Experimental Investigation on Mechanical and Physical Properties of Bamboo and Sisal Fiber Reinforced Hybrid polyester Composite

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Abstract. In composites, characteristic fibers are arising as minimal effort, lightweight and clearly naturally predominant choices to glass fibers, which are utilized in transportation, aviation and development businesses. The development of composites with their improved form is going on with intensive effort. Composite materials which have low densities are used for structural functions, leading to high strength to weight and high stiffness to weight compared to other conventional structural materials. Composites area unit of low value, bio degradable and simply will reclaimable through thermal strategies. Additionally, to the high fatigue strength to weight magnitude relation and fatigue harm tolerance of the many composites conjointly makes them a gorgeous possibility. The light-weight natural fiber composites improve fuel potency and cut back emissions within the use section of the element, particularly in automotive applications. In this investigation hybrid composite material was prepared and composed of bamboo and Sisal fiber which is reinforced composite with in three different fiber orientation, fabricated by hand layup method. Different fiber orientation of sample was prepared and test was carried out to find the Mechanical Behavior and water absorption tests as per ASTM standard. Micro structure was analyzed by optical microscope. Here observed that varying the fiber orientation of bamboo and sisal reinforced sample produced also vary mechanical properties and Unidirectional 0⁰ fiber orientation was found to have a impact strength and the water absorption is more compared to other fiber orientation whereas bidirectional (0⁰/90⁰) fiber orientation was found to be having higher hardness strength than unidirectional 90⁰ and Unidirectional 0⁰ fiber orientation which can be used for nonstructural automotive interior body application.

1. Introduction

Presently a day, replacement of ordinary materials, for example, steel, aluminum and other compound materials by composite materials has filled essentially in flying, car, maritime, and common development areas. This is because of their stunning properties, for example Composite materials have of high modulus to weight proportion and solidarity to weight proportion, brilliant weakness properties, and non-consuming practices. These favorable circumstances support the broad utilization of composite materials in various zones including car ventures [1].

The essential point of growing new materials for car application is to upgrade vehicle proficiency and efficiency by diminishing the weight of vehicle. Additionally aesthetical appearance of vehicles, ought to
be redesigned by investigating new materials for the vehicles as well [2]. Various explores have been exhibited light weighted composite materials, weakness safe and effectively formed to any shape, as such, an apparently alluring option in contrast to metallic materials. On the off chance that the advantages of composite materials as far as light weighing, strength, great aesthetical worth, high explicit energy ingestion capacity and simplicity of framing are to be misused all the more broadly by the car business, at that point there is a need to recognize the basic specialized boundaries that must be survived[6, 7].

Generally, the materials utilized in the development of vehicle bodies are principally different evaluations of steel and aluminum[2]. In addition, plastics and some manufactured materials generally overwhelm the vehicle inside parts. The makers meet the prerequisites of a specific crashworthiness standard and eco-friendliness by making the estimated configuration change in their vehicle structure and by presenting fundamental basic parts that fulfill the general plan goals [5, 7,9]. Weight reduction of the vehicle body is a major challenge faced by the industries .more weight of the vehicles causes more fuel consumption and higher harmful emissions at the moment light weight composite materials are prepared in the country using the imported synthetic fibers expensive and disposal of which causes environmental pollution. Replacement of interior nonstructural parts of the vehicle is also another challenge[1, 8,11].

In the present study involves that fiber reinforced polymer matrix of sisal and bamboo fiber hybrid composite developed by using hand lay-up method with reinforcements other varying Fiber orientation of bamboo and sisal fibers which may be in form unidirectional 0°, unidirectional 90° and bidirectional (0°/90°) . For achieving the better mechanical properties in composite materials, presently, polyester, reinforced with bamboo and sisal as a reinforcement material is hot topic of research and which can be a substitute for non-structural automotive interior body panels.

2. Methodology

2.1. Materials used

2.1.1. Sisal fiber. Sisal fiber is easily available natural fiber with low price and it is recyclable. It is having high modulus and specific strength. At the moment, engineers and scientists are showing higher interest in reinforced polymer composites all over the world [12].

2.1.2. Bamboo Fiber. From the classification of natural fiber select plant fiber source under leaf category sisal plant and grass/reed category bamboo plant used bamboo fiber is selected for this research work due to the numerous advantage of bamboo fiber over other natural fiber like high mechanical strength, high tensile strength, low specific weight, high modulus of elasticity and locally available [4, 10].

2.1.3. Polyester. Composite industries are famously using polyester resins. More attractive feature of polyester resin is its low cost compared to epoxies which are performing better.

2.1.4. Fiber orientation. The force and the rigidity of the composite depends on the fiber orientation and series of piles their orientation series of piles. For getting required structural strength selection of appropriate ply orientation is necessary in advanced composite materials [10, 13]. The structural part may need 90° piles to respond side loads, ±45° plies to respond shear loads and 0° piles to respond axial load.

2.2. Method

2.2.1. Fabrication methods. Hand Layup is the least difficult polymer preparing procedures. Above all else, the shape surface was cleaned by applying discharge gel/wax to avoid polyester tar sticking to the surface. Polyethylene Plastic were utilized at the top and lower part of the form plate to get good surface finishing of the item. Woven or unidirectional fiber were cut to the required size and arranged over
Perspex sheet. At that point Polyester pitch is blended completely in appropriate extent in with an endorsed hardener (restoring specialist) and poured onto the outside of woven effectively positioned in the shape. The polyester tar was smeared with brush.

