Study on Mechanical Behaviour of Lantana-Camara Fiber Reinforced EPOXY Based Composites

Bhupender[1], Anil Kumar[2]

[1]PG student, Dept. of Mechanical Engineering, OITM, Juglan, Hisar, Haryana, India.
[2]Assistant Professor, Dept. of Mechanical Engineering, OITM, Juglan, Hisar, Haryana, India.

Abstract - *Environmental awareness today motivates the researchers, worldwide on the studies of natural fiber reinforced polymer composite and cost effective option to synthetic fiber reinforced composites. The availability of natural fibers and ease of manufacturing have tempted researchers to try locally available inexpensive fibers and to study their feasibility of reinforcement purposes and to what extent they satisfy the required specifications of good reinforced polymer composite for different applications. There are many potential natural resources, which India has in abundance. Most of it comes from the forest and agriculture. Lantana-Camara is one such natural resource whose potential as fiber reinforcement in polymer composite has not been explored till date. This weed at present is posing serious problems in plantation forestry at various locations. It chokes all other vegetation and becomes the dominant species. The present research work has been undertaken with an objective to explore the use of natural fiber Lantana-Camara, as a reinforcement material in epoxy base. To study the mechanical properties of the composite, different volume fraction of fiber have been taken. These fibers were randomly distributed in the matrix. Usual hand- lay-up technique has been adopted for manufacturing the composite. The effect of fiber loading on various mechanical properties is studied. After the tensile test SEM image is taken to study the reason of failure.*

Key words: Epoxy, Lantana-Camara, Scanning Electron Microscopy, Tensile test etc.

1. INTRODUCTION

A composite material made from two or more constituent materials like reinforcement (fibres, particles, flakes, and/ or fillers) and matrix (polymers, metals, or ceramics). One or more discontinuous phases are, therefore, embedded in a continuous phase to form a composite. The discontinuous phase is usually harder and stronger than the continuous phase and is called the reinforcement, whereas, the continuous phase is termed as the matrix [1].

Kelly [2] defined that the composites should not be regarded simply as a combination of two materials. It clearly states that; the combination has its own unique properties. In terms of strength to resistance to heat or some other desirable quality, it is better to attain properties that the individual components by themselves cannot attain. The composite materials have advantages over other conventional materials due to their higher specific properties such as tensile, flexural and impact strengths, stiffness and fatigue properties, which enable the structural design to be more versatile. Due to their many advantages they are widely used in aerospace industry, mechanical engineering applications (internal combustion engines, thermal control, machine components), electronic packaging, automobile, and aircraft structures and mechanical components (brakes, drive shafts, tanks, flywheels, and pressure vessels), process industries equipment requiring resistance to high-temperature corrosion, dimensionally stable components, oxidation, and wear, offshore and onshore oil exploration and production, marine structures, sports, leisure equipment and biomedical devices [3, 4].

1.1 Matrix Materials

The main elements of polymer matrix composite are resin (matrix), reinforcement (e.g. fibre, particulate, whiskers), and the interface between them. The present work deals with the fibre reinforced polymer. FRP's offers significant advantages, like combination of light weight and high strength to weight ratio and it is way easy to fabricate which is better than many metallic components [1].

The matrix of FRPs is further classified into-

I. Thermosetting resin
II. Thermoplastic resin

Thermoset resin (e.g. polyester, vinyl esters and epoxy) undergo chemical reaction that cross link the polymer chain and thus connect the entire matrix into three dimensional network due to this they possesses high dimensional stability, resistance to chemical solvent, and high temperature resistance. On the other hand unlike thermoset, curing process of thermoplastic resin (e.g. polyamide, polypropylene, and polyether-ether-ketone) is reversible. Their strength and stiffness depends on the molecular weight. They are generally inferior to thermoset in case of high temperature, strength, and chemical stability but are more resistant to cracking and impact damage [2].

1.2 Reinforcement Materials

In fibre reinforcement polymer composites, the reinforcements are either synthetic or natural fibres. Synthetic fibres are made from synthesized polymer or small molecules. The compound used to make this fibre come from raw material such as petroleum based chemicals or petro chemicals. These materials are polymerized in to a long linear chemical that bond to adjacent carbon atoms. Different chemicals compound used to produce different types of fibre. There are different types of synthetic fibres nylon, polyester, carbon fibre, glass fibre, metallic fibre etc.

