Experimental Investigation of Vibration Characteristic of Jute Fiber Reinforced Polymer Composite

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Abstract- *The interest in natural fibre reinforced polymer composite materials is rapidly growing both in terms of industries application and fundamental research they are renewable ,low cost complexly and partially recyclable and biodegradable. Plants such as flax's cotton ,hemp ,jute ,sisal ,pineapple ,ramie ,bamboo ,banana and etc. today it is the lest expensive fibre for mass consumption , at only fraction of cost glass fibre , in terms of volume. Jute is now second most important fibre in the world , next to cotton . In traditional applications in carpets , ropes , sacks and etc . Jute fibre has been partially replaced by synthetic fibre which have some advantage compared to jute*

The aim is to make jute polymer composite using hand layup method and investigate the vibrational characteristic of jute fibre polymer composite. The jute fibre has been reinforced with unsaturated polyester resin and maleic anhydride and experimental investigations have been carried out using fast Fourier transform and damping factor is calculated for varying percentage of maleic anhydride.

Keywords- Jute fibre ,maleic anhydride, polyester resin, hand layup, fast Fourier transform.

I. INTRODUCTION

Fibre reinforced composites were in use since ancient times. Due to the disadvantage of synthetic and fibre glass as reinforcement, the use of fibre reinforced composites gained attention of modern researchers . The use of variable fibre as reinforcement in composites . With advancements of science and technology the new means of characterisation and evaluation of physic-chemico-thermo-mechanical properties of composites been used

The term composite in material science refers to material made up of matrix containing reinforcing agent . Reinforcement is the part of the composite that provides strength, stiffness, and the ability to carry load .

This jute fibre as reinforcement to the composite had outstanding physio-chemio-thermo-mechanical performance, durability and eco friendly nature that highlight and promoted its scope.

Jute polymer composite was made by using hand layup method and investigated the vibrational characteristic of jute fibre polymer composite. The jute fibre has been reinforced with unsaturated polyester resin and maleic anhydride and experimental investigations have been carried out using fast Fourier transform and damping factor is calculated for varying percentage of maleic anhydride

MATRIX PHASE

1. The primary phase, having a continuous character.
2. Usually more ductile and less hard phase.
3. Holds the reinforcing phase and shares a load with it.

REINFORCING PHASE

1. Second phase (or phases) is imbedded in the matrix in a discontinuous form.
2. Usually stronger than the matrix, therefore it is sometimes called reinforcing phase.

Composites as engineering materials normally refer to the material with the following characteristics:

1. These are artificially made (thus, excluding natural material such as wood).
2. These consist of at least two different species with a well defined interface.
3. Their properties are influenced by the volume percentage of ingredients.
4. These have at least one property not possessed by the individual constituents.

Performance of Composite depends on:

1. Properties of matrix and reinforcement.
2. Size and distribution of constituents.
3. Shape of constituents.
4. Nature of interface between constituents.

1.2 CLASSIFICATION OF COMPOSITES

Composite materials are classified as

a. On the basis of matrix material.
b. On the basis of filler material.

1.2.1 On the basis of Matrix:

a. Metal Matrix Composites (MMC)

Metal Matrix Composites are composed of a metallic matrix (aluminium, magnesium, iron, cobalt, copper) and a dispersed ceramic (oxides, carbides) or metallic (lead, tungsten, molybdenum) phase.

b. Ceramic Matrix Composites (CMC)

Ceramic Matrix Composites are composed of a ceramic matrix and imbedded fibres of other ceramic material (dispersed phase).

c. Polymer Matrix Composites (PMC)

Polymer Matrix Composites are composed of a matrix from thermoset (Unsaturated Polyester (UP), Epoxy) or thermoplastic (PVC, Nylon, Polysterene) and embedded glass, carbon, steel or Kevlar fibres (dispersed phase).

1.2.2 On the basis of Material Structure:

a. Particulate Composites

Particulate Composites consist of a matrix reinforced by a dispersed phase in form of particles.

1. Composites with random orientation of particles.
2. Composites with preferred orientation of particles.

Dispersed phase of these materials consists of two-dimensional flat platelets (flakes), laid parallel to each other.

b. Fibrous Composites

Short-fibre reinforced composites

Short-fibre reinforced composites consist of a matrix reinforced by a dispersed phase in form of discontinuous fibres (length < 100*diameter).

1. Composites with random orientation of fibres.2. Composites with preferred orientation of fibres.

Long-fibre reinforced composites

Long-fibre reinforced composites consist of a matrix reinforced by a dispersed phase in form of continuous fibres.

1. Unidirectional orientation of fibres.2. Bidirectional orientation of fibres (woven).

c. Laminate Composites

When a fibre reinforced composite consists of several layers with different fibre orientations, it is called multilayer (angle-ply) composite.

