FABRICATION AND TESTING OF HYBRID COMPOSITES USING JUTE AND MANGO ENDOCARP

Akshay kumar M[1],Mohan kumar K[2],Adarsh N[3],Arvind babu B A[4],Balaji S C[5]

[1,3,4,5] Student, Dept. of Mechanical Engg., MVJ College of Engg. Bengaluru 560067, Karnataka, India
[2] Assistant professor, Dept. of Mechanical Engg., MVJ College of Engg. Bengaluru 560067, Karnataka, India

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Abstract - *Polymeric materials reinforced with synthetic fibres such as glass, carbon and aramid provide advantages of high stiffness and strength to weight ratio as compared to conventional construction materials such as wood, concrete, steel.*

The production of synthetic fibre depends mainly on fossil fuels and needs nearly ten times more energy as compared to natural fibre. As a result, the pollutant gas emissions to the environment from synthetic fibre production are significantly higher than that from the natural fibre production. Also the polymers hence produced are not biodegradable, which makes the disposal difficult.

The increased interest in using natural fibres as reinforcements in plastics to substitute conventional synthetic fibres in some structural applications has become one of the main concerns to study the potential of using natural fibres as reinforcement for polymers.

To overcome these problems, natural fibres can be used as a replacement for synthetic fibres. Natural fibres are extracted from the plants and the animals through various processes/ treatments. These fibres are characterised according to lengths. Then the matrix material which holds the fibres together is decided, and then the material is fabricated using appropriate processes.

***Key Words*: composite materials, hybrid PMC jute and mango endocarp, hand lay-up, specimen preparation, mechanical properties**

1.INTRODUCTION

A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called the reinforcing phase and the one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous. Examples of composite systems include concrete reinforced with steel and epoxy reinforced with graphite fibers, etc.
Advanced composites are composite materials that are traditionally used in the aerospace industries. These composites have high performance reinforcements of a thin diameter in a matrix material such as epoxy and aluminium. Composites typically have a fiber or particle phase that is stiffer and stronger than the continuous matrix phase and serve as the principal load carrying members. The matrix acts as a load transfer medium between fibers, and in less ideal cases where the loads are complex, the matrix may even have to bear loads transverse to the fiber axis. The matrix is more ductile than the fibers and thus acts as a source of composite toughness. The matrix also serves to protect the fibers from environmental damage before, during and after composite processing.

In general the existing composite materials are classified into two main groups. The first group comprises composites that are known as 'filled materials.' The main feature of these materials is the existence of some basic or matrix material whose properties are improved by filling it with some particles.

Usually the matrix volume fraction is more than 50% in such materials, and material properties, being naturally modified with the fillers, are governed mainly by the matrix. As a rule, filled materials can be treated as homogeneous and isotropic, i.e., traditional models of mechanics of materials developed for metals and other conventional materials can be used to describe their behavior. The second group of composite materials that is under study here involves composites that are called 'reinforced materials.'

The basic components of these materials are long and thin fibers assessing high strength and stiffness. The fibers are bound with a matrix material whose volume fraction in a composite is usually less than50%.

The use of natural fibers as reinforcements in polymer composites to replace Synthetic fibers like glass is presently receiving increasing attention because of the advantages, including cost effectiveness, low density, high specific strength, as well as their Availability as renewable resources. Owing to the poor wettability and absorbability towards polymers resulting from the hydrophilicity of plant fibers, however, the adhesion between the fibers and polymer matrices is generally insufficient.

To improve the interfacial bonding, the surface modification of the fibers can be carried out. It is worth noting that the chemical composition and cell structure of natural fibers are quite complicated. Each fiber is essentially a composite in which rigid cellulose micro fibrils are embedded in a soft lignin and hemicelluloses matrix.