Now-a-days, the natural fibres have a great attention as they are a substitute to the exhausting petroleum sources [7]. Among all reinforcing fibres, natural fibres have increased substantial importance as reinforcements in polymer matrix composites. Studies on cements and plastics reinforced with natural fibres such as coir, sisal, bamboo, jute, banana and wood fibres have been reported [8-12]. Among various natural fibres, coir finds a wide variety of applications around the world.

There are many potential natural resources, which India has in abundance. Most of it comes from the forest and agriculture. Lantana-Camara is one such natural resource whose potential as fiber reinforcement in polymer composite has not been explored to date. This weed is now posing serious problems in plantation forestry and has been considered recently as one of the ten worst weeds in the world. Alternatively, visualizing the luxuriant growth and vigorous survival of this weed, researchers world-wide are trying to find out the potential economic value for its utilization into value added products and effective method for its management.

In the present work Lantana-Camara fibre is used as reinforcing agent because of its good strength, light weight, chemical resistance and more importantly its low cost.

2. COMPOSITE FABRICATION

For preparation of composite the following materials have been used;

1. Lantana-Camara fiber
2. Epoxy
3. Hardener

Preparation of Lantana-Camara Fiber

Fresh Lantana-Camara stems were collected locally. They were cut to sizes between two nodes. The upper skin was removed by scrapping without damaging the fiber surface. Then they were cut to sizes of 100mm lengthwise. Long fibers were washed with pressurized water to remove unwanted organic materials present on the surface. These fibers were then spread over a water proof sheet and stored in an enclosed shed to reduce the moisture content. After two weeks the long fibers were cut to lengths of 10mm (optimum fiber length found from single fiber pull-out test) and of width 1mm with a pair of scissor. Due to low moisture content of the fibers, no fungus grew during storage. The Lantana-Camara fibers after cutting were again washed with pressurized water to remove the fine particle and other organic material that grew and adhered to the surface of fiber during storage and cutting. The fibers were then dried with compressed air at a pressure of approximately 145 kPa at 108^{o}C. The required drying time was determined by weighing a trial sample every 10min. until the measured mass become constant. A drying time of 40min. was established to provide subsequent drying of the fiber.

Epoxy Resin

The type of epoxy resin used in the present investigation is Araldite which chemically belongs to epoxide family. Its common name is Bisphinol-A-Diglycidyl-Ether. The hardener with IUPAC name NNO-bis (2aminoethylethane-1,2diamin) has been used with the epoxy.

Composite preparation

A Per-pex sheet mold of dimension 130×100×6 mm was used for casting the composite sheet. The first group of samples were manufactured with 10, 20, 30 and 40% volume fraction by weight of fiber. The usual hand lay-up technique was used for preparation of the samples. For different volume fraction of fibers, a calculated amount of epoxy resin and hardener (ratio of 10:1 by weight) was thoroughly mixed with gentle stirring to minimize air entrapment. For quick and easy removal of composite sheets, a mould release sheet was put over glass plate and mould release agent was applied at the inner surface of the mould. After keeping the mould on glass sheet a thin layer (≈2mm thickness) of mixture was poured. The required amount of fiber was then distributed on the mixture. The remaining mixture was then poured into the mould. Care was taken to avoid formation of air bubbles. Pressure was then applied from the top and the mould was allowed to cure at room temperature for 72 hrs. During application of pressure a small amount of mixture of epoxy and hardener was squeezed out. Care has been taken to consider this loss during manufacturing of composite sheets. After 72 hrs the samples were taken out from the mould, cut in to different sizes and kept in an air tight container for further experimentation.

Table 1: Designation of Composites

Composites	Compositions
A1	Epoxy (100wt %) + Lantana-Camara Fibre (0wt%)
A2	Epoxy (90wt %) + Lantana-Camara Fibre (10wt%)
A3	Epoxy (80wt %) + Lantana-Camara Fibre (20wt%)
A4	Epoxy (70wt %) + Lantana-Camara Fibre (30wt%)
A5	Epoxy (60wt %) + Lantana-Camara Fibre (40wt%)

3 TESTING

The tensile test is conducted on all the samples as per standards. Specimens are positioned in the grips of universal testing machine and a uniaxial load is applied through both the ends until it gets failure. During the test, the crosshead speed is taken as 2 mm/min, specimens of rectangular cross-sections having length and width of 100 mm and 15 mm respectively are used. Figure 1 shows the experimental setup for the tensile test.

