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Investigation of Mechanical Properties of Natural Fiber Reinforced With Screw Pine and Jute Composite

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Abstract: Natural fiber reinforced composites gaining the demand in the engineering applications. Natural Fiber Reinforced Polymer Composites replaces the conventional material because it possesses mechanical, chemical, thermal properties comparable and higher than conventional material. Light weight, low cost and biodegradability increases the demand of NFRPC. The objective of this work is to prepare the composite fiber composite specimens as per ASTM Standard using hand layup method and conduct the tensile Test, impact Test (Charpy) and hardness Test (Rockwell). The testes carried out on Glass Fiber + Jute Fiber Composite, Glass Fiber + Jute Fiber + Screw Pine Fiber and Glass Fiber + Screw Pine Fiber composite. The comparative result is observed to know the optimized composite fiber.
Keywords: Glass Fiber, Hand layup method, Tension test, impact Test, Hardness test

I. INTRODUCTION

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market ranging from everyday products to sophisticated niche applications. While composites have already proven their worth as weight-saving materials, the current challenge is to make them cost effective. The efforts to produce economically attractive composite components have resulted in several innovative manufacturing techniques currently being used in the composites industry. It is obvious, especially for composites, that the improvement in manufacturing technology alone is not enough to overcome the cost hurdle. It is essential that there be an integrated effort in design, material, process, tooling, quality assurance, manufacturing, and even program management for composites to become competitive with metals. The composites industry has begun to recognize that the commercial applications of composites promise to offer much larger business opportunities than the aerospace sector due to the sheer size of transportation industry. Thus, the shift of composite applications from aircraft to other commercial uses has become prominent in recent years. Increasingly enabled by the introduction of newer polymer resin matrix materials and high- performance reinforcement fibers of glass, carbon and aramid, the penetration of these advanced materials has witnessed a steady expansion in uses and volume. The increased volume has resulted in an expected reduction in costs. High performance FRP can now be found in such diverse applications as composite armoring designed to resist explosive impacts, fuel cylinders for natural gas vehicles, windmill blades, industrial drive shafts, support beams of highway bridges and even paper making rollers.

II. MATERIALS & METHODOLOGY

A. The Following Materials Are Used To Prepare Sample Specimens

1) Jute Fiber

Jute is a long, soft, shiny plant fiber that can be spun into coarse, strong threads. It is produced from plants in the genus Corchorus. Jute is one of the cheapest natural Fibers and is second only to cotton in amount produced and variety of uses. Jute Fibers are composed primarily of the plant materials cellulose and lignin. Jute is a rainy season crop, growing best in warm, humid climates. The stalks are cut off close to the ground. The stalks are tied into bundles and retted (soaked) in water for about 20 days. This process softens the tissues and permits the Fibers to be separated. The Fibers are then stripped from the stalks in long strands and washed in clear, running water. Then they are hung up or spread on thatched roofs to dry. After 2-3 days of drying, the Fibers are tied into bundles. Jute is graded (rated) according to its colour, strength, and Fiber length. The Fibers are off-white to brown, and 1-4 m long.It is 100% bio-degradable & recyclable and thus environment friendly.

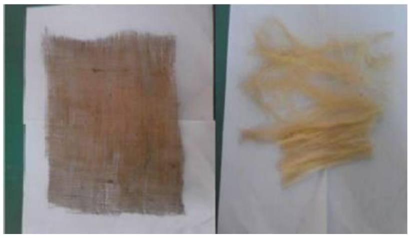

Figure 1. Jute Fiber (Mat & Fiber Type)

