A REVIEW ON DEVELOPMENT AND TESTING OF HYBRID FIBER COMPOSITE MATERIAL

Pandhre Ganesh C[a] Bhakare Rohan A[b]
Gaikwad Vishwajit A[c] Shinde Akshay M[d]
a,b,c,d UG Scholors
Department of Mechanical Engineering,
SMSMPITR, Akluj, Pin-413118,
Maharashtra, India.

Ravikiran. V. Adat,
Assistant Professor, Mechanical Engineering
S.M.S.M.P.I.T.R.Akluj-413118, MH, India
Mayur D. Jagtap
Assistant Professor, Mechanical Engineering
S.B.P.C.O.E Indapur-413106, MH, India.

Abstract—The hybrids composite has emerged and have the potential reinforcement material for composites and thus gain attraction by many researchers. Nature continues to provide mankind generously with all kinds of rich resources in plentiful abundance, such woven fiber carbon hybrid composites. In this composite laminates Kevlar and carbon fiber exhibit higher mechanical properties. So, the composite material shows the highest mechanical properties. This High-performance hybrid composite material has extensive engineering applications such as transport industry, aeronautics, naval, automotive industries. This is mainly due to their applicable benefits have they offer low density, low cost, renewable, biodegradability and environmentally harmlessness and also comparable mechanical properties with synthetic fiber composites. Kevlar fiber and carbon fiber composites were fabricated by using epoxy resin combination of hand lay-up method and cold press method. Specimen is cut from the fabricated laminate according to the ASTM standard for different experiments for tensile test, flexural text, and impact test.

Keywords: composites, Synthetic Fiber, mechanical properties, epoxy, hand layup.

I. INTRODUCTION

In recent years, polymeric based composites materials are being used in many applications such as automotive, sporting goods, marine, electrical, industrial, construction, household appliances, etc. Polymeric composites have high strength and stiffness, light weight, and high corrosion resistance. Natural fibers are available in abundance in nature and can be used to reinforce polymers to obtain light and strong material.

The natural fiber present important advantages such as low density, appropriate stiffness, mechanical properties with high disposability and renewability. In this project are used the natural fiber of banana and coconut. Moreover, these banana and coconut fiber are recycle and biodegradable. Banana fiber, a lignocellulosic fiber, obtained from the pseudo-stem of banana plant (Musa sepientum), is a bast fiber with relatively good mechanical properties. In tropical countries like India, fibrous plants are available in abundance and some of them like banana are agricultural crops. Banana fiber at present is a waste product of banana cultivation. Hence, without any additional cost input, banana fiber can be obtained for industrial purposes. Banana fiber is found to be good reinforcement in polypropylene resin. The properties of the composite are strongly influenced by the fiber length. [5]

Table 1 Comparison between natural and Carbon fiber

	Natural fibres	carbon fibres
Density	Low	Twice that of natural fibres
Cost	Low	Low, but higher than NF
Renewability	Yes	No
Recyclability	Yes	No
Energy consumption	Low	High
Distribution	Wide	wide
CO2 neutral	Yes	No
Abrasion to machines	No	Yes
Health risk when inhaled	No	Yes
Disposal	Biodegradable	Not biodegradable

II. TYPES OF COMPOSITE MATERIALS

Broadly, composite materials can be classified into three groups on the basis of matrix material. They are

i. Metal Matrix Composites (MMC)
ii. Ceramic Matrix Composites (CMC)
iii. Polymer Matrix Composites (PMC)

A. Metal matrix composites

Higher specific modulus, higher specific strength, better properties at elevated temperatures and lower coefficient of thermal expansion are the advantages of metal Matrix Composites over monolithic metals. Because of these attributes metal matrix composites are under chamber nozzle (in rocket, space shuttle), housings, tubing, cables, heat exchangers, structural members etc.

B. Ceramic matrix Composites

One of the main objectives in producing ceramic matrix composites is to increase the toughness. Naturally it is hoped and indeed often found that there is a concomitant improvement in strength and stiffness of ceramic matrix composites.

