, the mould was prepared with a release agent to avoid the adhering of the part to the mould. Reinforcement fibres was cut and laid in the mould as per the dimension. Then the required amount of resin is added to the fibres. A roller and brushes can be used to impregnate the fibres with the resin.

A) Experimental work

In this study, the tensile property of jute and kevlar reinforced polymer matrix hybrid composite will be investigated by cutting by means of water jet cutter to the required dimension as per ASTM :D638 standard (216 × 19 × 3 mm^3). The sample figure is shown below in fig.1 The tensile test for the hybrid composite is obtained using tensometer as shown in the fig 2. The specimens are loaded step by step untill failure under tensile loading along the longitudinal axis. A continous record of load and deflection is obtained by a digital data acquisition system.

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Fig 1. Tensile specimens before and after the test of jute kevlar epoxy composite

Fig 2. Tensometer

Table 4: Laminates designations

Laminates	Compositions
L1	J+J+J+J
L2	J+K+J+J+J
L3	J+K+J+K+J+K+J
L4	J+K+K+J+K+J+K+K+J

1V. TESTING AND EVALUATION

The test was conducted on the above four samples as shown in the table 4. The data measured from the mechanical testing was used to calculate the elastic properties and strength of the laminates. The table 5 shows the tensile properties that were determined from each laminate.

Table 5: Tensile properties of the laminates

Composites	Tensile strength (N/mm^2)	Ultimate load (KN)	% Elongation	Elasticity Modulus (GPa)
L1	50.807	2.353	3.24	1.733
L2	77.410	4.10	4.166	2.402
L3	117.637	8.00	4.814	3.944
L4	159.652	11.258	5.092	5.226

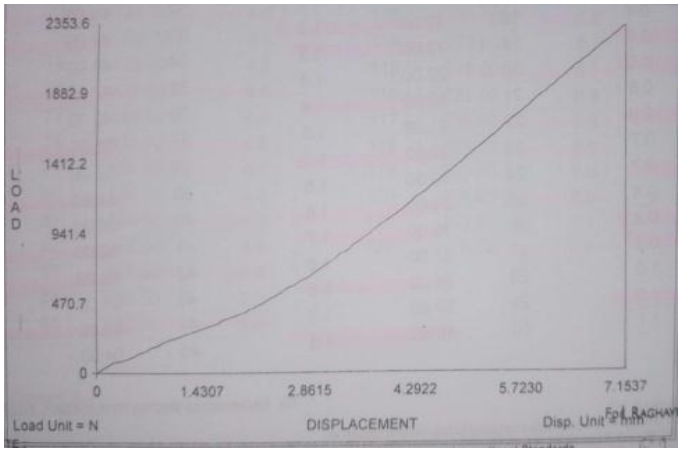

Fig 3: Sample graph obtained from tensometer for load vs displacement (tensile test)