Figure 2. Screw Pine Fiber

2) Screw Pine

Pandanus Utilis is also known as Screw Pine. Screw pine fibers (pandanus fascicularis lam) were mostly available in coastal areas like Derisanamcope, Nagercoil, Tamilnadu, India. It consists of a considerably large stem which are brown in color. Fibers are thus extracted from both the stems and prop roots. Raw screwpine fiber extracted from the prop roots. The Common Screwpine is despite its name a monocot and not a pine. Pandanus utilis is a palm-like evergreen tree, ranging in height up to 20 metres (66 ft). They are found in tropical areas and have an upright trunk that is smooth with many horizontal spreading branches with annular leaf scars. Old leaf scars spiral around the branches and trunk, like a screw. The anatomy of Pandanaceae stems can be distinguished from other Monocotyledons by the presence of a compound vascular bundle. The screw pine has been shown to have many uses. In coastal areas, it has been used for erosion control due to its numerous aerial roots. These roots help bind the sand dunes along the coast from eroding water and wind. The leaves of P. utilis are used in different cultures for thatching and the production of numerous materials. In areas like Madagascar, Réunion and Mauritius, the leaves are used to make ropes, baskets, mats, hats, place mats, nets, thatched roofs for homes and even paper. The waxy covering over the leaves makes them especially attractive for baskets and roofs with their natural water-resistant surface.

3) Epoxy Resin

Epoxy resin (Araldite LY 556) made by CIBA GUGYE Limited, having the following outstanding properties has been used.

a) Excellent adhesion to different materials
b) Great strength, toughness resistance
c) Excellent resistance to chemical attack and to moisture
d) Excellent mechanical and electrical properties
e) Odorless, tasteless and completely nontoxic
f) Negligible shrinkage

4) Hardener

HY 951 is a hardener which is used with the epoxy resin which is used for the encapsulation or coating of low voltage and electronic components. HY 951 is good mechanical strength, good resistance to atmospheric and chemical degradation, excellent electrical properties. In the present work Hardener HY 951 is used. This has a viscosity of 10-20 poise at 25^0C.

5) Glass Fiber

Glass fiber also called fiberglass. It is material made from extremely fine fibers of glass Fiberglass is a lightweight, extremely strong, and robust material. Although strength properties are somewhat lower than carbon fiber and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are also very favorable when compared to metals, and it can be easily formed using molding processes.

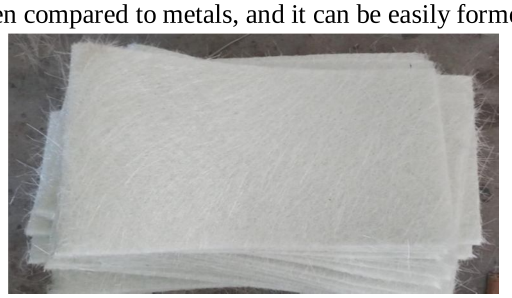

Figure 3. Glass Fiber

Figure 4. NAOH Solution

6) NAOH Solution

Sodium Hydroxide(NaOH) is a alkaline solution used to enhance the surface morphology of natural fibers.

B. Methodology

The Composite Material is completely Prepared by Hand Lay-Up Technique.

Step 1: Selection of matrix material

Epoxy LY-556 resin belonging to the Epoxide family was taken as the matrix. HY 951 was used as the hardener.

Step 2: Selection of reinforcement and Natural fibers: Natural fibers such as Jute and Screw Pine were taken to fill as reinforcements in the Polymer composite.

Step 3: Fibers Used- Jute Fiber, Screw Pine Fiber, Glass fiber

Step 4: Surface treatment of fibers

Freshly drawn fibers generally include lots of impurities that can adversely affect the fiber matrix bonding. Consequently the composite material made from such fibers may not possess satisfactory mechanical properties. Therefore it is desirable to eliminate the impurity content of the fibers and perhaps enhance the surface topography of the fibers to obtain a stronger fiber-matrix bonding. The fibers were left to treat with 5% NaOH for 1-2 hrs. Later they were drawn and dried under sunlight for 1 hours.