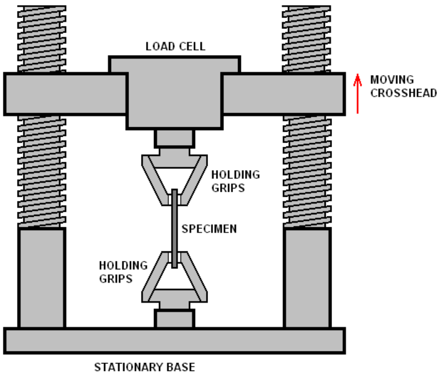

Fig -1: Block diagram for tensile test set up.

To determine the flexural strength of composites a three point bending test is performed. Before testing width and thickness of specimens measured at different point and mean value is taken. Samples were placed horizontally upon two points and midpoint is perpendicular to loading nose. The crosshead speed for test is maintained at 2mm/min. Flexural strength in terms of Mpa is determined using the equation

To determine the hardness and impact strength of composite, vicker hardness test and impact test is performed as per the standards.

4. RESULTS

4.1 Mechanical Properties of Composites

4.1.1 Effect of fibre loading on hardness of composites

Surface hardness of the composites is considered as one of the most important factor that governs the wear resistance of the composites. Figure 2 shows the effect of fibre loading on hardness of composites. The test results show that with the increase of fibre loading, micro-hardness of the Polymer matrix composites is improved. The effect of fibre loading with 30wt% fibre loading shows better hardness value as compared to 40wt%. The increase in hardness value is may be due to the incorporation brittle fibres in the epoxy resin.

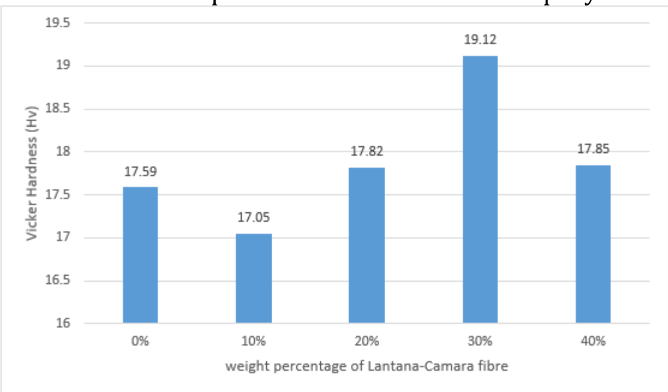

Fig- 2: Effect of fibre loading on hardness of composites

4.1.2 Effect of fibre loading on tensile properties composites

The effect of fibre loading on the tensile strength, modulus and percentage elongation of break are shown in Figure 3, 4 and 5 respectively. A gradually increase in tensile strength can be observed with the increase in the fibre loading up to 30%. This is due to the proper adhesion between the both types of fibre and the matrix. However, further increase in fibre loading i.e. 40% mm there is a decrease in the tensile strength.