C. Polymer Matrix Composites

Polymeric matrix composites are the most commonly used matrix materials. The reasons for this are two-fold. In general, the mechanical properties of polymers are inadequate for many structural purposes. In particular their strength and stiffness are low compared to metals and ceramics. By reinforcing other materials with polymers these difficulties can be overcome. Secondly high pressure and high temperature are not required in the processing of polymer matrix composites. For this reason, polymer composites developed rapidly and became popular for structural applications with no time. Polymer composites are used because overall properties of the composites are superior to those of the individual polymers. [5]

III. MATERIAL FOR POLYMER

A. Epoxy resin

Epoxy resins are available in liquid and solid forms and are cured into the finished plastics by a catalyst. They are cured at room temperatures as well as elevated temperatures of about 275^{0}C. The erosion resin of grade LY-556 was used of density 1.1-1.2gm/cc at 298K. It having the following outstanding properties has been used as the matrix material. [5].

a) Excellent adhesion to different materials.
b) High resistance to chemical and atmospheric attack. High dimensional stability.
c) Free from internal stresses.
d) Excellent mechanical and electrical properties. Odorless, tasteless and completely nontoxic. Negligible shrinkage.

B. Carbon Fiber

Carbon fiber reinforced polymer, carbon fiber reinforced plastic or carbon fiber reinforced thermoplastic (CFRP, CRP, CFRTP or often simply carbon fiber, carbon composite or even carbon), is an extremely strong and light fiber-reinforced plastic which contains carbon fibers. The spelling 'fiber' is common in British Commonwealth countries. CFRPs can be expensive to produce but are commonly used wherever high strength-to-weight ratio and rigidity are required, such as aerospace, automotive, civil engineering, sports goods and an increasing number of other consumer and technical applications.

1. High Strength to weight ratio
2. Rigidity
3. Corrosion resistance
4. Electrical Conductivity
5. Fatigue Resistance
6. Good tensile strength but Brittle
7. Fire Resistance/Not flammable
8. High Thermal Conductivity in some forms
9. Low coefficient of thermal expansion
10. Non-poisonous
11. Biologically inert
12. X-Ray Permeable
13. Self-Lubricating
14. Excellent EMI (Electromagnetic Interference) Shielding Property
15. Relatively Expensive

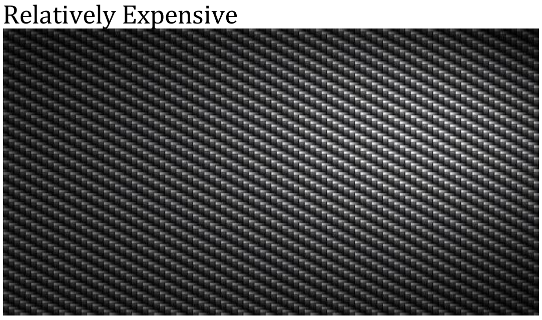

Fig.2 Carbon Fiber

C. Kevlar Fibers

Kevlar fibers are made up of aromatic polyamides which are long polymeric .chains and aromatic rings. They are structured in six carbon atoms are bonded to each other of hydrogen atoms. In Kevlar fibers, these rings occur and reoccur to form the fibers. They were initially used to reinforce automobile tires also used in bullet proof vests; power boats. Kevlar have high tensile strength, high modulus and low weight. Impact- resistant structures can be produced from Kevlar. The density of Kevlar fibers is less than that of glass and graphite fibers.

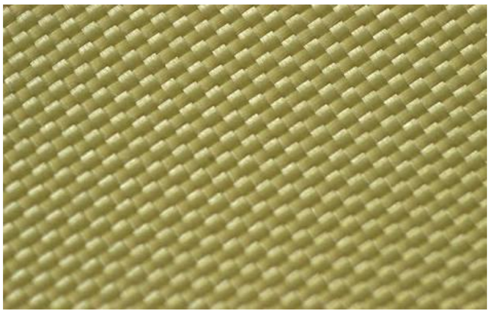

Fig.2 Kevlar Fiber

4. MATERIALS OPTIONS

Resins: Epoxy, polyester, vinyl ester, phenolic and any other resin.

