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EXPERIMENTATION AND ANALYSIS OF NATURAL FIBER REINFORCED POLYMER MATRIX COMPOSITE

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Abstract **-** The high cost of synthetic fibers such as glass, carbon, etc, results in high cost of production and products derived from these materials which has necessitated alternative means of materials development. This has also informed the utilization of locally available bamboo fiber for composite materials development. Natural fiber has emerged as a renewable and cheaper substitute to synthetic materials such as glass, carbon and afraid, which are used as reinforcements. In this work, the objective was to develop, investigate and analyze the mechanical properties of a composite material using bamboo fiber and jute fiber sandwich type composite. The long bamboo fiber was extracted using chemical digestion and maceration methods. The fabrication of the composite was carried out using epoxy resin as the matrix and the bamboo fiber and jute fiber as reinforcement. Tests were carried out to determine the mechanical properties such as tensile, hardness strengths. The results were studied and compared with the composite of bamboo fiber with epoxy resin and it process that the material developed can be used in structural applications with strong dependence on its mechanical properties

Index Terms **-** composites, types of fiber, reinforcement materials, and mechanical properties.

INTRODUCTION

Composites are combination of two materials in which one of the material act as Reinforcement and the other as matrix. The reinforcement may be in the form of fiber woven cloth or in particulate form which may be embedded in the other material called matrix. The reinforcement material may be of ceramic, polymer or metallic and matrix material may be of polymer, metallic or ceramic in nature. Composites are used, as the mechanical properties of the composite as a whole is superior to that of the individual components.

Composites are able to meet diverse design requirements with appreciable weight saving. The high strength to weight ratio is an important aspect to be considered making these materials for automotive applications,

Epoxy resin is one of the excellent thermosetting polymer resins. The cost-to- performance ratio of epoxy resin is outstanding. Epoxy resins possess characteristics such as high strength low creep, good adhesion to most of the substrate materials, low shrinkage during curing and low viscosity. Due to these reasons epoxy resins are significantly used as matrix material in many applications such as aerospace, structural applications, ship building, and automobile industries and so on. The tensile strength and the tensile modulus of Glass fiber/Epoxy composite increases in fiber loading and the addition of Nano-clay particles to the Glass fiber/ Epoxy composite increase the tensile strength and the tensile.

- **Types of Composites**: The 3 Basic Types of Composites are generally identified as Particle-Reinforced (Aggregates), Fiber-Reinforced (Continuous Fiber or Chopped Fiber), Natural Composites (Examples: Wood and Bone).

NANO COMPOSITE

Composite is a multiphase solid material where one of the phases has one, two or three dimensions of less than 100 nanometers (nm), or structures having nano-scale repeat distances between the different phases that make up the material. In the broadest sense this definition can include porous media, colloids, gels and copolymers, but is more usually taken to mean the solid combination of a bulk matrix and nano-dimensional phase(s) differing in properties due to dissimilarities in structure and chemistry. The mechanical, electrical, thermal, optical, electrochemical, catalytic properties of the nano-composite will differ markedly from that of the component materials. Size limits for these effects have been proposed, <5 nm for catalytic activity, <20 nm for making a hard magnetic material soft, <50 nm for refractive index changes, and <100 nm for achieving super para magnetism, mechanical strengthening or restricting matrix dislocation movement.

Nano composites are found in nature, for example in the structure of the abalone shell and bone. The use of nano particle-rich materials long predates the understanding of the physical and chemical nature of these materials. In mechanical terms, nano composites differ from conventional composite materials due to the exceptionally high surface to volume ratio of the reinforcing phase and/or its exceptionally high aspect ratio. The reinforcing material can be made up of particles (e.g. minerals), sheets (e.g. exfoliated clay stacks) or fibers (e.g. carbon nano-tubes or electro spun fibers).

The area of the interface between the matrix and reinforcement phase(s) is typically an order of magnitude greater than for conventional composite materials. The matrix material properties are significantly affected in the vicinity of there inforcement.

Other kinds of Nano particulates may result in enhanced optical properties, dielectric properties, heat resistance or mechanical properties such as stiffness, strength and resistance to wear and damage. In general, the nano reinforcement is dispersed into the matrix during processing. The percentage by weight (called mass fraction) of the Nano particulates introduced can remain very low (on the order of 0.5% to 5%) due to the low filler percolation threshold, especially for the most commonly used non-spherical, high aspect ratio fillers (e.g. nanometer-thin platelets, such as clays, or nanometer-diameter cylinders, such as carbon nano-tubes). The orientation and arrangement of asymmetric nano-particles, thermal property mismatch at the interface, interface density per unit volume of nano composite, and polydispersity of nano particles significantly affect the effective thermal conductivity of nano composites.

Nano composites are further classified into 3-types are Ceramic-matrix nano composites, Metal-matrix nano composites, Polymer-matrix nano composites.

