FEA AND EXPERIMENTAL ANALYSIS OF HYBRID COMPOSITE OF GLASS FIBRE AND BANANA FIBRE

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ABSTRACT

The increasing demand for environmental friendly materials and the desire to reduce the cost of traditional fiber lead to the development of natural fiber composites. Natural fibers presented in the composite have some important advantages such as low density, appropriate stiffness, mechanical properties and renewability.. Banana fibers (BF) obtained from the stem of banana plant have been characterized for their diameter variability and their mechanical properties, with a stress on fracture morphology. In the present work Glass and banana fiber reinforced composite material is developed. Epoxy based four hybrid composites was examined using scanning electron microscope (SEM).. Variations in tensile and flexural properties of banana fibre reinforced polyester composites caused by the addition of glass fibre have been analysed. Banana fibre in combination with glass is very good for making economical composite materials. In the present work Epoxy based four hybrid composites (C1, C2, C3 and C4) have been fabricated with short banana and glass fiber loading (85 wt% Epoxy +7.5 wt% Banana fiber +7.5 wt% Glass fiber), (80 wt% Epoxy + 10 wt% Banana fiber +10 wt% Glass fiber), (75 wt% Epoxy + 12.5 wt% Banana fiber +12.5 wt% Glass fiber) and (70 wt% Epoxy + 15 wt% Banana fiber +15 wt% Glass fiber). A gradual increase in tensile and flexural strength can be observed with the increase in the fiber loading up to 25 wt% of composites. It has been observed that the tensile modulus increases by addition of fiber content up to 20 wt% then decreases due to addition of 25 wt% of fibers. Hardness value increases as wt% of fibers (banana and glass) increases. Hardness is maximum for sample C4 (70 wt% Epoxy + 15 wt% Banana fiber +15 wt% Glass fiber) as compared to pure epoxy. Experimental and analytical approach shows that the tensile and flexural strength increases as the fiber loading in the composite increases. Both the strength analysis shows 26.75%, 6.59%, 7.22% and 9.77% deviation in the experimental and analytical tensile test and 12.40%, 5.28%, 5.01% and 2.93% deviation in the experimental and analytical flexural test corresponding to sample C1, C2, C3 and C4 respectively.in XRD analysis Sharp peaks in sample with 15 wt%, 20 wt%, 25 wt% and 30 wt% of fiber sample confirm the semi crystalline nature of composites. SEM images shows that the increase in strength properties of composites at 30wt% fiber loading is due to the better adhesion between fiber and matrix**.**

Keywords : Banana fibers (BF), Glass fiber, Epoxy , tensile and flexural test, SEM, XRD

1. INTRODUCTION

1.1 Composite Materials: A composite is a structural material consists of two or more 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. [1].Any material consists of two or more materials having different properties and distinguishable boundaries between the different components may be called as a composite material.[2]. Composite are hybrid of two or more material such as reinforced polymer, metal or ceramics. The reinforcement may be in the form of fibers, particles, whiskers or lamellae, and are incorporated in a suitable matrix, thereby providing a material that combines the most useful properties of the constituents.[3].

1.2 Classification of composites

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

1.2.1 Metal Matrix Composites (MMC)

1.2.2 Ceramic Matrix Composites (CMC)

1.2.3 Polymer Matrix Composites (PMC)

These composites, containing discontinuous or continuous reinforcement with particulates, whiskers or fibers are capable of providing properties not achievable in monolithic alloys. Many potential aerospace applications have been identified for MMC. These are also having automotive applications. These composites are processed by sintering, hot pressing, hot isotactic pressing, infiltration, reaction bonding and combustion synthesis. Currently ceramic matrix composites are used as cutting tool inserts; wear resistant composites, space shuttle tiles and aerospace components. Among various types of composites, PMC is the most commonly used composites, due to its advantages such as simple manufacturing principle, low cost and high strength. There are two major classes of polymers used as matrix materials such as thermoplastic and thermosetting. Thermoplastic (e.g. nylons, acrylic, polyethylene, polystyrene etc.) are reversible and can be resized by application of heat and pressure. [4]

1.3 Types of polymer composites

Broadly, polymer composites can be classified into two groups on the basis of reinforcing material. They are:

i. Fiber reinforced polymer (FRP)

ii. Particle reinforced polymer (PRP)

Fiber-reinforced polymer (FRP) is a composite material made of a polymer matrix reinforced with fibers. The fibers such as glass, carbon, natural fiber and polymers such as epoxy, vinyl ester, polyester thermosetting plastic and polyethylene, polypropylene thermoplastics are in use. Particulate composites have an additive constituent which is essentially one or two dimensionally and macroscopic/microscopic. In some composites however, the additive constituent shows non-dimensional nature at macroscopic scale, i.e., conceptually a points.