Synthetic Fibers: Glass, Carbon, Aramid and any other reinforcement, although heavy aramid fabrics can be difficult to wet-out by hand.

Natural fiber: Banana, Coconut.

Cores: Any core materials can be used provided that should be compatible with resin system, i.e. polystyrene core cannot be used with polyester or vinyl ester resin system.

5. Material Composition

A releasing agent is used on the mould release sheets to facilitate easy removal of the composite from the mould after curing. The entrapped air bubbles (if any) are removed carefully with a sliding roller and the mould is closed for curing at a temperature of 30°C for 24 h at a constant load of 50 kg. After curing, the specimens of suitable dimension are cut using a diamond cutter for mechanical tests as per the ASTM standards. The composition and designation of the composites prepared for this study are listed in the following table. The samples have been prepared by varying the fiber length and fiber loading for the two fibers.

On addition to hardener the resin will begin to become more viscous until it's not at all liquid and has lost its ability to flow. This is 'Gel Point' the resin will continue to hardened after it has gelled, until, at some time later. It has obtained maximum hardness and all its properties. This reaction itself is accompanied by the generation of exothermic heat, which, in turn speed up the reaction. This whole process is known as 'Curing' of the resins.

Curing at high temperature has the added advantage that it actually increases the end mechanical properties of the material. And many resin systems will not reach their ultimate mechanical properties unless the resin is given this 'Postcure'. This posture process involves increasing the laminate temperature after the initial room temperature cure, which increase the amount of cross linking of the molecules that can take place. To some degree this posture will occur naturally at warm room temperatures, but higher properties and shorter posture times will be obtained if elevated temperatures are used. [1][2][3]

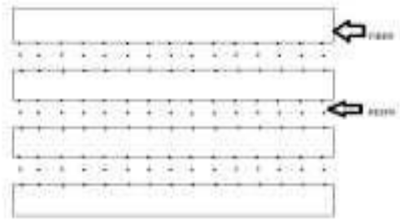

Fig.4 Fiber and Resin Layers

IV. Methods of Manufacturing

A. Description of hand layup technique

Matrixes/Resins are impregnated by hand into fibers which are in the form of chopped strand mat 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. [5]

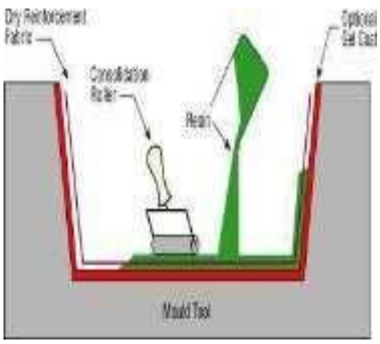

Fig.5 Hand Layup technique

B. Vacuum bagging technique

Vacuum bagging uses atmospheric pressure as a clamp to hold laminate plies together. The laminate is sealed within an airtight envelope. The envelope may be an airtight mold on one side and an airtight bag on the other. When the bag is sealed to the mold, pressure on the outside and inside of this envelope is equal to atmospheric pressure: approximately 29 inches of mercury (Hg), or 14.7 psi. As a vacuum pump evacuates air from the inside of the envelope, air pressure inside of the envelope is reduced while air pressure outside of the envelope remains at 14.7 psi. Atmospheric pressure forces the sides of the envelope and everything within the envelope together, putting equal and even pressure over the surface of the envelope. The pressure differential between the inside and outside of the envelope determines the amount of
Clamping force on the laminate.[8]

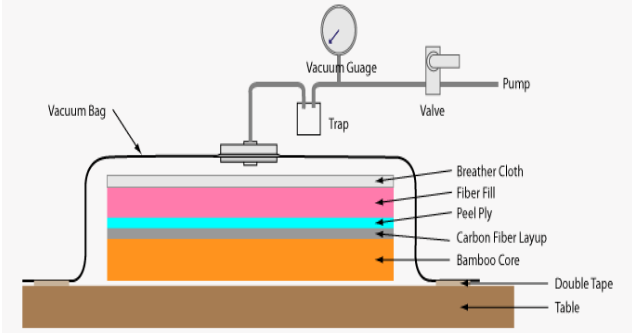

Fig.6 vacuum bagging technique

V. TESTS

A. TENSILE TEST

The ability to resist breaking under tensile stress is one of the most important and widely measured properties of materials used in structural applications.

