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Experimental Investigation of Banana Fiber Composite Material

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Abstract: In the present work, the experimental investigation on mechanical properties of banana natural fiber hybrid composites is done by testing for tensile ,impact and water absorption. Various samples were fabricated and tested for the better result .The outcome of the presented work will help the better utilization of natural composites as a replacement to the metals component. The leaf spring can be manufactured using banana natural fiber and the mechanical performance can be checked to know the effectiveness of the natural fiber composites. Various mechanical components made of natural fibers will be tried in future effectively.
Keywords: composite materials, Banana fiber, natural fibers

I. INTRODUCTION

A composite is a structural material that consists of two or more combined 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. The reinforcing phase material may be in the form of fibers, particles, or flakes. The matrix phase materials are generally continuous. Fiber reinforced polymer materials are composites consisting of high strength fibers (reinforcement) embedded in polymeric matrices. Fibers in these materials are the load-carrying elements and provide strength and rigidity, while the polymer matrices maintain the fibers alignment (position and orientation) and protect them against the environment and possible damage. A pure polymer does not usually have the requisite mechanical strength for application in various fields. The reinforcement by high strength fibers provides the polymer substantially enhanced mechanical properties and makes the fiber reinforced polymer composites (FRPCs) suitable for a large number of diverse applications ranging from aerospace to sports equipment. Natural fiber composites combine plant-derived fibers with a plastic binder.In the past few decades, research and engineering interest has been shifting from monolithic materials to fiber-reinforced polymeric materials. These composite materials (notably agamid, carbon and glass fiber reinforced plastics) now dominate the aerospace, leisure, automotive, construction and sporting industries. Glass fibers are the most widely used to reinforce plastics due to their low cost (compared to agamid and carbon) and fairly good mechanical properties. However, these fibers have serious drawbacks so I tried to investigate in one of the good natural fibers that is banana plant stem fibers.

V.S. Srinivasan et al (2014) Hybrid composites made by Hand lay up using flax, banana and glass fiber and tested on different testing machines and find several mechanical properties of Hybrid and individual NFCs with GFCs it is seen that impact energy absorbed by (F+B+ GFRP) hybrid composite higher than other two individual composites. Fatimat O. Bakare, et al (2016) The results show that the flax/basalt composite has better mechanical and thermal properties than the pure flax composite. The flax/basalt composites showed relatively good flexural, tensile and impact strengths than the pure flax composite. Jeff Flynn, et al (2016) By experimently it is found that the hybridized flax and carbon fiber composite was found to exhibit the following mechanical property gains: Tensile properties: tensile modulus: 2%, tensile strength: 252% Vibrational properties: damping ratio: 114% In addition to the mechanical properties, there was also a 49% weight savings as a result of the reduced composite density. Saeed Manteghia, et al (2017) by investigate the mechanical feasibility of a hybrid Glass/Flax/ Epoxy composite material for bone fracture fixation such as fracture plates. It is found that. the proposed hybrid composite plates are significantly more flexible axially compared to conventional metallic plates. Furthermore, they have considerably higher ultimate strength in tension, compression and flexion. Such high strength will ensure good stability of bone implant construct at the fracture site. D. Chandramohan, et al (2017) In this study the powdered coconut shell, walnut shells and Rice husk are used as reinforcements with bioepoxy resin to form hybrid composite specimens. From experimentally it is found that Hybrid of Walnut and Coconut Shell has better Tensile, Flexure, Impact and shear strength with and without moisture than other two composites.

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E. Nisini et al (2017) in this paper Ternary hybrids including carbon, basalt and flax fibers in an epoxy matrix have been fabricated by hand lay-up, and experiments were carried on by using tensile, flexural, shear and impact test and found that 1) Intercalation of basalt with flax layers proved beneficial for flexural and interlaminar strength.2) the presence of a compact core of flax fibre laminate or else its intercalation with basalt fibre layers had a predominant effect on impact damage features, with intercalation increasing their complexity. M R Sanjay and B Yogesha (2017) This paper presumed that the hybrid composites made of natural fiber with glass fiber exhibit better mechanical properties than natural fiber composites. It is recommended to do the research on the incorporation of different natural fiber polymers with synthetic fibers leads to increase the applications and supplant the non-renewable materials in the field of engineering and technology. Saeed Manteghia, et al (2017) by investigate the mechanical feasibility of a hybrid Glass/Flax/ Epoxy composite material for bone fracture fixation such as fracture plates. It is found that. the proposed hybrid composite plates are significantly more flexible axially compared to conventional metallic plates. Furthermore, they have considerably higher ultimate strength in tension, compression and flexion. Such high strength will ensure good stability of bone implant construct at the fracture site. El Hadi Saidane, et al (2017) In this work presents an assessment of the damage mechanisms occurring during tensile tests in hybrid flax-glass fibres reinforced epoxy composites. It is found that although the hits number associated with the fibre failure was the lowest, their contribution to the overall failure of composites became predominant regarding the cumulative of AE energy. J. Page, et al. (2017)

Fig: VARTM setup

Jute Fiber composite

Flax Fiber composite

Fig. Laminate sheets of Natural and Synthetic fiber composite.