1.1.3. Advantages and Limitations of Composites Materials

Advantages of Composites Summary of the advantages exhibited by composite materials, which are of significant use in aerospace industry are as follows:

- High resistance to fatigue and corrosion degradation.
- High ‘strength or stiffness to weight’ ratio. As enumerated above, weight savings are significant ranging from 25-45% of the weight of conventional metallic designs.
- Due to greater reliability, there are fewer inspections and structural repairs.
- Directional tailoring capabilities to meet the design requirements. The fibre pattern can be laid in a manner that will tailor the structure to efficiently sustain the applied loads.
- Fibre to fibre redundant load path.
- Improved dent resistance is normally achieved. Composite panels do not sustain damage as easily as thin gage sheet metals.
- It is easier to achieve smooth aerodynamic profiles for drag reduction. Complex double-curvature parts with a smooth surface finish can be made in one manufacturing operation.
- Composites offer improved torsional stiffness. This implies high whirling speeds, reduced number of intermediate bearings and supporting structural elements. The overall part count and manufacturing & assembly costs are thus reduced.
- High resistance to impact damage.
- Thermoplastics have rapid process cycles, making them attractive for high volume commercial applications that traditionally have been the domain of sheet metals. Moreover, thermoplastics can also be reformed.
- Like metals, thermoplastics have indefinite shelf life.

III. OBJECTIVES

The following are the main objectives of this project:

1. Fabrication of jute fibre reinforced composite with coupling agent with varying composition for different orientations by using hand lay-up method.
2. To experimentally investigate vibrational characteristics of jute fibre reinforced composite by using FFT
3. To find the damping factor and natural frequency of jute fibre reinforced composite

IV. MATERIALS USED PREPARATION OF COMPOSITE

The raw materials taken for the preparation of specimen are-

- Jute fiber (treated)
- Unsaturated polyester resin
- Maleic Anhydride ($C_4H_2O_3$)
- Hardener

Jute is a multi-cell in structure . The cell wall of fibre is made of number of layers: the primary wall and the secondary wall which again is made up of the three layers In all lingo cellulose fibers, those layers mainly contains cellulose, hemicellulose and lignin in varying amounts. The individuals fibers are bonded together by a lignin-rich region known as the middle lamella. Cellulose attains middle lamella(about 90%) which in principle is free of cellulose.

Properties of jute fibre

- Jute fiber is 100% biodegradable and recyclable and thus environmentally friendly.
- Jute is a natural fiber with golden and silky shine and hence called the golden fibre.
- Jute is cheapest vegetable fiber procedure from the blast or skin of the plants stem.
- It is the second most important fiber after cotton in term of Usage, global consumption, production and availability.It has the high tensile strength, low extensibility and ensure

Unsaturated Polyester Resin

Unsaturated polyester resin Unsaturated polyester resins are the condensation products of unsaturated acids or anhydrides and diols with/without diacids. The unsaturation present in this type of polyesters provides a site for subsequent cross-linking . Since 1930, unsaturated polyester resins have been used remarkably for wide range of applications making them a thermosetting system of major importance . These resins are compounded with varied fillers, reinforcements and cured by using free radical initiators to yield thermoset articles having a wide range of chemical and mechanical properties depending upon the choice of diacids, diols, cross- linking agents, initiators and other additives .

Maleic Anhydride

Maleic anhydride is an organic compound with the formula $C_2H_2(CO)_2O$. It is the acid anhydride of maleic acid. It is a colorless or white solid with an acrid odour. It is produced industrially on a large scale for applications in coatings and polymers

Maleic anhydride was traditionally manufactured by the oxidation of benzene or other aromatic compounds. As of 2006, only a few smaller plants continue to use benzene; due to rising benzene prices, most maleic anhydride plants now use n-butane as a feedstock.The chemistry of maleic anhydride is very rich, reflecting its ready availability and bifunctional reactivity. It hydrolyzes, producing maleic acid, cis-HOOC–CH=CH–COOH. With alcohols such as methanol, the half-ester is generated, e.g., cis-HOOC–CH=CH–$COOCH_3$.

V. METHODOLOGY AND FABRICATION

To execute any work properly, it should follow some order, the present work is given with plan, and the steps followed are given in following lines**,**

- Formulate the problem and defining the objectives of work.
- Selection of proper matrix material and reinforcement.
- Deciding the volume fractions.
- Procuring the raw materials needed for fabrication of the composites
- Fabricate the composites using hand layup process
- Specimen preparation: prepare test specimen according to ASTM (American society for material testing) standard
- Testing of prepared specimens.
- Obtaining results for tested specimens.
- Analysis of result

Method of Fabrication

The method that is used in present work for manufacturing the laminated composites plates is **Hand layup,** which isoldest method that was used to get the composite material.