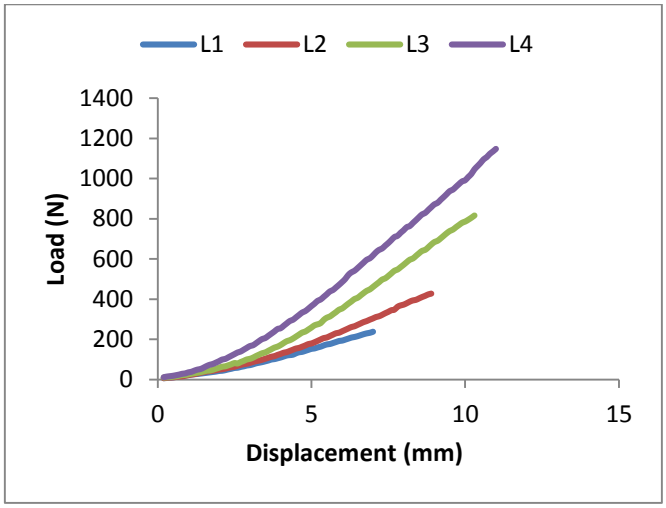

Fig 4: Load vs displacement

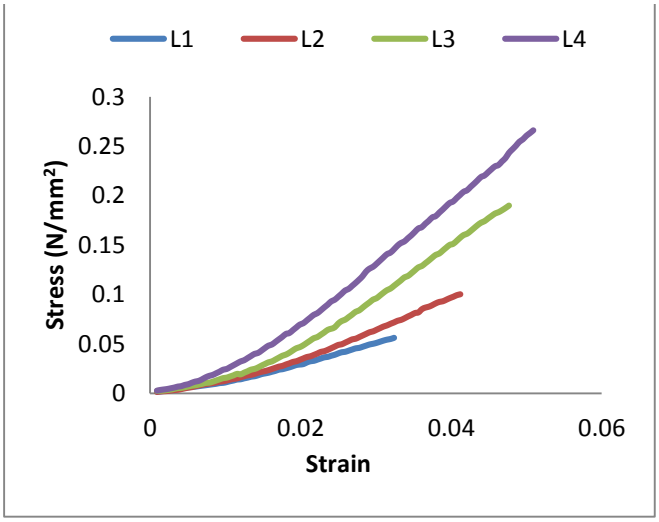

Fig 5: Stress vs strain

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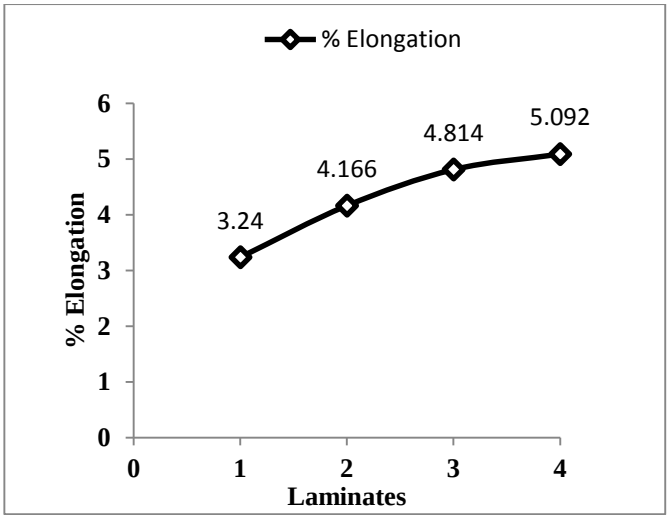

Fig 6: Elongation vs laminate

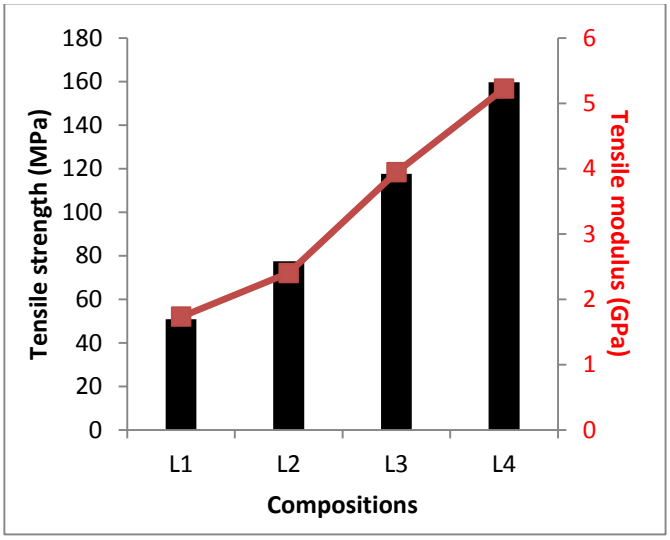

Fig 6: Tensile strength and tensile modulus of the composites

IV. RESULTS AND DISCUSSIONS

The composite specimens L1, L2, L3, L4 are tested for tensile properties in tensometer and obtained tensile properties are shown in **table 5**. The sample graph of load vs displacement obtained by tensometer after tensile test is shown the **fig 3**. The load vs displacement curves are shown in **fig 4.** The stress vs strain curve is shown in **fig 5**. The elongation with respect to laminates are shown in **fig 6.** The variation in tensile strength and tensile modulus of composite with increase in fibre content is shown in **fig 7**. It is clearly visible that with the increase in kevlar content in the jute epoxy matrix, the load is increasing and as such the elongation is enhanced which shows the improvement in tensile strength and tensile modulus in the laminates. It is due to the fact that there is proper transmission and distribution of the applied stress by the epoxy resin resulting in higher strength. Similar obsevations have been made by Vivek Mishra[12] in case of Bi-Directional jute fibre epoxy composites. Laminate L1 which consists of pure jute layers shows lower tensile strength as the layers of kevlar is not placed. The kevlar fibre inclusion enhances the load bearing capacity to the jute epoxy composite and the ability to withstand the tension. Thus from the results, it can be asserted that the laminate L4 is performing well as compared to the other type of fibres used.

V. CONCLUSION

The following conclusions have been drawn from the Jute Kevlar Epoxy Hybrid Composite:

1. This work shows successful fabrication of the bidirectional jute kevlar reinforced epoxy hybrid composite that is adopted by hand lay up technique for different proportions.
2. It is proved that when natural fibre (jute) and synthetic fibre (kevlar) are incorporated to the resin, the tensile strength is greatly influenced by the different fibre proportions.
3. The proper transmission and distribution of the applied stress by the epoxy resin results in higher strength of the hybrid composite.
4. The tensile properties of the bidirectional jute kevlar reinforced epoxy hybrid composite increases with increase in the layer of kevlar addition, this is due to the strong bonding of the matrix with the reinforcement and the load carried by them.
5. In this study it is observed that the thickness of the composite enhances the tensile strength due the addition of kevlar which is required for the dynamic loading applications.

AKNOWLEDGEMENT

The author expresses his sincere thanks to Vishwanath. M, Asst Prof, MED, Dr AIT, Bengaluru for being the source of encouragement to carry out this research.

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