Figure 5. Surface Treatment of Fibers

Step 5: Hand Lay-up Technique:

The fiber piles were cut to size from the jute fiber cloth. The appropriate numbers of fiber plies were taken: two for each. Then the fibers were weighed and accordingly the resin and hardeners were weighed. Epoxy and hardener were mixed by using glass rod in a bowl. Care was taken to avoid formation of bubbles. Because the air bubbles were trapped in matrix may result failure in the material. The subsequent fabrication process consisted of first putting a releasing film on the mould surface. Next a polymer coating was applied on the sheets. Then fiber ply of one kind was put and proper rolling was done. Then resin was again applied, next to it fiber ply of another kind was put and rolled. Rolling was done using cylindrical mild steel rod. This procedure was repeated until eight alternating fibers have been laid. On the top of the last ply a polymer coating is done which serves to ensure a god surface finish. Finally a releasing sheet was put on the top; a light rolling was carried out. Then a 20 kgf weight was applied on the composite. It was left for 72 hrs to allow sufficient time for curing and subsequent hardening.

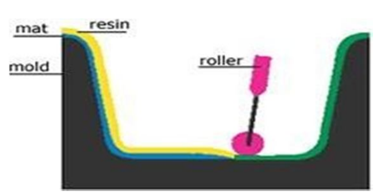

Figure 6. Hand Lay-up Technique

C. Fabrication by Hand-Lay Up Process

The composites sheets were fabricated from jute fiber, Screw Pine with Glass Fiber and resin matrix. The resin used was epoxy resin. The weight fraction of composites was maintained at 70% fiber and 30% resin. Number of plies for each fiber taken was two i.e. total number of plies used in hybrid composite are Three.

One natural hybrid composites are made i.e.

1) GF+SPF+JF (Glass Fiber + Screw Pine Fiber + Jute Fiber) Two Natural Composites are made i.e.
2) JF+ GF (Jute Fiber + Glass Fiber).
3) SPF+GF (Screw Pine Fiber + Glass Fiber).

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For the preparation of the composite we calculate the percentage of Fibers, Epoxy and Hardener required from the table we come to know about the amounts accurately.

Table 1 Percentage of Fibers Used

S.No	Composition	Jute	Glass	Screw Pine	Epoxy+ Hardner
1	J+G+S+E	20%	20%	20%	40%
2	J+G+E	30%	30%	_	40%
3	G+S+E	_	30%	30%	40%

Figure 7. Fabrication by Hand-Lay Up Process

D. Sample Specimens Preparation

After Complete Drying of Composite Material Then the cutting of the material is started and with ASTM Standards. The specimen is cut into required number of parts for making tests on the materials. There are Three Composite Material that are fabricated by us

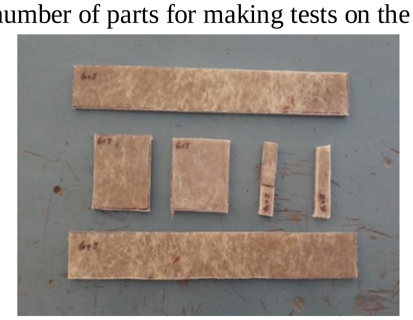

Figure 8. Glass Fiber + Jute Fiber Composite Material

Figure 9. Glass Fiber + Jute Fiber + Screw Pine Fiber

Figure 10. Glass Fiber + Screw Pine Fiber

III. EXPERIMENTATION

A. ASTM Standard for Tensile Test Specimen

The Tensile test for the natural fiber composite material was conducted in accordance with ASTM D 638 OF Type III. According to standard the specimen should have the similar standard specification.

1) Length of the specimen = 246mm
2) Width of the specimen = 29mm
3) Gauge Length = 57mm

Shape of the Specimen is Dumbbell shape (or) Dog-bone Shape. This shapes are mostly used in all tensile test to know the properties of the required specimen that is to tested.

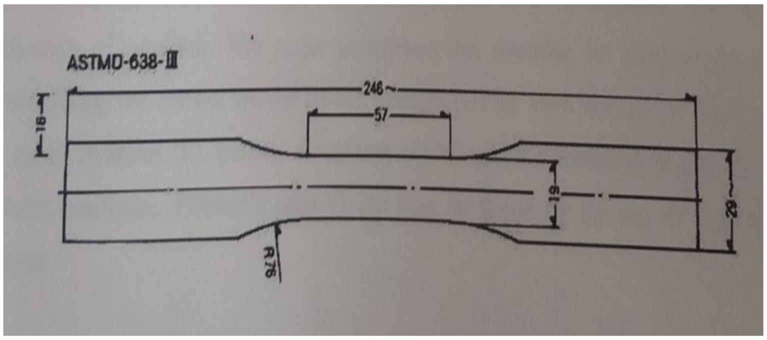

Figure 11. ASTM D 638 TYPE III Tensile test specimen specification

B. ASTM Standard for Impact Test Specimen

For conducting the impact test we followed ASTM E 23 Standard. According to this standard specification composite plates are machined. The specimen having length of 55mm, width is about 10mm, a "V" notch is placed at a depth 2mm from top with 45 degrees inclination