Second layer of unidirectional bamboo fiber was then positioned on the gum surface and a roller was moved with a gentle tension on the fiber-sap layer to eliminate any air caught just as the abundance gum present. For stacking the necessary layers, the cycle was repeated for making sandwiched structures.

After cleaning the lower surface of the top plate with discharge gel, it was kept on stacked layers and then weight is applied. The prepared composite part was taken out by opening it for further processing.

**Figure 1.** Fabrication approach of composite

### 2.3. Experimental Procedure and Setups

#### 2.3.1. Impact strength test (ISO 9001:2001).

The samples of length 55 mm, width 10 mm & thickness 5.5 mm were used for conducting impact test. The impact speed of hammer is 3.8 meters per second having 30-kilogram weight mounted pendulum. The notch cut on the specimen shall be facing the opposite direction of the striker. The toughness of the material can be measured by the energy required for fracturing the material.

**Figure 2.** Impact test specimen  
**Figure 3.** Fixing of test condition
2.3.2. Water absorption test of composites materials. Standard ASTM 570 was utilized in this work to contemplate the water retention qualities of sisal/bamboo fiber fortified half and half unsaturated polyester composite. Tests were taken out at ordinary spans and weighed following cleaning endlessly water from the surface, and an exact 4-digit balance was utilized to discover the substance of water ingested.

Equations (1) used to determine the water absorption:

\[ \text{Moisture Absorption} = \frac{w_2 - w_1}{w_1} \times 100 \% \] ............................. (1)

With \( w_1 \) and \( w_2 \) being the weight of dry and wet samples

The material is submerged in water at determined upon condition, at room temperature for 24hrs. Tendency towards moisture absorption in humid air or in water was found by polymer composite reinforced with natural fibers. Effect of moisture absorption results the poor fiber-matrix interface region as a resulting in a reduction in mechanical properties along with change in dimensions of composite.

2.3.3. Microstructures of composite. In this test, fiber orientation effect on the microstructure of the composite mechanical properties such as Vickers Hardness test was examined. Both physically and mechanically were determined using standard methods and the microstructure of the samples examined using Optical microscope equipped with camera, with others such as Vickers Hardness, polishing machine, Grinding machine and others.

2.3.3.1 Sample Preparations. The first step of sample preparation is cutting composite have length of 2 cm of three different fiber orientation by using Cutter.

2.3.3.2. Mounting the sample. Mounting serve the sample for two things. One is for convenience in handling of difficult shapes of size during the subsequent steps of preparation and the other is to protect and preserve defects during preparation.
2.3.3.3 Grinding and Polishing. The main object of grinding is to generate initial flat surface, removes saw marks and levels and free from excessive deformation. This several steps are; rough grinding, fine grinding, and polishing.

In the first step, saw cut specimens are rough ground on a outer surface are supplied with a sand paper or grinding paper of number 400, 800, 1200 and 2000 respectively. Starting with 400 after finishing using the next one clean with running water and dry by air compressor then rotate the specimen 90° from the first to make continuously. After grinding to removes the artifacts of little stock polishing is needed that make the surface mirror by adding diamond suspension. When do this moderate pressure is needed at the start of each step and then gradually reduce the pressure as the step proceeds for keeping the specimen from plastic deformations.

This is to examine and analyze the microstructure of the specimen the picture took from Optical Microscope can be measured the grain size and volume fraction of each phase by ASTM method. This is make grid line at equal distance on the photograph of the different samples.
The hardness of a material is an inadequately characterized term which has numerous implications relying on the experience of the individual in question. All in all, hardness normally suggests a protection from disfigurement. Vickers hardness test is a mechanical test to know the strength of the specimen by applying load on the surface of the specimen.

With the application of the load on the surface of the specimen, strength of the specimen is measured in Vickers hardness test.

3. Results and Discussion

3.1. Impact test

Average result was measured as shown in Figure 13 and 14,
From figure 14, it has been observed that unidirectional 0° fiber orientation of bamboo and sisal fiber composite have higher impact strength than other types of orientation.

3.2. Water absorption

Water absorption test data is given in table 1

| Fiber orientation | Water absorption test (dry mass) (gram) | Average (dry) gram | Average (wet) gram |
|-------------------|----------------------------------------|--------------------|-------------------|
|                   | Sample -1 | Sample -2 | Sample -3 | Average |
| Unidirectional (0°) | 3 | 3 | 3.5 | 3.166 | 3.5 |
| Bidirectional | 6 | 6 | 6 | 6.33 |
| Unidirectional (90°) | 3 | 3 | 3 | 3.166 |

From the data given in Figure 15, it is observed that the water absorption is more for unidirectional fiber 0° orientation compared to other fiber orientation. Where water molecules got interlocked in composite material, the weight of it increases, thus evidenced that with immersion time the absorption behavior of BSFHRRC varies in different orientation.
3.3. Hardness test result

The results obtained during hardness test on composite specimen of different fiber orientation are summarized in figure 16.

Figure. 15. Water absorption in different fiber orientation

Figure. 16. Hardness test result

From the data given in figure 17. It is observed that the hardness of the material is more for fiber bidirectional fiber orientation compared to other fiber orientation.

Figure. 17. Hardness value in different fiber orientation
4. Conclusion

1. Impact experimental test results show that impact energy of unidirectional 0° fibers composite higher compared to others which is about 5.1 Joules.
2. The hardness of the material is more for fiber bidirectional fiber orientation compared to other fiber orientation.
3. It is observed that the water absorption is more for unidirectional fiber 0° orientation compared to other fiber orientation.

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