iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 6 **Issue:** XII **Month of publication:** December 2018

DOI:

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 6 Issue XII, Dec 2018- Available at www.ijraset.com

Mechanical Characterization and Hybridization of RAMIE and Jute Fiber Reinforced with Epoxy Resin

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***Abstract:** Natural fibers have been used to reinforce materials for over 3000 years.More recently they have been employed in combination with plastics. These fibers are naturally found in nature. Natural fibers have the advantage as they are renewable resources and have a market demand. Natural fibers are increasingly used in automotive and packaging industries as well. Polymer matrix composites are gaining more importance when compared to monolithic materials as they are more reliable and are cheaply available.*

In my project, ramie fiber was chosen as the major reinforcement and jute fiber was considered as the additional fiber. Epoxy was used as the base material and the composite was fabricated using the Hand Layup Process according to ASTM standards. Specimens with different weight fractions of ramie fiber and jute fiber were prepared. Tests were conducted and the change in mechanical properties (tensile strength, flexural strength, impact strength and hardness) of the hybrid composite material was observed.

***Keywords:** Epoxy Resin, Ramie fiber, Jute fiber, Hand Layup Process, Hybrid Polymer Composite.*

I. INTRODUCTION

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and the 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 nice 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 attractive composite components economically 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 one ensures 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.

Hybrid composites are more advanced composites as compared to conventional FRP composites. Hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing and multiple matrix phases. They have better flexibility as compared to other fiber reinforced composites. Normally it contains a high modulus fiber with low modulus fiber. The high-modulus fiber provides the stiffness and load bearing qualities, whereas the low-modulus fiber makes the composite more damage tolerant and keeps the material cost low. The mechanical properties of a hybrid composite can be varied by changing volume ratio.

Ramie is a flowering plant in the nettle family Urticaceae, native to eastern Asia. It is a herbaceous perennial growing to 1.0–2.5 metres tall; the leaves are heart-shaped, 7–15 centimetres long and 6–12 centimetres broad, and white on the underside with dense, small hairs—this gives it a silvery appearance; unlike stinging nettles, the hairs do not sting. The true ramie or China grass is also called Chinese plant or white ramie.

Ramie fibers are used for a wide variety of industrial applications. [7]

1) Industrial Sewing Thread, Packing Materials, Fishing Nets, Hand Kerchiefs, Parachute Fabrics, Owen Fire Hoses, Narrow Weaving Canvas, Filter Cloth etc.
2) Fabrics for household furnishings, Example. Upholstery and Canvas, and Clothing, Frequently in blends with other textile fibers, Curtains, Draperies, Bedspreads, Table Linens, Sheets, Dish Towels.
3) High Quality Papers, Example. Bank Notes and Cigarette papers.
4) Apparel, Example. Dresses, Suits, Skirts, Jackets, Pants, Blouses, etc.

Ramie fiber has comparable specific modulus and strength to traditional synthetic fibers for composite production. There are many advantages of using Ramie fiber; renewable and biodegradability being the significant ones. A technology of separating ramie core and bast has been developed, thus there is a possibility of using the entire Ramie plant or its separated parts in the production of a composite. The advantages of ramie fibers over traditional reinforcing materials such as glass fibers and mica are acceptable specific strength properties, low cost, low density, high toughness, good thermal properties, reduced tool wear, reduced dermal and respiratory irritation, ease of separation, enhanced energy recovery and biodegradability. The ramie fiber is shown in the figure below.

Fig 1: Ramie fiber

Jute is a long, soft, shiny vegetable fiber that can be spun into coarse, strong threads. The fibers are off-white to brown, and 1-4 meters long. Jute is also called Golden Fiber for its color and high cash value. Jute has high specific properties, low density, less abrasive behavior to the processing equipment, good dimensional stability and harmlessness. Jute is renewable, versatile, nonabrasive, porous, hydroscopic, viscoelastic, biodegradable, combustible, and reactive. The fiber has a high aspect ratio, high strength to weight ratio, and has good insulation properties. Jute textile is a low cost eco-friendly product and is abundantly available, easy to transport. Being made of cellulose, on combustion, jute does not generate toxic gases. Some might consider part of these properties as disadvantages, such as biodegradable and combustible, but these features provide a means of predictable and programmable disposal not easily achieved with other resources.

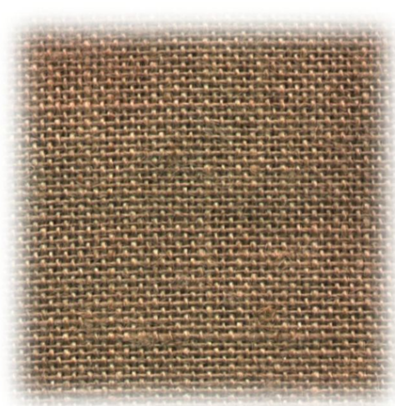

Fig 2:Jutefiber

Fig 3:Resin and hardener

The reinforcement, matrix materialsand processing chemicals used in the present researchare shown in Table I

TABLE I
Specifications of the Materials Used In the Research

Sl.No.	Materials Used	Specifications
01	Epoxy resin (HSC 7600) Hardener (HSC 8210)	Density: 1.1 g/cm^3 UTS: 50MPa
02	Jutefiber	Density: 1.3 g/cm^3
03	Ramie fiber	Density :1.5 g/cm^3

II. METHODOLOGY

The hand lay-up is one of the oldest and most commonly used methods for manufacture of composite parts. Size of the mold hat is used is 300mm × 250mm × 5mm.The working surface was cleaned with thinner to remove dirt and a thin coat of wax is applied on the surface to get smooth finish. Then a thin coat of polyvinyl alcohol (PVA) is applied for easy removal of mold. Ramie and jute fibers are cut to the required dimensions for test specimen pre-impregnated with matrix material and placed one over the other in the mold. Hand layup process was carried out with epoxy as matrix and bidirectional jute fibers. Three laminates were produced with 35%, 40% and 45 % weight percentage of jute and ramie combination (each fiber equally divided). Resins are impregnated by hand into fibers by rollers. Laminates are left to cure under standard atmospheric conditions by loading it externally using about 75 kg weight to allow the effective curing of the resin. All test specimens were molded and prepared according to ASTM-D standard to avoid edge and cutting effect, thereby minimizing stress concentration effect.