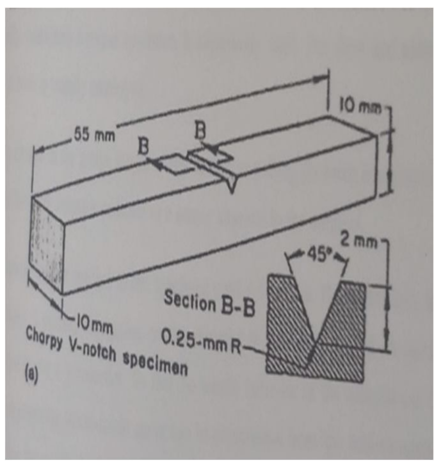

Figure 12. ASTM E 23 V-notch Charpy impact test specimen specification

IV. RESULTS AND DISCUSSION

A. Specimen Preparation as Per ASTM Standards

The samples are cut to the following dimensions as per ASTM standards for testing shown in Table2

Table 2 Specimen Preparation as per ASTM

Sl. No	ASTM Code	Mechanical Test	Sample Dimensions(mm)
1	ASTM D638 Type III	Tensile Test	236 x 29 x 5mm
2	ASTM E 23	Impact Test	55 x 10 x 10mm
3	_	Rockwell Hardness Test	50 x 50 x 5mm

B. Mechanical Testing of Composite Material

Mechanical properties such as Ultimate tensile strength (UTS), Young's modulus, Flexural strength (FS), Flexural modulus, Inter laminar shear strength (ILSS) of carbon and glass fiber reinforced composites are computed from the test conducted using universal testing machine (UTM) in accordance to ASTM standards for specimen preparation.

Figure 13. UTM Machine

1) Tensile Test Reports of Glass Fiber + Jute Fiber + Screw Pine Fiber

LENDI ENGINEERING COLLAGE

Jonnada Village,Denkada Mandal,Vijayanagaram-535005.

TENSILE TEST REPORT

Machine Model	: **TUE-C-600**	Test File Name	: **42_2018.Utm**
Machine Serial No	: **2015/135**	Date & Time	: **01/03/2018 02:11 PM**
Customer Name	: **Fine Spavy Assco. & Engg. Pvt Ltd**	Customer Address	: **C-45/2, M.I.D.C. Miraj 416410**
Lot No.	:	Test Type	: **Tensile**
Order No.	:	Heat No.	:

Input Data

Specimen Shape	: **Flat**	
SpecimenType	: **glass+jute+screwpine**	
Specimen Description	:	
Specimen Width	: **30**	**mm**
Specimen Thickness	: **5**	**mm**
Initial G.L. For % elong	: **67**	**mm**
Pre Load Value	: **0**	**kN**
Max. Load	: **600**	**kN**
Max. Elongation	: **200**	**mm**
Specimen Cross Section Area	: **150**	**mm2**
Final Specimen Width	: **27**	**mm**
Final Specimen Thickness	: **4**	**mm**
Final Gauge Length	: **77**	**mm**
Final Area	: **108**	**mm2**

Output Data

Load At Yield	: **5.58**	**kN**
Elongation At Yield	: **0.010**	**mm**
Yield Stress	: **37.2**	**N/mm2**
Load at Peak	: **11.850**	**kN**
Elongation at Peak	: **4.590**	**mm**
Tensile Strength	: **79.000**	**N/mm2**
Load At Break	: **4.980**	**kN**
Elongation At Break	: **5.020**	**mm**
Breaking Strength	: **33.200**	**N/mm2**
% Reduction Area	: **28.00**	**%**
% Elongation	: **14.93**	**%**