A. Cutting of Coupons

After manufacturing sheets of all natural fiber composites cutting according to ASTM: D638 standards by Water Jet Machining (WJM), OMAX 60120 Jet Machining Center at Kakade Laser, Narhe Pune It is used to cut the coupons as per the ASTM standards. In WJM, mechanical energy of water i.e high pressure about 3800 bar is used to achieve material removal or machining. As the process does not produce any heat, there is less damage to the component.

Figure Water Jet Machine

B. Casting

Fiber-Reinforced Polymers (FRPs): FRPs typically have fiber volume fractions in the range of 40% to 70%. Carbon fiber composites used in high-performance applications may have higher fiber volume fractions, approaching 60% to 70%. Glass fiber composites often have fiber volume fractions in the range of 40% to 60%.

Ceramic Matrix Composites (CMCs): Ceramic matrix composites generally have fiber volume fractions ranging from 20% to 60%. The exact percentage depends on the specific ceramic fibers and matrix materials used.

Metal Matrix Composites (MMCs): Metal matrix composites typically have lower fiber volume fractions compared to polymer or ceramic composites. Fiber volume fractions in MMCs can range from 10% to 40%.

It's important to note that the fiber volume fraction directly affects the mechanical properties of the composite. Increasing the fiber volume fraction generally improves the composite's strength and stiffness, but it may also increase the manufacturing complexity and cost**.**The specific fiber volume fraction for a given composite is determined through a combination of design considerations, material selection, and manufacturing process optimization. Engineers and designers carefully balance the desired properties, such as strength, weight, and cost, to determine the appropriate fiber volume fraction for a particular application.

C. Tensile Test

Tensile testing is a common method used to evaluate the mechanical properties of composite materials, particularly their strength and stiffness in tension. The test involves applying an axial force to a standardized specimen of the composite and measuring the resulting deformation and stress. Here is an overview of the typical procedure for conducting a tensile test on a composite.Specimen Preparation: Standardized specimens, usually in the form of dogbone-shaped samples, are prepared from the composite material. The dimensions of the specimens are determined according to relevant standards or specific testing requirements.Mounting the Specimen: The specimen is securely mounted into the grips of the testing machine, ensuring that it is aligned along the axis of loading. It's essential to avoid any slippage or misalignment during the test.Preloading: A small preloading force is applied to remove any slack in the system and ensure proper contact between the grips and the specimen.Test Setup: The tensile testing machine is set up to apply a steadily increasing tensile force to the specimen. The force is typically applied at a constant rate, following the specified testing standard or a predetermined testing program.Data Collection: During the test, various data are collected. The most critical parameters include the applied force (load) and the corresponding elongation or displacement of the specimen. These data are used to calculate stress and strain values.Stress-Strain Curve: The collected data is used to plot the stress-strain curve for the composite material. The stress is calculated by dividing the applied force by the original cross-sectional area of the specimen, and the strain is determined from the ratio of the change in length to the original length of the specimen.Failure Analysis: The tensile test continues until the specimen fractures. The fracture behavior and location are examined to assess the failure mechanism of the composite material, such as fiber breakage, delamination, or matrix failure.Calculation of Mechanical Properties: Various mechanical properties can be determined from the stress-strain curve, including elastic modulus, yield strength, ultimate tensile strength, and elongation at break. These properties provide insights into the material's performance and help in design and material selection.

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D. Izod Impact Test

The Izod impact test is a widely used method to assess the impact resistance or toughness of materials, including composite materials. It measures the energy absorbed by a specimen when struck by a pendulum hammer. The following procedure is used .Specimen Preparation: Standardized specimens with specific dimensions and notch configurations are prepared from the composite material. The dimensions and notch geometry typically follow relevant standards or specific testing requirements. The notch is introduced to create a stress concentration and initiate crack propagation during the impact.Mounting the Specimen: The specimen is securely clamped in a fixture, with the notch facing the direction of impact. The fixture ensures proper alignment and stability during the test.