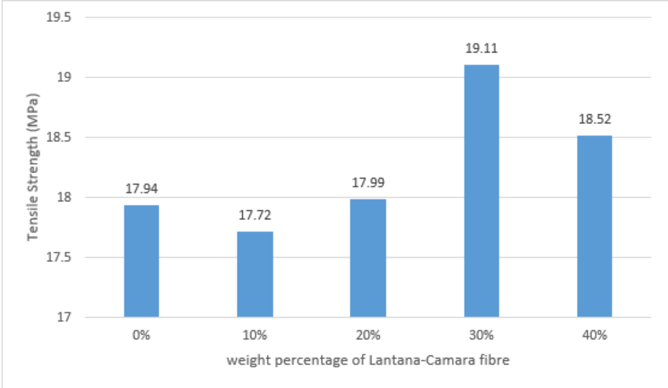

Fig-3: Effect of fibre loading on tensile strength of composites

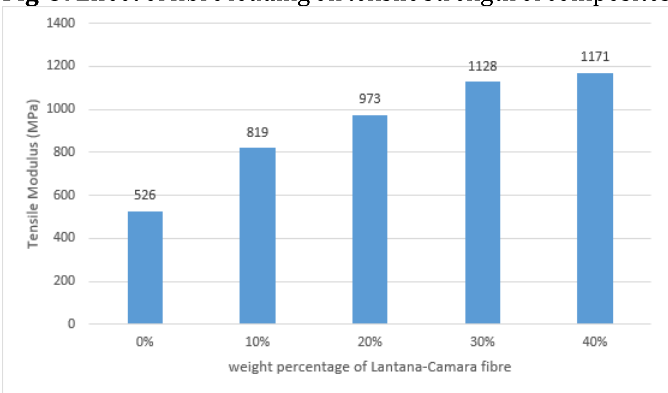

Fig-4: Effect of fibre loading on tensile modulus of composites

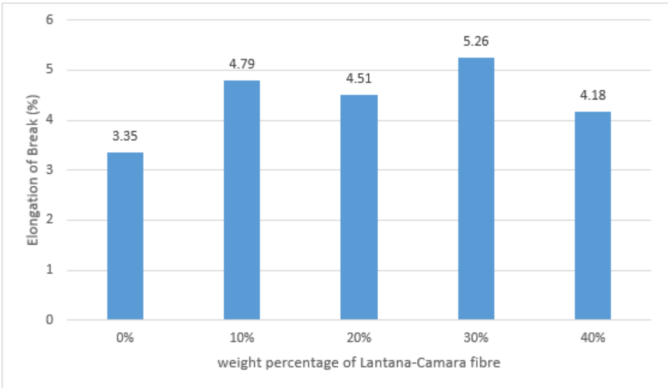

Fig-5: Effect of fibre loading on Percentage elongation of break

Figure 4 shows the variation of the tensile modulus of polymer matrix composite with different fibre loading. It can be observed that with the increase of fibre lading, the tensile modulus increases. Previous reports reveal that normally the fibres in the composite restrain the deformation of the polymer matrix, reducing the tensile strain. So even if the strength decreases with fibre loading, the tensile modulus of the composite is expected to increase as has been observed in present investigation.

Figure 5 shows the variation of the elongation of break of polymer matrix composite with different fibre loading. There are no particular trend find in this property.

4.1.3 Effect of fibre loading on flexural strength of composites

The effect of fibre loading on flexural strength of composites is shown in Figure 6. It is evident from the figure that the flexural strength of composite increases with increase in fibre loading up to 30%. However, further increase in fibre loading (up to 40%) the value decreases.

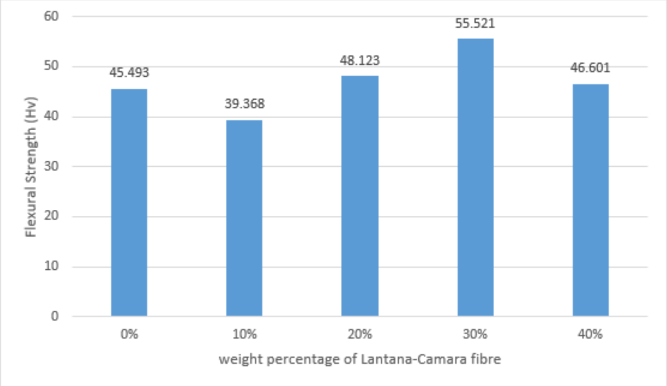

Fig-6: Effect of fibre loading on flexural strength of composites

4.1.4 Effect of fibre loading on Impact strength of composites

The effect of fibre loading on Impact strength of composites is shown in Figure 7. It is evident from the figure that the Impact strength of composite increases with increase in fibre loading up to 200%. However, further increase in fibre loading (up to 40%) the value decreases.

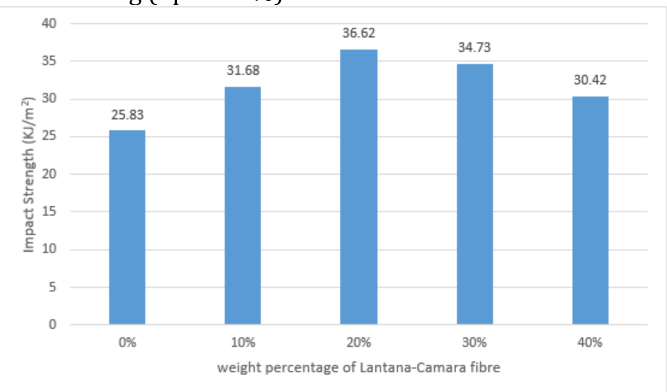

Fig-7: Effect of fibre loading on Impact strength of composites

4.2 Surface Morphology

A SEM micrograph (magnified view) of the tensile fracture surface of 30 vol% of Lantana-Camara fiber composites is shown in Figure 8. The phenomenon of pull-out fibers was clearly observed, which indicates the poor interfacial bonding between matrix and fiber.