Stress Vs. Strain

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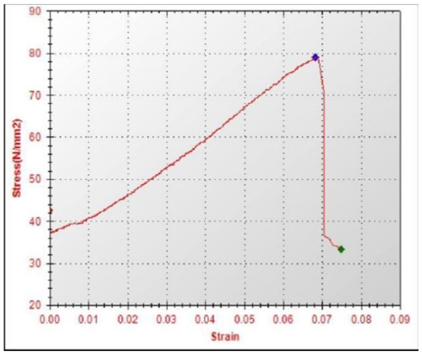
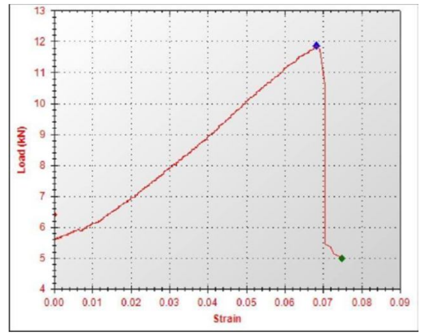
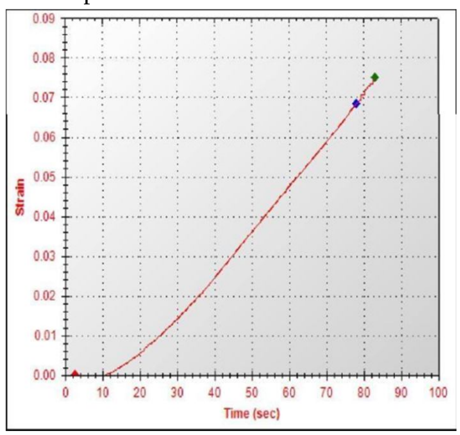
Stress Vs Strain Graph of Glass Fiber + Jute Fiber + Screw Pine Fiber



Load Vs Strain Graph Glass Fiber + Jute Fiber + Screw Pine Fiber

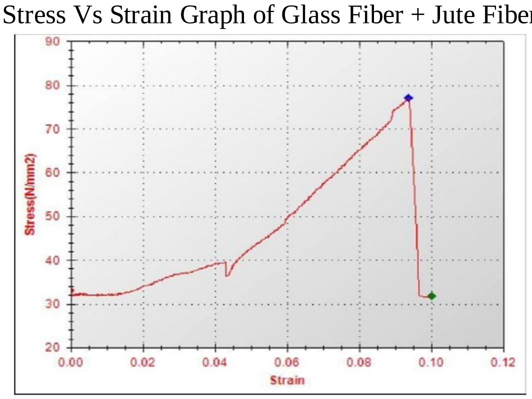


Strain Vs Time Graph Glass Fiber + Jute Fiber + Screw Pine Fiber

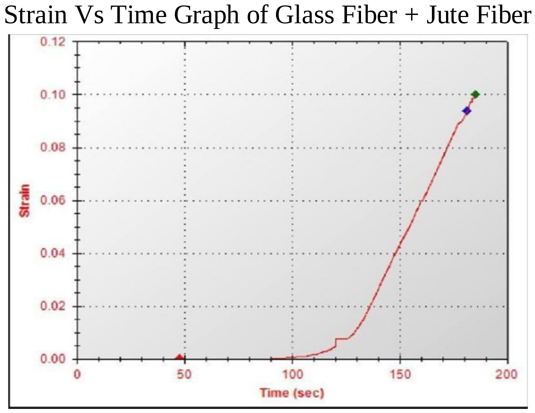


2) *Tensile Test Reports of Glass Fiber + Jute Fiber*

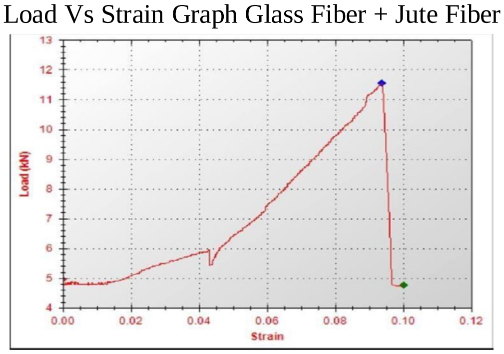
Stress Vs Strain Graph of Glass Fiber + Jute Fiber