2. LITERATURE REVIEW

2.1 Natural fiber based polymer composites

Shashi Shankar et al. [5] studied the effect of different parameters on mechanical behaviour of banana fiber reinforced epoxy composites. It was found that the ultimate tensile strength value was maximum at 15% (45.18Mpa) and start decreasing from 15% to 20% (45.18Mpa to 38.30 Mpa) of the fiber. The flexural strength value slightly decreases from 5% (92.12%Mpa) to 10% (87.31Mpa) and after that the value increased from 10% to 20%(87.31 Mpa to 321.38 Mpa) of the fiber. The alteration in the tensile strength depends on the kind of fiber that can be caused by other factors, such as the fiber length, and hydrophilicity as well as the difference in the chemical nature of the fiber.

Shinji Ochi et al. [6] Described the mechanical properties of kenaf fibers and kenaf reinforced polylactic acid (PLA) resin based matrix composites. Experimental results showed that, the unidirectional fiber-reinforced composites showed tensile and flexural strengths of 223 MPa and 254 MPa, respectively. Moreover tensile and flexural strength and elastic moduli of the kenaf fiber-reinforced composites increased linearly up to a fiber content of 50%.

Sain et al. [7]had investigated the potential of wheat straw fibers prepared by mechanical and chemical processes as reinforcing additives for thermoplastics. It was concluded that Composites prepared with chemically processed wheat straw fibers showed comparatively lower strength properties compared to mechanically processed fibers.

2.2 Structure and property of banana fiber

The cross sectional area of the banana fiber was investigated by using optical laser beam equipment by **Ratna Prasad et al. [8]**, and it was found to be 0.3596 mm2.The plot of stress vs. percentage of strain for banana fiber is approximately linear; with a stress value of around 560 MPa, when the % of the strain is 3.5. A truck model ―Manaca‖ was developed and tested by **Al-Qureshi [9]**, using banana fiber and epoxy resin.

2.3 Banana fiber reinforced composites

Raghuramn et al. [10] deals with fabrication and investigation of mechanical properties of natural fibers such as abaca and banana fiber and compares with the hybrid natural fiber composite. It is found that Abaca-Glass composite is found to have better tensile strength than the other two combinations and Abaca-Glass-Banana Hybrid Composite is found to have better Flexural strength and Impact value.

Niranjanaa et al. [11] investigated and compared the mechanical and thermal properties of raw jute and banana fiber reinforced epoxy hybrid composites. To improve the mechanical properties, jute fiber was hybridized with banana fiber. Experimental results showed that addition of banana fiber in jute/epoxy composites up to 50% by weight results in increasing the mechanical and thermal properties and decreasing the moisture absorption property.

Dharmalingam et al. [12] investigated the tensile, flexural and impact properties of banana-coir reinforced composite materials with a thermo set for treated and untreated fibers. It was concluded that the tensile and impact tests of treated banana-coir epoxy hybrid composites have higher tensile strength and impact strength than untreated.

2.4 Synthetic fiber based polymer composites

Chouhan et al. [13] studied the effect of fiber loading on mechanical properties, friction and wear characteristics of composites of vinyl ester under dry and water lubricated conditions. It was reported that the density of composite specimens is affected marginally by increasing the fiber content. For the composites with a higher percentage of fiber content, cured at room temperature shows slight increase in density.

Hemachandra Reddy et al. [14] studied the effect that the use of glass fibers has on the morphology developed by a thermoplastic polymer modified epoxy. In particular, three surface modifications of the glass fibers were studied. These results might be attributed to a gradual phase separation process due to stoichiometric gradients which, on the other hand, seems to be conditioned by the nature of glass fibers surface.

3. MATERIALS AND METHODS

3.1 Raw materials

Raw materials used in this experimental work are listed below:
Matrix material: Epoxy
Filler material 1: Banana fiber
Filler material 2: E glass fiber

3.2 Composite fabrication

A mold of dimension (200×180×5) mm3 is used for casting the composite slabs .The low temperature curing epoxy resin and corresponding hardener are mixed in a ratio of 10:1 by weight as recommended. The short banana/glass fibers are mixed with epoxy resin by the simple mechanical stirring process. The composites are prepared with four different fiber loading say (15%, 20%, 25% and 30%) by weight using simple hand lay-up technique.

3.3 Composite tests

3.3.1 Mechanical testing of fiber reinforced composites

Mechanical testing plays an important role in evaluating fundamental properties of composites materials as well as in developing new materials and in controlling the quality of composites materials for use in design and constructionIf a material is to be used as part of an engineering structure that will be subjected to a load, it is important to know that the material is strong and rigid enough to withstand the loads that it will experience in service.

3.3.2 Tensile test of fiber reinforced polymer composites

Tensile testing is a way of determining how composites materials react when it is pulled apart - when a force is applied to it in tension. It is one of the simplest and most widely used mechanical tests. By measuring the force required to elongate a specimen to breaking point, material properties can be determined that allows designers and quality managers to predict how materials and products will behave in their intended applications.

3.3.3 Flexural test of fiber reinforced polymer composites

The flexural test was performed on the same tensile testing machine as per the ASTM D2344 standards. It was performed at room temperature and close to 40% relative humidity for three different types of specimens. In this test, the specimen to be tested is subjected to a load at its midway between the supports and until it fractures and breaks.