Pendulum Setup: A pendulum hammer with a specific geometry and weight is selected based on the desired test conditions. The pendulum is raised to a predetermined height, creating potential energy that will be converted into kinetic energy upon release. Impact: The pendulum is released, swinging down and striking the specimen. The impact causes the specimen to fracture or deform, absorbing energy in the process. Measurement and Data Collection: The impact energy absorbed by the specimen is measured using a scale or data acquisition system. The energy is typically reported in units of joules (J) or foot-pounds (ft-lbs).Analysis and Reporting: The impact energy absorbed by the specimen is recorded, and the results are analyzed. The toughness or impact resistance of the composite material is evaluated based on the energy absorbed during the test. Additionally, the fracture behavior and location are examined to assess the failure mode, such as fiber breakage, delamination, or matrix failure.

Fig : Impact testing set up of component.

Thick in mm	width in mm	impact value J	impact strength J/M
2.7	10	1.5	555.55
2.8	10	1.52	565.43
2.75	10	1.55	543.86

Table Impact test results

INITIAL WEIGHT	THICKNESS MM	AREA 50X50 MM	VOLUME mm cube	DENSITY KG/M3
8.855	2.7	2500	6750	1311.8
8.998	2.7	2500	6750	1333.0
8.854	2.7	2500	6750	1311.7

Table density of castings

E. Water Absorption Test

The water absorption test is performed to evaluate the ability of a composite material to absorb water over time. It helps assess the material's resistance to moisture ingress, dimensional stability, and potential degradation due to water exposure. Here's an overview of the procedure. Specimen Preparation: Standardized specimens are prepared from the composite material, typically in the form of rectangular or disc-shaped samples. The dimensions and thickness of the specimens are determined based on relevant standards or specific testing requirements. Preconditioning: The specimens are preconditioned to achieve a stable initial weight. This involves drying the specimens in an oven or conditioning them at a specific temperature and humidity level until a constant weight is obtained. Weighing: The initial weight (Wi) of each specimen is measured using a balance with sufficient accuracy. Immersion: The specimens are immersed in a container filled with distilled water or an appropriate immersion medium. The specimens are fully submerged, and care is taken to prevent air entrapment. Soaking Period: The specimens remain immersed in water for a predetermined period, which can range from a few hours to several weeks or months, depending on the test requirements and material characteristics. Drying and Weighing: After the specified soaking period, the specimens are removed from the water, and the surface moisture is gently wiped off. The specimens are then dried using a soft cloth or paper towels to remove any residual surface moisture. The specimens are weighed again (Wf) to measure the absorbed water. Calculation of Water Absorption: The water absorption is calculated using the following formula: Water Absorption (%) = [(Wf - Wi) / Wi]x100 , This equation provides the percentage of weight gain due to water absorption relative to the initial weight of the specimen. Data Analysis: The obtained water absorption values can be used to compare different composite materials, assess the effectiveness of surface coatings or treatments, or evaluate the long-term durability of the material under exposure to moisture.

INITIAL WEIGHT	FINAL WEIGHT	WEIGHT DIFFERENCE	MOISTURE PERCENTAGE
8.855	8.866	0.011	0.1242236
8.998	9.011	0.013	0.1444766
8.854	8.867	0.013	0.1468263

Table water absorption test

Fig. banana fiber Weight of 0.1 layer 5.382 gram used in composite making

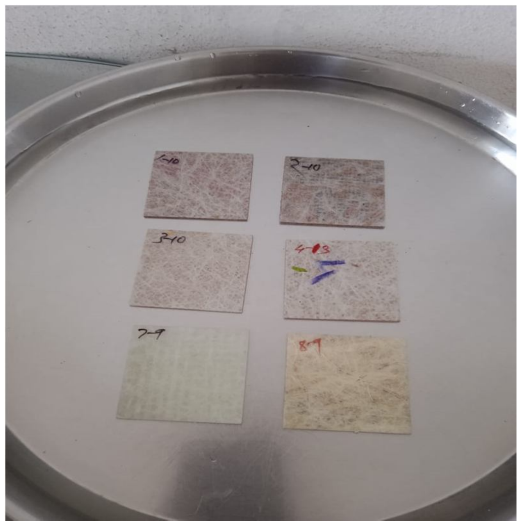

Fig : Sample kept for water absorption test for 7 days

II. RESULT AND DISCUSSION

In this study natural banana fiber Glass fiber composite are made and their effect on tensile and impact test properties are evaluated and compared.