The force per unit area (MPa or psi) required to break a material in such a manner is the ultimate tensile strength or tensile strength at break. Tensile properties indicate how the material will react to forces being applied in tension. A tensile test is a fundamental mechanical test where a carefully prepared specimen is loaded in a very controlled manner while measuring the applied load and the elongation of the specimen over some distance. Tensile tests are used to determine the modulus of elasticity, elastic limit, elongation, proportional limit, and reduction in area, tensile strength, yield point, yield strength and other tensile properties. [2]

Table 2. Tensile strength of Synthetic fibers

Sl.no	**Synthetic fibre**	**Tensile Strength (Mpa)**	**Reference**
1	E-glass	2000-3500	**7**
2	S-glass	4570	**7**
3	Aramid	3000-3150	**7**
4	Carbon	4000	**7**

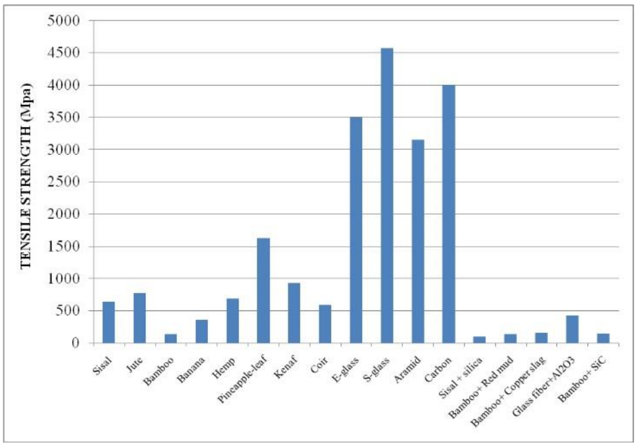

Fig.5 Comparative evaluation of tensile property of Fiber Reinforced Composites

B. FLEXURAL STRENGTH

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using a three point flexural test technique.

The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress, here given the symbolσ.When an object formed of a single material, like a wooden beam or a steel rod, is bending, it experiences a range of stresses across its depth. At the edge of the object on the inside of the bend (concave face) the stress will be at its maximum compressive stress value. At the outside of the bend (convex face) the stress will be at its maximum tensile value. These inner and outer edges of the beam or rod are known as the 'extreme fibers'. Most materials fail under tensile stress before they fail under compressive stress, so the maximum tensile stress value that can be sustained before the beam or rod fails is its flexural strength. [5]

C. CHARPY IMPACT

The Charpy impact test, also known as the Charpy v-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent ductile-brittle transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. A major disadvantage is that all results are only comparative. The apparatus consists of a pendulum axe swinging at a notched sample of material.[1]

Conclusion

The mechanical properties of coir fiber have a strong association with the dynamic characteristics. Both of the properties are greatly dependent on the volume percentage of fibers. The composite having a coir fibers volume of 5% showed a significant result compared to high fiber loading composites due to the effect of material stiffness.

Carbon fiber is an extremely strong and lightweight fiber reinforced polymer. It is usually expensive to manufacture but used wherever a high strength-weight ratio is needed.

Banana fiber is a natural fiber with relatively good mechanic properties. It can withstand stone strikes and exposure to the environment, such as ultraviolet from the sun, water, some chemicals.

The study shows that hybrid composite has composites, emphasizes both mechanical and physical properfar better properties than single fiber reinforced compo- ties and their chemical composition.

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