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Investigation of Mechanical Properties of Natural Fiber Reinforced Hybrid Composite

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Abstract: Hybrid composite is a material composed of matrix and two or more reinforcements. Two or more reinforcements in hybrid composite replace the limitation of conventional composites by providing uniform strength to thematerial. Recently, natural fibers reinforced hybrid composites are gaining increased interest due to the encouraging properties of natural fibers such as high strength to weight ratio, low cost, no harm to environment etc. Many studies dealt with natural fibers based composite reported that the hybrid composites has the potential to replace glass fiber based composites and to reduce the weight of conventional composite.

This project reports on the manufacturing of the Indian elm and Acacia fibre reinforced epoxy composite laminate as per the ASTM (American Society for Testing and Materials) Standards. This laminate consists of matrix and reinforcement. Epoxy is used as a structural matrix material which is then reinforced by Indian elm fiber, combining Acacia fibres with resin matrix results in composites that are strong, lightweight, corrosion-resistant and dimensionally stable. They also provide good design flexibility, high dielectric strength and act as inflammable materials. Their tremendous strength-to-weight and design flexibility make them ideal in structural components for the aerospace industry.

In this project the Indian elm and Acacia fibre reinforced epoxy composite is manufactured into two different parts each having ratios of Indian elm and Acacia fibre to epoxy resin as 60:40, 40:60 respectively and are compared for ultimate tensile strength, impact strength, hardness strength and flexural strength of the material by conducting experiment such as tensile test, flexural test, hardness test and impact test.

Keywords: Indian elm and Acacia Fibers, epoxy resin, , Testing, lamina.

I. INTRODUCTION

The term composite can be defined as a material composed of two or more different materials, with the properties of the resultant material being superior to the properties of the individual materials being superior to the properties ofindividual material that make up the composite. Different materials can be combined on a microscopic scale, such as in alloying of metals, but the resulting material is, for all practical purposes, macroscopically homogeneous, i.e., the components cannot be distinguished by the naked

Eye and essentially act together. The advantage of compositematerials is that, if well designed, they usually exhibit the best qualities of their components or constituents and often some qualities that neither constituent possesses. Some of the properties that can be improved by mechanical properties a composite material are strength, fatigue life, stiffness, temperature- dependent behavior, corrosion resistance, thermalinsulation, wear resistance and weight.

Composite materials are nowadays employed in many engineering structures such as helicopter and wind turbinerotor blades, boat hulls, and buildings, implying the application of variable loadings for long time spans. In this project the Indian elm and Acacia fibers is bi direction arranged, flattened into a sheet (called a woven strand mat), woven into a fabric. In this work, Indian elm and Acacia Fibers, and epoxy resin is bi direction arranged by hand layup procedure.

II. INDIAN ELM(HOLHOPTELEA INTEGRIFOLIA)

Indian Elm natural fibers in hybrid composites involves incorporating fibers derived from the Indian Elm tree, such as those from its bark or leaves, into composite materials. These natural fibers can be combined with synthetic fibers or other natural fibers to create a composite material with enhanced properties.

The Indian Elm fibers can act as reinforcements within the composite, providing strength, stiffness, and other mechanical properties. By using natural fibers, such as those from Indian Elm, in composites, the environmental impact of the materials can be reduced compared to traditional synthetic fibers.Hybrid composites, which combine different types of fibers, can offer a balance of properties, such as strength, durability, and lightweight characteristics.

The specific properties of the Indian Elm fibers, combined with those of other fibers in the composite, can be tailored to suit various applications, such as automotive parts, construction materials, or consumer goods. Using Indian Elm natural fibers in hybrid composites presents an opportunity to create sustainable, eco-friendly materials with desirable properties for a range of applications.

III. ACACIA (PROSOPIS JULIFLORA) :

The integration of Acacia fiber into hybrid composites presents an intriguing opportunity for sustainable material development. Acacia fiber, derived from Acacia trees, offers a renewable and biodegradable alternative to synthetic fibers, contributing to reduced environmental impact. When incorporated into composite materials, Acacia fiber can enhance mechanical properties such as strength, stiffness, and impact resistance, making it suitable for various applications. By combining Acacia fiber with other fibers in hybrid composites, manufacturers can tailor the material to meet specific performance requirements while maintaining cost-effectiveness. Additionally, the lightweight nature of Acacia fiber hybrid composites makes them suitable for applications where weight reduction is essential, such as automotive parts or sporting equipment. Overall, the utilization of Acacia fiber in hybrid composites represents a sustainable approach to material innovation, offering versatility, durability, and environmental responsibility across diverse industries.