- **PMC manufacturing processes:** They are lot of well-established manufacturing processes which are available to produce components with polymer composite materials few of them are Wet lay-up/hand lay-up method, Spray up Molding, Resin Transfer Molding, Filament winding Method

In the present work epoxy resin is chosen as matrix, E-glass fiber, Wollastonite / Silicon is chosen as reinforcement. Room temperature cured Epoxy System filled with glass Fiber and Wollastonite / Silicon were synthesized by mechanical shear mixer, and then the mixture of epoxy and Wollastonite / Silicon is blended.

Mechanical properties like Flexural strength, Tensile strength of the micro hybrid composite are studied by UTM (Universal Testing Machine). The images of the fractured structures are taken using Scanning

Electron Microscope. The observation established good miscibility of Epoxy and Homogenous dispersion of silicon / Wollastonite in the matrix.

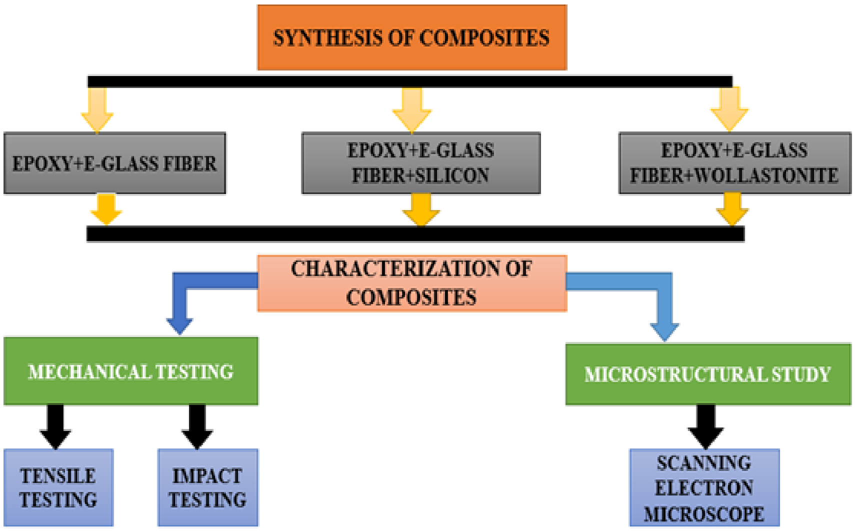

Figure 1

OVERVIEW OF THE WORK

PREPARATION OF COMPOSITES

4.1 PROCEDURE FOR PREPARING TEST SAMPLES:

The present problem has been formulated to implement different test to the structures so as to establish facts related to the flexural behavior of glass epoxy. the experimental work consist of preparing test samples, the samples are prepared made of e-glass woven fabric epoxy laminates made of various orientation sequences have been prepared as per ASTMD

- **Design and Fabrication of Metallic Mould:** The pressure to be applied to consolidate laminate after impregnating resign should be applied by compression as the required specimen are to be manufactured as per ASTM specifications. The mould is made of MS material.
- **Pressure plate:** Pressure plate is made of the MS plate with surface finish ensuring perfect flatness 5mm thickness is maintain to meet the requirement to withstand the compressive force. This particular method of making laminate to ensure that the thickness of the laminates will be uniform with constant volume fraction of matrix and reinforcement.

In the present work composite templates are prepared as per the required dimensions. According to the required dimensions the glass fiber mat has been cut, by making use of different mechanical equipment and measuring equipment's. And then excess material is removed on the surface of the mould and poly vinyl alcohol viscous liquid is applied on the surface of the mould uniformly and left for drying about 15 minutes. This liquid creates an invisible film which works as impervious layer prevents sticking to the mould surface.

Spacers are placed on the borders of the mould to get exact thickness of the laminate and uniform distribution of resin. Each layer of the fiber is kept in the mould and applying resin on to it, then the rolling is done by roller to distribute the resin evenly on to the layers. After completion of distribution of resin on to the layers amylar film is placed to get the surface finish, while after a pressure plate is placed onthe layers by that the uniform load is distributed and exact thickness occurs by the spacers. To get the required laminate it has been taken 24 hours while after remove the pressure plate and mylar film and removes the laminate from the mould. The same processes have done for various different layers of sandwich composite laminates. And finally cut the laminates by using cutter machine in to a required ASTM standard dimension.

The excess sides of the laminate which are formed because of pressure plate during the fabrication is chopped out and according to the required dimension i.e. ASTM638 standards, the sample pieces are taken out with the help of wood cutting machine as shown below.

Figure 2

WORK CUTTING THE LAMINATE IN TO A REQUIRED DIMENSION

DATA EXPERIMENTATION AND ANALYSIS

There are two stages in the process of familiarizing with plastics. The first is rather general and involves an introduction to the unique molecular structures of polymers, their physical and transitions which have a marked influence on their behaviour. The study of specific properties of plastics reveals their application. Besides the relative ease of their moulding and fabrication, many plastics offer range of important advantages in terms of high strength/weight ratio, toughness, corrosion-resistance, wear-resistance, frictional co-efficient, tensile, flexural, compression, impact strength and chemical resistance. Due to these qualities, plastics are acceptable as materials for wide variety of engineering applications. It is important therefore, that an engineer be aware of the performance characteristics and significant properties of plastics. Plastics are generally dealt with, in respect of broad categories of properties, namely, mechanical, thermal and chemical. An important facet of materials development and proper materials selection is testing and standardization. This chapter represents schematically (in simplified form) a number of standard test methods for plastics, highlighting the principles of the mechanical tests and the properties measured with them. List of salient features of testing has been stated below.