Fig 4: Mold used for hand layup

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III. EXPERIMENTATION

A. *Tensile Testing of Composite Specimen*

Ultimate tensile strength, often referred to tensile strength is the maximum stress that a material can withstand while being stretched or pulled before fracture. The tensile test for the specimens was conducted according to ASTM D3039. The specimens of size 250 mm x 25 mmx 4 mm were tested with a cross head speed of 1 mm / min.

Fig 5:Tensile test specimen and experimental setup

B. *3-Point Bending Test of Composite Specimen*

Bending strength also known as the flexural strength is the maximum stress in the material just before it yields during a flexural loading. The flexural test for the specimens was conducted according to ASTM D790. The specimens of size 125 mm x 12.7 mm x 4 mm were tested with a cross head speed of 1 mm / min.

Fig 6:3-point bending test specimen and experimental setup

C. *Impact Test of Composite Specimen*

Impact strength is the capability of the material to withstand a suddenly applied load and is expressed in terms of energy. The specimens of size 55 mm x 10 mm x 4 mm were tested.

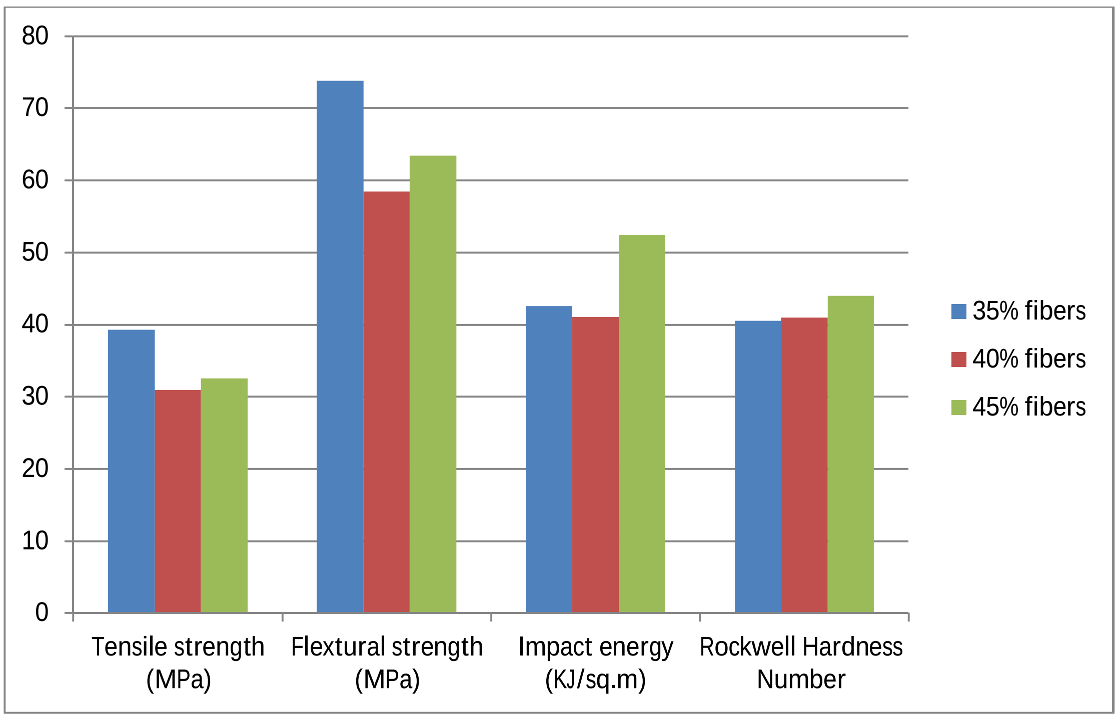
Fig 7:Izod impact test experimental setup

D. Hardness Test of Composite Specimen

Hardness is the capability of the material to resist deformation due to indentation loading. The hardness of the composite is determined by use of a Rockwell hardness tester considering the L scale, with a weight of 60kgf, using 2.5mm ball indenter.

Fig 8: Hardness test specimen

IV. RESULTS



V. CONCLUSION

The experimental investigation on the determination of mass fraction of ramie and jute for optimum mechanical propertiesleads to the following conclusions:

A. From the result obtained, it can be concluded that tensile strength is maximum for the lowest of the mass fractions. This might be because of the usage of excess resin in the lower mass fraction compared to the other two. This improves the bonding between the fillers and the resin.

B. Flexural strength was found to be maximum for the lowest of the mass fractions. This might be attributed to the better bonding of the resin and the fillers.

C. In case of requirements of enhanced strength and performance from the ramie and jute hybrid composite, a phenomenal 100% increase in tensile strength could be achieved by going for lower combinedfibre mass fraction.

D. The Impact and the Hardness results were better for the higher mass fraction. This may be due to the higher mass percentage of the fillers.

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