3.3.4 Hardness testing

Hardness may be defined as a material's resistance to permanent indentation .The hardness of plastics is most commonly measured by the Shore hardness test, which measures the resistance of plastics toward indentation and provides an empirical hardness value. Shore hardness test is performed by the apparatus Durometer (figure 3.12) according to ASTM 2240.

3.3.5 Preparation of test specimen for mechanical testing

The dog-bone type specimen with end tabs is common for tensile test. Dimension of the samples for the test is 80 mm ×15 mm ×4 mm..

Preparation of flexural test specimen

The short beam shear test performed on the composite samples for calculating flexural strength. The test was conducted as per the ASTM-D2344-84 standard. The dimension of the samples for the test is 60 mm ×15 mm × 5 mm.

Preparation of hardness test specimen

The hardness test is performed on the square specimens. The dimension of the samples for the test is 20 mm ×20 mm ×5 mm. Figure 3.17 shows dimension of hardness test specimen. **Preparation of flexural test specimen**

The short beam shear test performed on the composite samples for calculating flexural strength. The test was conducted as per the ASTM-D2344-84 standard. The dimension of the samples for the test is 60 mm ×15 mm × 5 mm.

Preparation of hardness test specimen

The hardness test is performed on the square specimens. The dimension of the samples for the test is 20 mm ×20 mm ×5 mm. Figure 3.17 shows dimension of hardness test specimen.

4. RESULTS

Table 4.1 shows the comparison of experimental and analytical result of tensile and flexural test. The percentage difference between two approaches is also given.

Table 4.1: Comparatively study between experimental and analytical results

Designation	Composiion	Experimental result		Analytical result		% Variation in tensile strength	% Variation in flexural strength
		Max. tensile strength MPa	Max. flexural strength MPa	Tensile strength MPa	Flexural strength MPa		
C1	85 wt% epoxy +7.5 wt% banana fiber + 7.5 wt % glass fiber	11.550	29.342	12.365	31.569	6.59%	5.028%
C2	85 wt% epoxy +7.5 wt% banana fiber + 7.5 wt % glass fiber	18.901	43.751	20.471	46.471	7.22%	5.01%
C3	85 wt% epoxy +7.5 wt% banana fiber + 7.5 wt % glass fiber	24.69	62.694	27.832	63.835	9.77%	2.93%
C4	85 wt% epoxy +7.5 wt% banana fiber + 7.5 wt % glass fiber	32.062	70.739	36.195	71.238	8.27	3.46%

6. CONCLUSIONS

The experimental investigation on the mechanical behavior of banana/glass fiber reinforced epoxy based hybrid composites leads to the following conclusions:

(i) Successful fabrication of hybrid banana/glass fiber reinforced epoxy composites by simple hand lay- up technique.

(ii) Epoxy based four hybrid composites (C1, C2, C3 and C4) have been fabricated with short banana and glass fiber loading (85 wt% Epoxy +7.5 wt% Banana fiber +7.5 wt% Glass fiber), (80 wt% Epoxy + 10 wt% Banana fiber +10 wt% Glass fiber), (75 wt% Epoxy + 12.5 wt% Banana fiber +12.5 wt% Glass fiber) and (70 wt% Epoxy + 15 wt% Banana fiber +15 wt% Glass fiber).

(iii) It has been noticed that the mechanical properties of the composites such as hardness, tensile strength and flexural strength are influenced by the fiber loading. A gradual increase in tensile and flexural strength can be observed with the increase in the fiber loading up to 25 wt% of composites.

(iv) It has been observed that the tensile modulus increases by addition of fiber content up to 20 wt% then decreases due to addition of 25 wt% of fibers.

(v) Hardness value increases as wt% of fibers (banana and glass) increases. Hardness is maximum for sample C4 (70 wt% Epoxy + 15 wt% Banana fiber +15 wt% Glass fiber) as compared to pure epoxy.

(vi) Finite element method (FEM) has been gainfully employed for determination of tensile and flexural strength of hybrid fiber reinforced polymer composites with different fiber loading.

(vii) Experimental and analytical approach shows that the tensile and flexural strength increases as the fiber loading in the composite increases. Both the strength analysis shows 26.75%, 6.59%, 7.22% and 9.77% deviation in the experimental and analytical tensile test and 12.40%, 5.28%, 5.01% and 2.93% deviation in the experimental and analytical flexural test corresponding to sample C1, C2, C3 and C4 respectively.

(viii) XRD analysis of banana/glass hybrid fiber epoxy composites sample with 15 wt%, 20 wt%, 25 wt% and 30 wt% of fiber has been done. Sharp peaks in all samples confirm the semi crystalline nature of composites.

(ix) SEM images of the fracture surfaces of composites after the tensile test shows that the increase in strength properties of composites at 30wt% fiber loading is due to the better adhesion between fiber and matrix.

(x) Finally optimum mechanical properties are obtained for composition C4 (70 wt% Epoxy + 15 wt% Banana fiber +15 wt% Glass fiber).

(xi) Epoxy based banana/glass fiber reinforced hybrid composites can be utilized

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