Strain Vs Time Graph of Glass Fiber + Jute Fiber



Load Vs Strain Graph Glass Fiber + Jute Fiber



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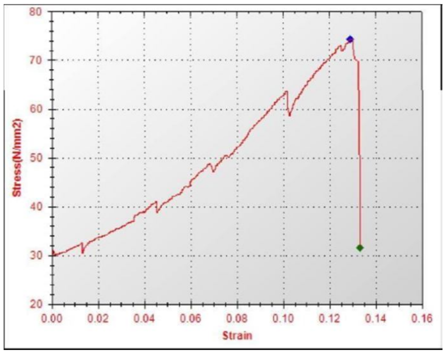
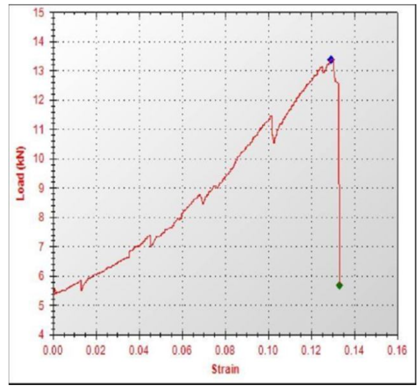
3) Tensile Test Reports of Glass Fiber + Screw Pine Fiber

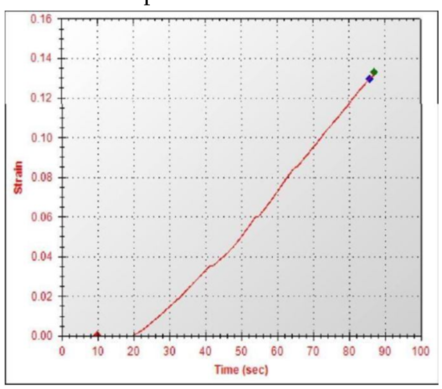
Stress Vs Strain Graph of Glass Fiber + Screw Pine Fiber



Load Vs Strain Graph Glass Fiber + Screw Pine Fiber



Strain Vs Time Graph Glass Fiber + Screw Pine Fiber



C. Impact Strength Testing of Composites

ASTM E 23: Standard test method for impact properties of polymer matrix composites. Charpy impact strength of composite samples is evaluated as per ASTM E 23, using Impact Testing Machine

Figure 14. Impact Test Machine

1) Impact Test Results

The following tables provides the details of the Impact test results obtained for various combinations of Natural fibers reinforced composites

Table 3 Impact Test Result Table

Specimen	Composition	Impact Energy Absorbed (Joules)
Specimen I	Glass Fiber + Screw PineFiber + Jute Fiber	10J
Specimen II	Glass Fiber + Jute Fiber	15J
Specimen III	Glass Fiber + Screw Pine	18J

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D. Rockwell Hardness Testing on Composites

The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload. There are different scales, denoted by a single letter, that use different loads or indenters. This result is a dimensionless number noted as HRA, HRB, HRC, etc. This Important relation permits economically important non-destructive testing of bulk metal deliveries with light weight, even portable equipment, such as hand-held Rockwell hardness.