IV. RESIN

Epoxy Resins (monomers or oligomers) can be powders,or they can be thick, clear or yellow liquids. Some common epoxy resins are: the diglycidyl ether of bisphenol A (DGEBA), novolac resins, cycloaliphatic epoxy resins, brominated resins, epoxidized olefins, Epon^{R}and Epikote Epoxy resins are available in liquid and solid forms and arecured into the finished plastics by a catalyst. They are cured at room temperature as well as elevated temperatures of about 275°. The resin grade LY-556 was used of density 1.1-1.2gm/cc at 298k has been used as the matrix material.

Epoxies tend to be stronger than other resins, certainly much less brittle on their own than polyester in other words, they have very good flexural strength! They comeas two parts which are commonly mixed in ratios ranging 10:1 resin to hardener by weight. Also compared to others, epoxy resin generally has a very long pot-life (working time A ‘fast’ epoxy may be demouldable in 24hrs METHODOLOGY

A. Material Preparation

1) Die preparation

The mold box was made with the dimension of 300 mm (L) ×300 mm (W) ×3mm (T) mm, the matrix was prepared by mixing the hardener to epoxy resin. The epoxy and hardener ratio was maintained at 10:1. To get the well- cured and a standard-quality specimen, the epoxy and hardener must be mixed smoothly and slowly. Initial layer of the mold was filled with epoxy resin mixture and then the appropriate quantity of fibers was placed such that epoxy mixture completely spread over the fibers. Before applying compression, efforts were made to remove all bubbles with roller. Finally, the compression pressure was applied evenly to achieve the uniform thickness of 3 mm and cured for 24 h at room temperature. The obtained composite plates are of the size (300 ×300×5) mm^{3}and(300 ×300×7) mm^3.

Die Size 300x300x10 mm^3
Fig 1: Die without cover

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2) Preparation Of Resin And Hardener

For the making of good composite the measurement of the samples should be accurate and the mixture should be very uniform. We take accurate amount of polymer which we have calculated earlier and 10% of its hardener. Then this mixture is stirred thoroughly till it becomes a bit deep.Bit extra amount of hardener is taken for the wastage in the process. Hardener should take very closely becauselittle extra amount of hardener can spoil the composite.

(a)

(b)

Fig 2 :(a) HARDNER (HY 951) AND EPOXY RESIN (b) Both hander and epoxy are mixed a bowl

3) Manufacturing of composite by HAND LAY-UPMETHOD

Hand lamination process is considered as one of the easiest method of fabricating any composites. Here the base plate is fixed inside the frame. For fabricating theIndian elm 18.05 %and Acacia 16.46 % Fibers, epoxy resin hardener mixture 65.49 % . and Indian elm 19.12 %and Acacia 37.57 % Fibers, epoxy resin hardener mixture 56.96 % At first, the mixed epoxy is been applied as a base layer and on top of that the fibers were kept. The epoxy is kept as a base because it will prevent from any air gap that may affect theentire fabrication process. The roller is used to roll the mold and for making the layer even throughout the mold. Then the process is continued for multiple layers of fiber sheet and epoxy. The final layer of epoxy is been covered with the laminated sheet and has been kept in the dryplace for 24 hours for the drying purpose. The simplest of the fabrication process is used in low volume products of large products.

Fig3: (a) Initial setup of mould frame

(b)During curing of the fiber plate

(c) Final lament

V. TESTING PROCESS

The fabricated specimen has to be tested according to the ASTM (American Standard for Testing Materials) standards.
Tests to Be Carried Out
The tests that are to be carried out on the fabricated plate are:

A. Tensile Test

The Tensile specimens were prepared as per the ASTM (D638) standard. Tensile testing, also known as tension testing is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined Young's modulus, passion’s ratio, yield strength, and strain-hardening characteristics. Uniaxial tensile testing is the most commonly used for obtaining the mechanical characteristics of isotropic materials. For anisotropic material, such as composite materials and textiles, biaxial tensile testing is required. This test method covers the determination of the tensile properties of unreinforced and reinforced plastics in the form of standard dumbbell-shaped test specimens when tested under defined conditions of pretreatment, temperature, humidity and testing machine speed.

(a).Before Tensile Test

(b).After Tensile test
Fig 4: Fabrication of tensile Specimen

B. Flexural Test

The Flexural specimen is prepared as per the ASTM (D790) standard outlines testing of flexural properties of polymer matrix composites using a bar of rectangular cross section supported on a beam and deflected at a constant rate.

(a) Before flexural test

(b)After Flexural test

Fig 5: Fabrication of Flexural Specimen

C. Hardness Test

The Rockwell superficial hardness scales are available in the relevant ASTM standards (ASTM 1984). The Rockwell hardness values are expressed as a combination of hardness number and a scale symbol representing the indenter and the minor and major loads.