In addition, the micro fibrils are helically wound along the fiber axis to form ultimate hollow cells. Uncoiling of these spirally oriented fibrils consumes large amounts of energy and is one of the predominant failure modes. As a result, pretreatment of the fibers would result in chemical and structural changes not only on the fiber surface, but also in the distinct cells, which in turn also influences the properties of the fibers and composites.

MATERIALS, FABRICATION METHODS ANDSPECIMEN PREPARATION

2.1 MATERIALS

Following materials have been used in the proposed work. Jute fiber and mango endocarp are used as reinforcement. Epoxy resin LY-556 is used as the matrix.

2.1.1 MATRIX MATERIAL

The role of matrix material in a fiber-reinforced composite are
1) To keep the fibers in place.
2) To transfer stresses between the fibers.
3) To provide a barrier against an adverse environment, such as chemicals and moisture.
4) To protect the surface of the fibers from mechanical degradation.

2.1.1.1 Epoxy Resin

Epoxy resin is widely used in industrial application because of their high strength and mechanical adhesiveness characteristic. It is also good solvent and have good chemical resistant over a wide range of temperature. LY–556 is used as matrix in the present investigation. The properties and curing details of epoxy resin shows the Table 2.1,

Table 2.1 Some Important Properties of Epoxy Resin (LY-556)

PROPERTIES	VALUES
Density	1.15-1.20gm/cm^3
Viscosity	50-100MPa s
Flash point	>200^{o}C
Storage temperature	2-40^{o}C

The epoxy resins do not soften at a specific temperature but appear to undergo a gradual and imperceptible change. The curing of epoxy resins is an exothermic process, resulting in the production of limited-size molecules, having molecular weights of a few thousands. Epoxy resins shrink on curing. Thus density increases. The temperature, location, and magnitude of these transitions directly influence the thermo-mechanical properties of the resins.

2.1.1.2 Hardener

HY-951 hardener is used as curing agent. The weight percentage of hardener used in the present investigation is in the ratio of 10:1.

Araldite HY-951 is an unfilled casting resin system that is renowned for its excellent properties and possibility of a high filler addition.HY-951 low viscosity, aliphatic amine hardener for epoxies that offers incredible mechanical strength that cures at room temperaturke.HY-951 is also well known for its excellent resistance to chemical and atmospheric degradation.HY-951 is useful for encapsulating or potting of low voltage electric components using the vacuum casting method.

2.2 REINFORCEMENTS

Reinforcing agents are added to the resin to improve the mechanical properties and failure rates of the material.

2.2.1 JUTE FIBRE:

Fig 2.1Jute Plant and Jute Fiber

Jute fibers are composed primarily of the plant materials cellulose, lignin, and pectin. Both the fiber and the plant from which it comes are commonly called jute. It belongs to the genus Corchorus in the basswood family, Tiliaceae.

It is one of the cheapest natural fibers. Jute is a best fiber used for sacking, burlap, and twine as a backing material for tufted carpets. It is a long, soft, shiny fiber that can be spun into coarse, strong threads.

2.2.2PROPERTIES OF JUTE FIBRE:

1. Jute fibre is 100% bio-degradable and recyclable and thus environmentally friendly.
2. Jute is a natural fibre with golden and silky shine and hence called The Golden Fibre.
3. Jute is the cheapest vegetable fiber procured from the bast or skin of the plant's stem.
4. It is the second most important vegetable fiber after cotton, in terms of usage, global consumption, production, and availability.
5. It has high tensile strength, low extensibility, and ensures better breathability of fabrics. Therefore, jute is very suitable in agricultural commodity bulk packaging.

PROPERTIES OF MANGO FIBRE:

1. Mango endocarp is 100% bio-degradable material and thus environmentally friendly.
2. Mangos are seasonal, but they are abundantly available in a particular season.
3. Mango endocarp is considered as a waste part of the mango fruit, except for the seed, if required. Hence it is readily available with least cost.
4. It has high tensile strength and low extensibility.
5. It has good wetting properties and hence adheres well to epoxy resin which gives good bonding.
6. Mango endocarp can be easily machined into required shapes.