Figure 15. Rockwell Hardness Testing Machine

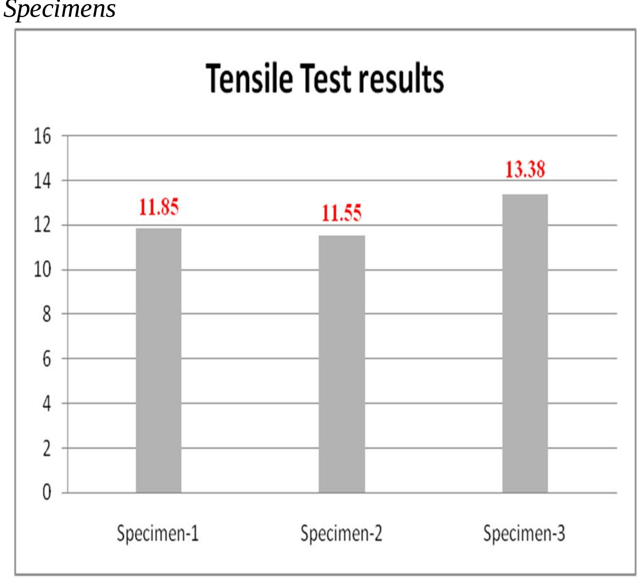
Specimen	Composition	Hardness Number
Specimen I	Glass Fiber + Screw PineFiber + Jute Fiber	46
Specimen II	Glass Fiber + Jute Fiber	54
Specimen III	Glass Fiber + Screw Pine	59

Table 4 Hardness Test Result Table

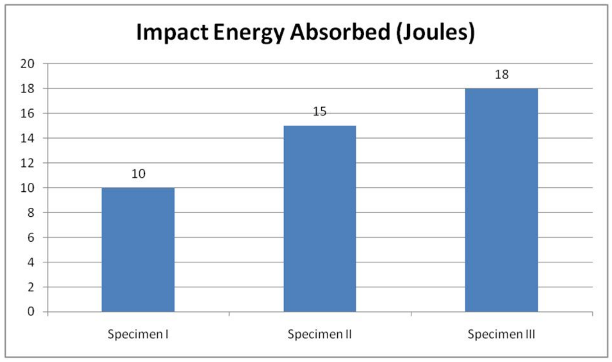
E. Comparative Results

Specimen-1 = Glass Fiber + Jute Fiber + Screw Pine Fiber.
Specimen-2 = Glass Fiber + Jute Fiber.
Specimen-3 = Glass Fiber + Screw Pine Fiber.

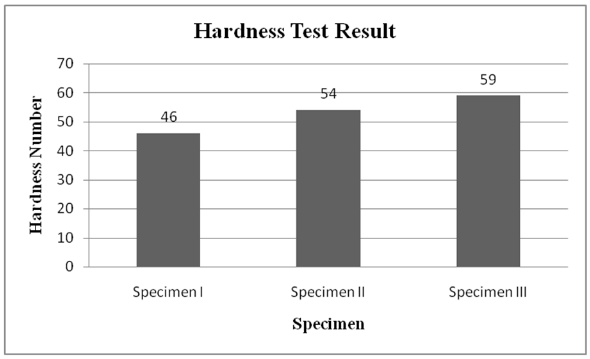
1) Tensile Test Result of all Three Specimens



2) Impact Test Results on all Three Specimens



3) Rockwell Hardness Test for all Three Specimens



V. CONCLUSION

This work shows that successful fabrication of a natural fiber (Screw Pine & Jute) reinforced epoxy composites by simple hand lay-up technique. The hybrid composites glass/screw pine) showed comparatively better performance. Screw pine, jute and glass (hybrid) and jute and glass (hybrid) fiber composites, on loading condition, showed a brittle like failure compared to Screw Pine/Glass. Its not failure but it obtained lesser values compared to another composite materials that prepared by us. Less fiber pull out is observed and this could be reason for the reduction in the strength.

1) The natural fibers have been successfully reinforced with the epoxy resin by simple wet hand lay-up technique. The aim of this project is to find the tensile, Hardness Test, and impact strength of natural fiber reinforced composites.
2) Tensile and impact properties were studied for three different hybrid composites such as Jute/glass, Screw Pine/glass and Screw Pine/Jute/glass.
3) Treatment of Screw Pine and jute with NaoH resulted in increase an adhesive strength and tensile strength.
4) Because naturally glass fiber has good specific strength and high elongation but it cannot recycle throughout.
5) Screw Pine/ Jute hybrid composite can be easily recyclable and biodegradable. So, it can be apply for similar applications.
6) Finally, the best material in this project compared to other two materials is Glass Fiber and Screw Pine Fiber (hybrid) can be used for Automobile and Aerospace applications compared to other materials. The most important thing that researchers have to have in mind is that these step taken now, will help humans to develop and to have a more pleasant life.