(a) Before Hardness Test

(b) After Hardness Test

Fig 6: Fabrication of Hardness Specimen

D. Impact Test

The Impact test specimen is prepared as per the ASTM(D256) standard. Notched Izod Impact is a single point testthat measures a materials resistance to impact from a swinging pendulum. Izod impact is defined as the kinetic energy needed to initiate fracture and continue the fracture until the specimen is broken. Izod specimens are notched to prevent deformation of the specimen upon impact. The standard specimen for ASTM is 64 x 12.7 x 3.2 mm (2½ x ½ x 1/8 inch). The most common specimen thickness is 3.2 mm (0.125 inch), but the preferred thickness is 6.4 mm (0.25 inch) because it is not as likely tobend or crush. The depth under the notch of the specimen is 10.2 mm (0.4 inches).

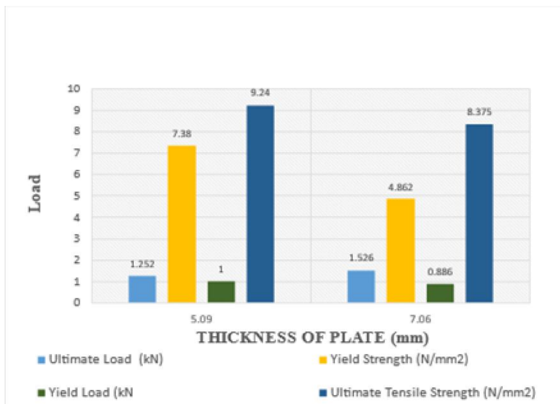
(a)Before Impact Test

(b)After impact test
Fig 7: Fabrication of impact Specimen

VI. RESULTS AND DISCUSSION

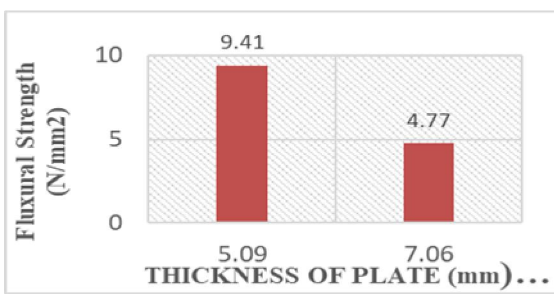
The Specimens are prepared and tested in the laboratory. The results all are show the performance of composite in different thickness hybrid composite the following tables all are shown the value after conducting thedifferent kind of in test using universal testing machine .The graph show the different forms inthe performance it will make help to understand the realitywhat happened in the part of the work There are the Tensile test, hardness test, Flexural test and Impact Izod test are listed below.

A. Tensile Test



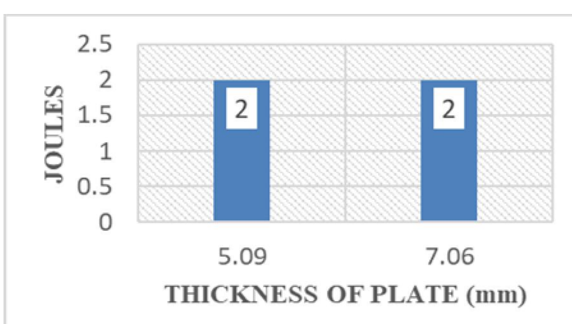
Grap 1: Thickness of plate vs Load

B. Flexural test



Graph2: Flexural strength vs Thickness of plate

C. Impact Test



Graph3: Joules vs Thickness of plate

Table 3: Tensile test

Fiber	Fiber Layers	Thickness (mm)	Impact Strength (joules)
Acaciaea& Indian elm	I_2	5.09	2
Acaciaea& Indian elm	I_3	7.06	2

Table 4: Compression test

Fiber	Fiber Layers	Thickness (mm)	Ultimate Load (kN)	Ultimate Tensile Strength (N/mm^2)	Yield Load (kN)	Yield Strength (N/mm^2)
Acaciaea & Indian elm	T_2	5.09	1.252	9.240	1.000	7.38
Acaciaea & Indian elm	T_3	7.06	1.526	8.375	0.886	4.862

Table 5: Flexural test

Fiber	Fiber Layers	Thickness (mm)	Fluxural Strength (N/mm^2)
Acaciaea& Indian elm	F_2	5.09	9.41
Acaciaea& Indian elm	F_3	7.06	4.770

Table 6: Harness Test

Fiber	Fiber Layers	Thickness (mm)	Load (kg)	Hardness Strength
Acaciaea& Indian elm	H_2	5.09	100	89
Acaciaea& Indian elm	H_3	7.06	100	57

VII. CONCLUSIONS

The investigation of Indian elm and Acacia fiber hybrid composite leads to the following conclusions:
Successful fabrication of Acacia, Indian elm fiber with different weight fractions is possible by simple hand lay-up technique. The mechanical properties of the composites such as tensile strength, flexural strength and impact strength of the composites are also greatly influenced mostly by the fiber lengths and also its dimensions.