Table .Tensile

Sr. No.	Sample ID	Tensile Strength MPa
1	Banana + glass	71.29
2	Banana + glass	73.9
3	Banana + glass	73.3

1) *Tensile properties:* The composite samples are tested in the universal testing machine (UTM) and the load – deformation curve is plotted. The typical graph generated directly from the machine for tensile test for natural fiber hybrid composites
2) *Conculsion:* In the present work, the experimental investigation on mechanical properties of natural banana fiber hybrid composites for the same fiber volume fraction leads to the accompanying ends. The impact of composites on the mechanical properties is also examined. From the experimental findings, following conclusions were drawn: Banana plant fiber composites shows the favorable mechanical properties tried in the present work.The performance analysis shows the effectiveness of banana fiber . Natural fiber hybrid composite produced by VARTM process gives a chance of supplanting existing materials with a higher strength, minimal effort elective that is earth benevolentThe banana natural fibers strengthened with epoxy were delivered utilizing Vacuum Assisted Resin Transfer Molding. The banana natural fiber composite samples posses good tensile strength and can withstand the good strength

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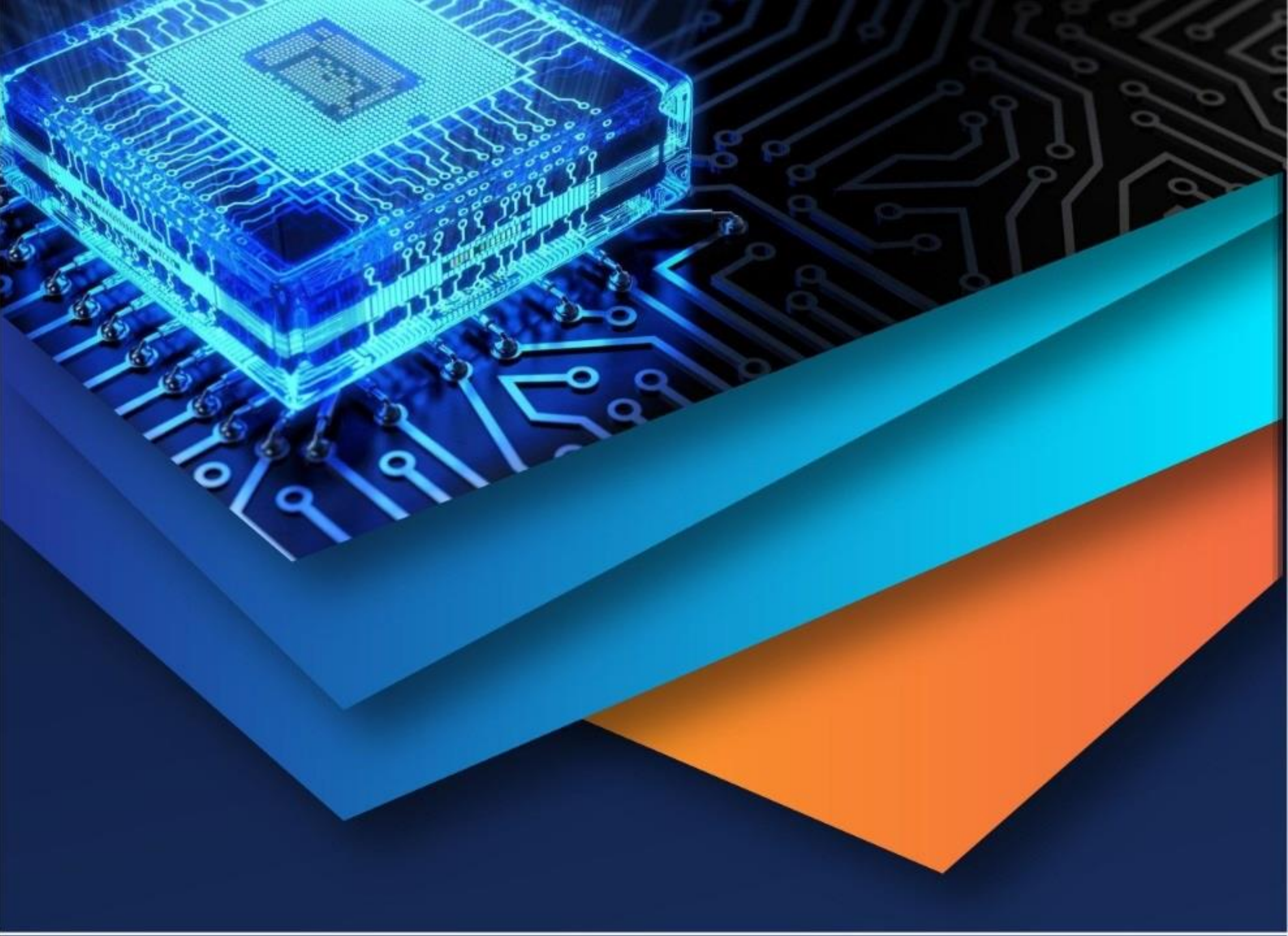

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