HAND LAYUP METHOD

Hand lay-up is an open moulding method suitable for making a wide variety of composites products from very small to very large. Production volume per mould is low; however, it is feasible to produce substantial production quantities using multiple moulds. Hand lay-up is the simplest composites moulding method, offering low cost tooling, simple processing, and a wide range of part sizes. Design changes are readily made. There is aminimum investment in equipment. With skilled operators, good production rates and consistent quality are obtainable.

SPECIMEN PREPARATION BY HAND LAYUP METHOD

- Procuring all the materials
- Cut the fibre mat into required shape and size
- Tabulate the volume of jute, unsaturated polyester for further work.
- A granite slab of dimensions greater than the specimen is used so that composite does not stick with it.
- Sandwich the jute with unsaturated polyester resin and percentage of maleic anhydride
- For curing the specimen keep it in room for 12 – 24 hrs in normal temperature.
- After curing the composite remove it carefully from the granite base.

Composition

Serial no.	Percentage of Maleic Anhydride	Percentage of Jute	Percentage of Polyester resin
1.	5	10	85
2.	10	20	70
3.	15	30	55

Table : Composition of materials

*Total volume of material= 150*150*3 mm³*

Density of fibre =1.46gm/cm^3

Density of unsaturated polyester resin = 1.52gm/cm^3

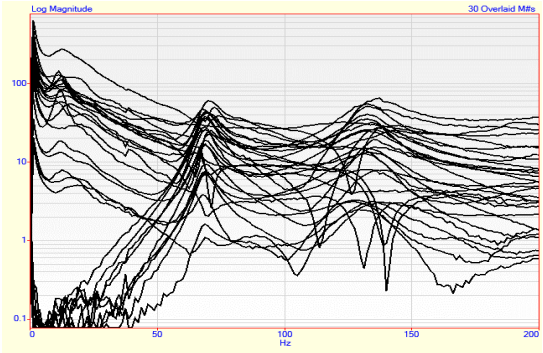
Density of maleic anhydride = 1.11gm/cm^3

VI. RESULTS

From the vibrational analysis the results and graphs are obtained which are as follows:-

1. Graph of jute fibre polymer composite with 5% Maleic Anhydride10% jute ,85% unsaturated polyester resin

Graph Plot : Log magnitude vs Frequency



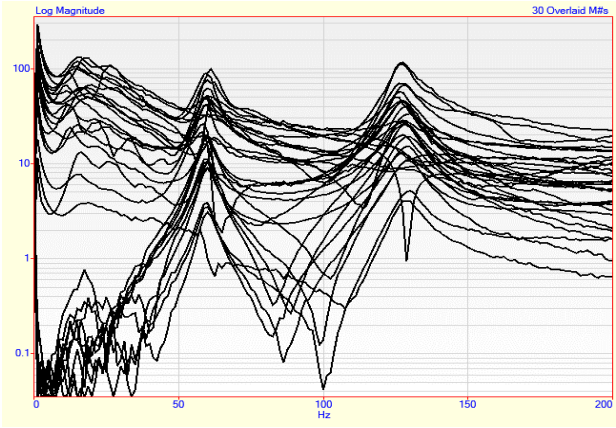
Graph 1: for 5% Maleic Anhydride

Table 9.1 : Damping Ratio and Frequency of 5% Maleic Anhydride

Select shape	Frequency	Units	Damping%
1	68.5	Hz	4.55
2	132	Hz	6.77

2. Graph of composite with 10% Maleic Anhydride,20% juteand 70 % unsaturated polyester resin

Graph Plot : Log magnitude vs Frequency



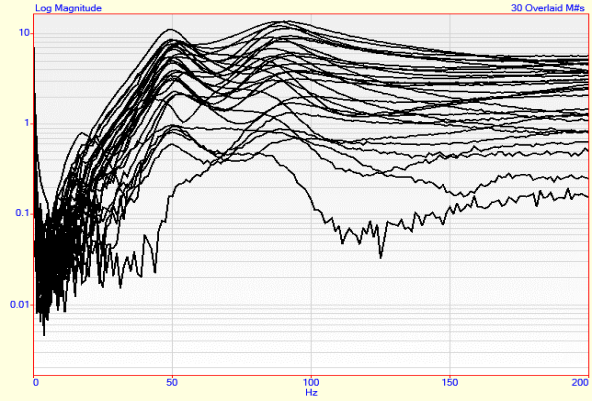
Graph 2 For 10% maleic Anhydride

Table 2 : Damping Ratio and Frequency of 10% Maleic Anhydride

Select shape	Frequency	Units	Damping%
1	59.7	Hz	3.66
2	127	Hz	3.47

3. Graph of jute fibre reinforced polymer compoite wiyh 15% maleic anhydride ,

30% jute and 55% unsaturated polyester resin
Graph Plot : Log magnitude vs Frequency



Graph 3: for 15% maleic anhydride

Table 3: Damping Ratio and Frequency of 15% Maleic Anhydride

Select shape	Frequency	Units	Damping %
1	48.9	HZ	13.2
2	86.5	HZ	13.2