The best results obtained in tensile tests are in sample-2 and sample-3,compare to sample -3 sample - 2 has good results.
The best results obtained in flexural tests are in sample-2 and sample-3 , compare to sample-3 sample-2 results are good.
The best results obtained in impact tests are in sample-2 and sample-3 , both the sample-2 sample-3 results are good.

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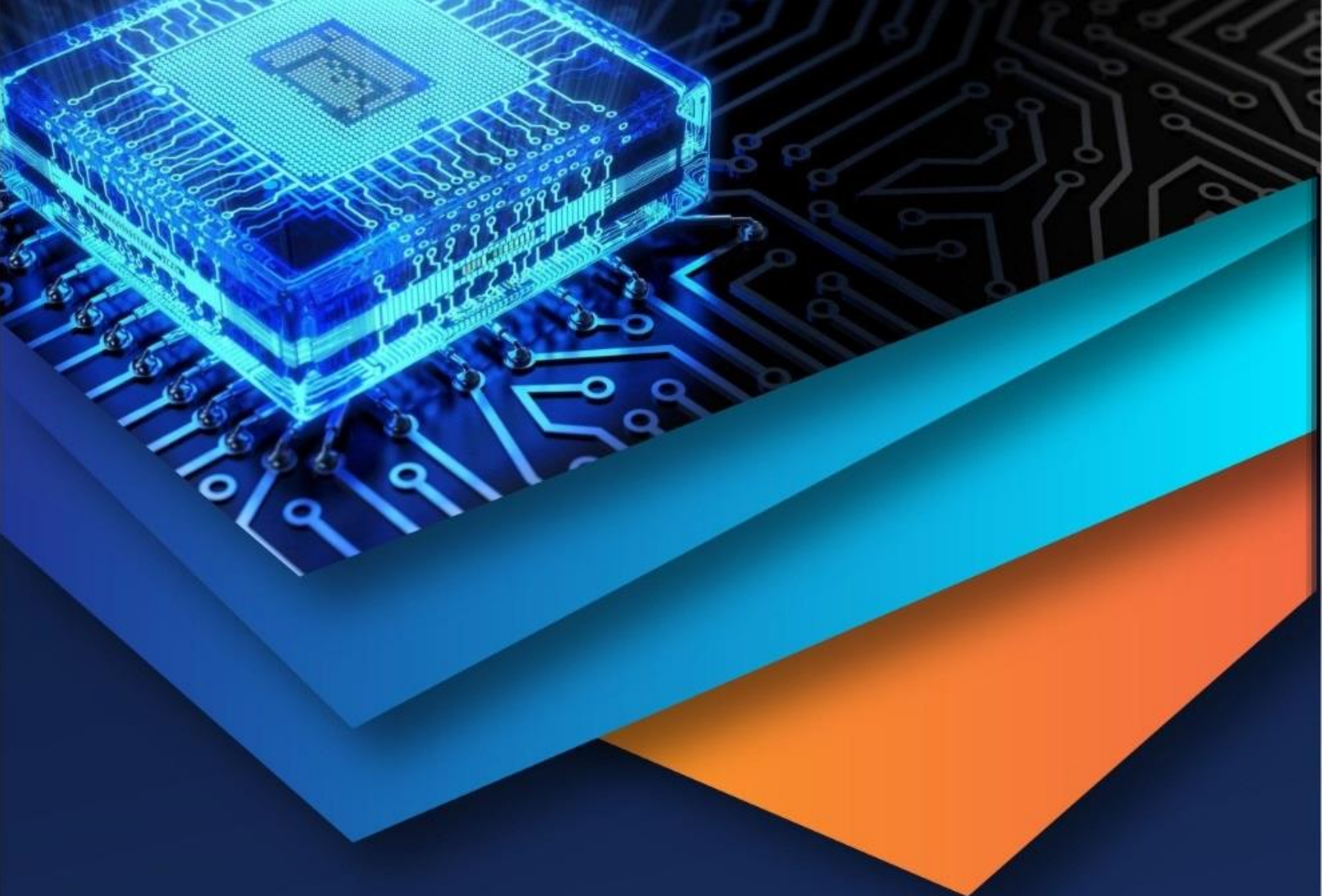

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