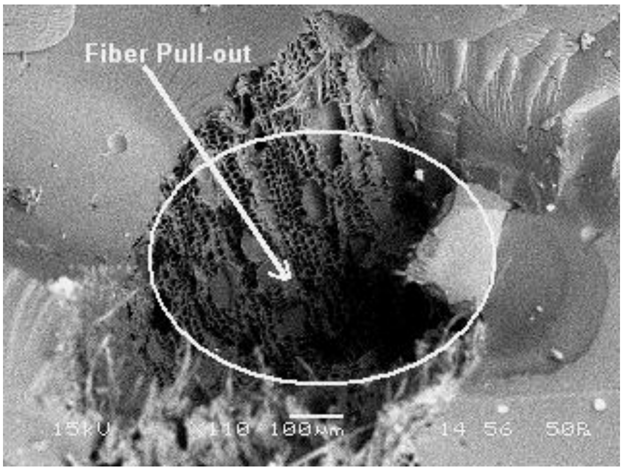

Fig-8: Scanning electron micrographs of Lantana-camara fibre (30 wt%) reinforced epoxy composite specimen subjected to tensile test

Figure 9 shows the SEM micrographs of the fracture surface 40 vol% of untreated Lantana-Camara fiber reinforced composites during bending test. Debonding between fiber and matrix, fiber pullout and an empty space between fibers due to insufficient wetting are observed. This reveals that at higher fiber loading poor fiber wetting occurs due to insufficient matrix material, resulting in a lowering in strength and modulus as discussed earlier. This debonding at the fiber-matrix interface is mainly responsible for degradation in the mechanical properties.

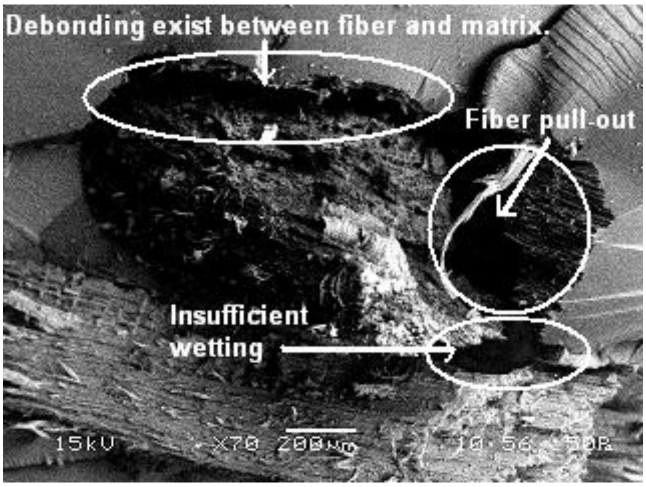

Fig-9: Scanning electron micrographs of Lantana-camara fibre reinforced epoxy composite specimen

5. CONCLUSIONS

The experimental investigation on the mechanical behaviour of Lantana-Camara fibre reinforced epoxy based composites lead to the following conclusions:

1. Lantana-Camara a known worst weed, which creates problem in plantation forestry, can successfully be utilized to produce composite by suitably bonding with resin for the development of value added products.
2. Successful fabrication of Lantana-Camara fibre reinforced epoxy composites by simple hand lay- up technique.
3. On increasing the fiber content the tensile strength, tensile modulus, hardness and flexural strength increases up to 30 wt % and then decreases for 40 wt % of fiber.
4. Impact strength increase on increasing the fibre loading up to 20 wt % then its decrease on further increasing of wt % of fibre.
5. There is a good dispersibility of Lantana-Camara fiber in the matrix, which improves the hardness, strength, modulus and work fracture of the composite. Thirty volume percent of reinforcement fiber gives the best combination among the tested composites.
6. Fiber breakages are found to be the predominant mode of failure as ascertained from the morphology of the treated fiber composites.

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