- To assess numerically the fundamental mechanical properties of ductility, malleability, resilience, stress-strain and visco elastic behaviour.
- To determine data (i.e. force deformation or stress values) to draw up sets of specifications, upon which the engineer can depend for his design.
- To determine the surface or subsurface defects in raw materials or processed parts.
- To check chemical composition.
- To determine the stability of a materials for particular applications.

The most common testing machine used in tensile testing is the UTM. This type of machine has two crossheads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen.

The machine must have the proper capabilities for the test specimen being tested. There are three main parameters: force capacity, speed, and precision and accuracy. Force capacity refers to the fact that the machine must be able to generate enough force to fracture the specimen. The machine must be able to apply the force quickly or slowly enough to properly mimic the actual application. Finally, the machine must be able to accurately and precisely measure the gage length and forces applied; for instance, a large machine that is designed to measure long elongations may not work with a brittle material that experiences short elongations prior to fracturing.

Alignment of the test specimen in the testing machine is critical, because if the specimen is misaligned, either at an angle or offset to one side, the machine will exert bending force on the specimen. This is especially bad for brittle materials, because it will dramatically skew the results. This situation can be minimized by using spherical seats between the grips and the test machine. A misalignment is indicated when running the test if the initial portion of the stress-strain curve is curved and not linear.

The strain measurements are most commonly measured with an extensometer, but gauges are also frequently used on small test specimen or when Poisson’s is being measured. Newer test machines have digital time, force, and elongation measurement systems consisting of electronic sensors connected to a data collection device (often a computer) and software to manipulate and output the data.

The test process involves placing the test specimen in the testing machine and applying tension to it until it fracture. During the application of tension, the elongation of the gauge section is recorded against the applied force. The data is manipulated so that it is not specific to the geometry of the test sample.

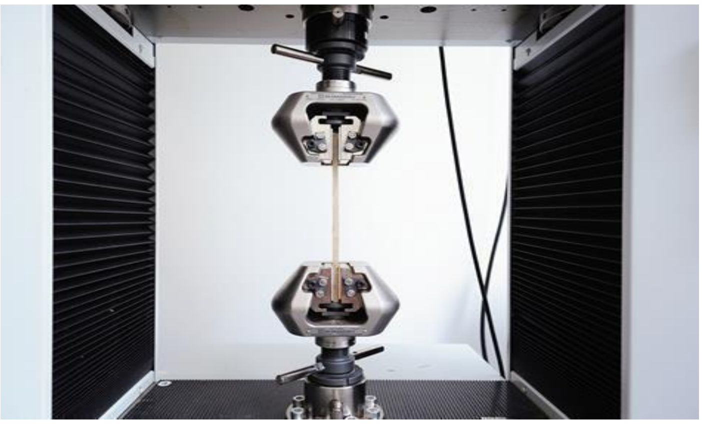

Figure 3

LAMINATE IS FIXED BETWEEN JAWS FOR TENSILE LOADING

RESULTS AND DISCUSSIONS

The Tensile test (UTM), hardness test has been done and the results obtained were furnished in the form of Data Sheets and the output screen shots and the results were published by performing these testing in the KELVIN LAB Hyderabad are as follows:

TABLE I

TENSILE AND ELONGATION TEST REPORT
SAMPLE-01

Test Sr. No.	**3813**	Test Date	**16/10/2021**
		Test Time	**3:15:09 PM**
Customer Name	**AVIH HYD**		
Customer Code	**BAMBOO+**		
Sample Details:			
Specimen code	**JF-01**		
Ref. Standard	**ASTM D638**		
Grip Length	**55**	Guage Length	**65**
Sample Width	**11.31**	Sample Thickness	**5.67**
Speed of testing (mm/min): **5**			

TABLE II

Obtained Results	Value	Unit
Area	64.1277	**mm^2**
Yield Force	837.37	**N**
Yield Elongation	3.13	**Mm**
Break Force	926.3	**N**
Break Elongation	3.34	**Mm**
Tensile Strength at Yield	13.06	**N/mm^2**
Tensile Strength at Break	14.44	**N/mm^2**
Tensile Strength at Max	14.48	**N/mm^2**
% Elongation	5.14	**%**
Max Force	928.69	**N**
Max Elongation	3.34	**Mm**
Modulus of Elasticity	330.71	**N/mm^2**

CONCLUSION

Sandwich type composite with bamboo and jute fiber were prepared by Hand Lay Up Techniques and characterized by mechanical tests (tensile Test, hardness test). The test results of the sandwich type composite are compared with bamboo fiber composite laminate.

The tensile test results of composite with bamboo improved with addition bamboo and jute sandwich type composite. This test was performed by universal testing machine; it was found that tensile strength addition jute and bamboo shown very good results compare to the bamboo fiber with epoxy resin.

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