Fig 2.2 Mango Endocarp

2.3 COMPOSITES COMBINATION

In the proposed work, specimens were prepared for three different compositions. Table 2.2 gives the detailed information of all combinations of composite prepared and used.

Table 2.2 Composites Combinations

Sl.no	Fibre with Orientation (Jute-Mango Endocarp)	Combination
1	0^o-0^o	90% LY-556+10% HY-951
2	0^o-45^0	90% LY-556+10% HY-951
3	45^o-45^o	90% LY-556+10% HY-951
4	45^0-0^o	90% LY-556+10% HY-951

2.4 FABRICATION OF COMPOSITES.

Following materials have been used in the proposed work. Jute fiber is used as reinforcement. Epoxy resin LY-556 is used as the matrix. The proposed work involves the use of hand layup method for fabrication and is explained as follows.

2.4.1Hand layup method

Hand lay-up technique is the simplest method of composite processing. First, a release gel is sprayed on the mold surface to avoid the sticking of polymer (jute fibre) to the surface. Thin plastic sheets are used at the top and bottom of the mold plate to get good surface finish of the product.

Reinforcement in the form of epoxy are put as per the mold size and placed at the surface of mold after polythene sheet. Then LY-556 in liquid form is mixed thoroughly in suitable proportion with a hardener HY-951 (curing agent) and poured onto the surface of mat already placed in the mold. The mixture is uniformly spread with the help of brush. Then a roller is moved with a mild pressure on the layer to remove any air trapped as well as the excess mixture present. The process is repeated for each layer of mixture, till the required layers are stacked. After curing either at room temperature or at some specific temperature, mold is opened and the developed composite part is taken out and further processed. The time of curing depends on type of matrix used for composite processing.

For example, for epoxy based system, normal curing time at room temperature is 24-48 hours. This method is mainly suitable for thermosetting polymer based composites. Capital and infrastructural requirement is less as compared to other methods. Hand lay-up method finds application in many areas like aircraft components, automotive parts, boat hulls, deck etc.

International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 11 | Nov -2017 www.irjet.net p-ISSN: 2395-0072

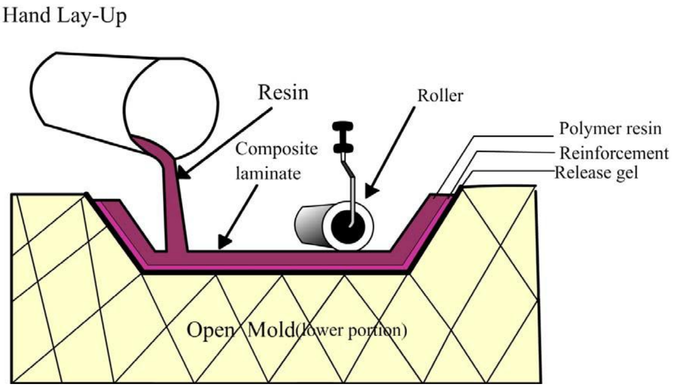

Fig 2.3: Hand lay-up Process

Fig 2.4: Hand lay-up Process

SPECIMEN PREPARATION AND EXPERIMENTATION

3.1 SPECIMEN PREPARATION

The composites which are prepared initially were marked for required dimensions of 250mm*25mm*2.5mm (l*b*h).The specimens are as per the standards of ASTM (D-3039).The specimens are prepared for both Tensile and Flexural test.

Fig 2.5: specimens for Tensile and Flexural

3.2 EXPERIMENTATION

The specimens are of four types:

1. Specimen with 45°/90°/45° orientation.
2. Specimen with 90°/45°/90° orientation.
3. Specimen with 90° orientation.
4. Specimen with 45° orientation.