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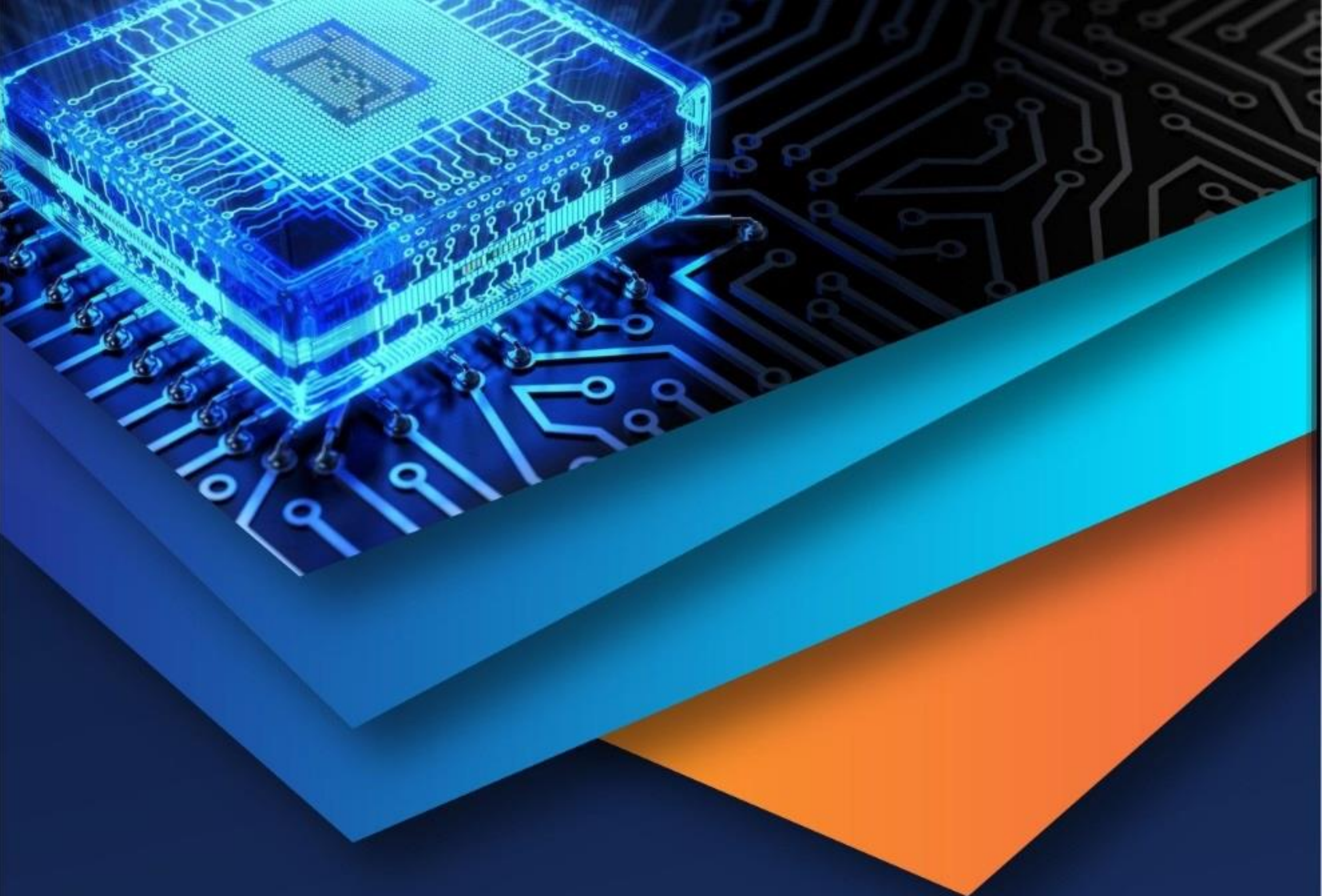

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