On each specimen Tensile and Flexural tests were done and results are shown in graphs

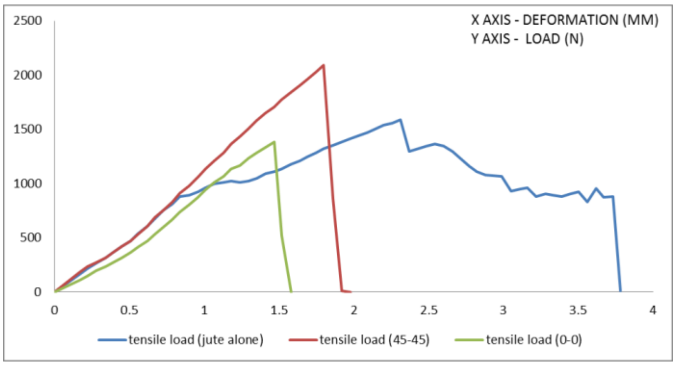

Fig 2.6 Graph of comparison of different orientation under tensile load

Conclusion on tensile test:-

The following conclusions are drawn as a reason for highest peak load values for 45°/45° orientation specimen.

- Composite containing 2 materials whose thermo mechanical properties are different and may have residual stress or underwent structure alterations owing to internal stress.

- The plastic constraint on the matrix owing to large difference in Poisson's ratio of matrix and fiber especially in the stage where fiber deforms elastically and the matrix plastically.

- The higher peak loads can also be reasoned out with the use of continuous fiber which have flaws distributed along their length and resulted in fiber pullout.
- Also the strength of the fiber is higher in longitudinal direction than that of transverse.
- The laminate with 45 showed more creep strain than the other orientations because in the 45 ° sequence the epoxy had creep strain contributions from:-
- Tension in loading direction
- Shear in the 45 o/135 o direction.
- Rotation of plies in scissor like action.
- Difference in the state of shear near the free edges.

Also present were large inter-laminar tensile stress in the thickness direction.

Conclusion on flexural test:-

- 0/45 :The top and the bottom layer is 90^0 and as weight is loaded on the top layer there is huge amount of deflection offered because of 45 sandwiched in between the top and bottom layer which in turn deflects the 90 orientated fibre.
- 45/45: The top and bottom layer of jute is 45 ° and mango endocarp is at 45 ° both of them resist any load.
- 45/0 Each laminar of jute is at an angle of 45 ° and mango endocarp at an angle of 0° and both aren't able to deflect because of the structure or resist any load and thus breaks at a lower load than others.

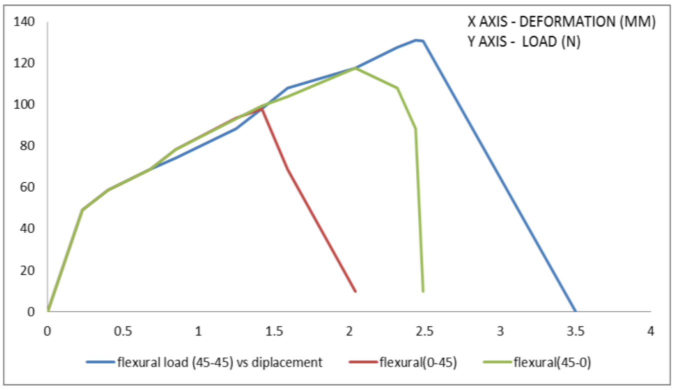

Fig 2.7: Graph comparing different orientations under flexural load

4. CONCLUSIONS

The jute fibre and mango endocarp reinforced with composites is found to have better strength at a particular orientation of the fibres at 45 ° -45 ° compared to other orientation. The investigation interest in the present study was to manufacture and to analyses and study the mechanical properties of the PMC.

The investigation resulted in concluding that these PMC can be used as a substitute for the back covers of mirror, plastic doors and handles, the foot rest and bumpers in automobiles. These have shown excellent strength, economy and sturdiness and are fit to be replaced.

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