FABRICATION AND STUDY OF MECHANICAL PROPERTIES OF COMPOSITE NATURAL FIBER

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Abstract : Natural fibers (Sisal, Jute, Banana, Coir) in combination with Epoxy resin has proved to be excellent for making cost effective composite materials. To have the genuine results , the retting process of each fiber has been done by ourselves to obtain the pure form of fibers. Each fiber is sorted to have equal length and assembled properly. They are prepared using pultrusion method. A bunch of fibers are forcibly extruded through the tube and obtained a uniform diameter using pultrusion process. The resin used in the preparation of composites was epoxy in combination with hardener. Fibers were used as reinforcement and epoxy resin is used as matrix in the fabrication process. Fibers and epoxy were hybridized at percentage of 70% and 30%. Samples prepared were tested to evaluate its properties, such as tensile strength, compressive strength, impact strength and hardness. Sisal fiber reinforced epoxy composite exhibited better mechanical properties among the five types of fiber composite specimens.

Key words- Sisal fiber, Banana fiber, Jute fiber, Coir fiber, Mixed fiber, Pultrusion process.

I. INTRODUCTION

A composite is a material made by combining two or more dissimilar materials in such a way that the resultant material is endowed with properties superior to any of its parental ones. Natural fibers have been used to reinforce materials for over last two decades. Fiber-reinforced composites, owing to their superior properties, are usually applied in different fields including door panels, trunk liners, instrument panels, interior roofs, parcel shelves, among other interior components, are already in use in European cars due to the more favorable economic, environmental and social aspects of the vegetable fibers, sports goods, aerospace, engineering applications, defence, house hold appliances, decorative items, safety appliances like industrial helmets, etc,. Recently, they have been involved in combination with different materials. Natural fibers are eco friendly, biodegradable, abundantly available, renewable and cost effective, high strength and have less weight. Natural fibers do not possess any type of health hazard properties and finally, provide a solution to environmental pollution by preparing new composites using natural fibers. Natural fibers have the potential to be used as a replacement for traditional reinforcement materials in composites for applications which requires high strength to weight ratio and further weight reduction. Currently, different types of natural fibers have been investigated for use in plastics including flax, hemp, jute straw, wood, rice husk, wheat, cane (sugar and bamboo), grass, reeds, kenaf, ramie, oil palm empty fruit bunch, sisal, coir, water, hyacinth, pennywort kapok, banana fiber, pineapple leaf fiber. Fibers obtained from the various parts of the plants are known as vegetable fibers. Animals can also provide a source of fibers. A wide variety of properties can be achieved through proper selection of fiber type, fiber orientation and fiber reinforcement form. The mechanical behavior of a natural fiber composite depends on numerous factors. For example, fiber length and quality, matrix, fiber-matrix adhesion bond quality and so forth. A good interface bond is required for effective stress transfer from the matrix to the fiber where by maximum utilization of the fiber strength in the composite is achieved . Modification to the fiber also improves resistance to moisture induced degradation of the interface and the composite properties. Mechanical properties of natural fibers especially flax, hemp, jute, banana and very good. A number of investigations have been conducted on several types of natural fibers such as bamboo, banana and jute to study the effects of these fibers on the mechanical properties of composite materials. Information on the usage of banana fibers in reinforcing polymers is limited in the literature. Development of polymer composites with natural fibers and fillers as a sustainable alternative material for some engineering applications, particularly in aerospace applications and automobile applications are being developed. Natural fibers show superior mechanical properties such as stiffness, flexibility and modulus compared to glass fibers. The main advantages of natural fibers are of low cost, light weight, easy production and friendly to environment. Composite materials are intended to combine desired characteristics of two or more distinct materials. The main benefits of exploitation of natural fibers are: abundance and renewability, low cost, non- abrasiveness, simple process, non-toxicity, high flexibility, acoustic insulation and low density. On the other hand, there are some drawbacks such as their poor mechanical properties and high moisture absorption. The latter is due to their hydrophilic nature that is detrimental to many properties, including dimensional stability. Nevertheless, some composite components (e.g. for the automotive sector), previously manufactured with glass fibers are now produced with natural fibers. It have been observed that the effect of fiber length and weight percentage increases the flexural modulus and impact strength when increase in length of fiber and weight percentage of fiber. The strength of short fiber composites depends on the type of fiber matrix, fiber length, fiber orientation, fiber concentration and the bonding between the fiber and matrix. The results show that the tensile strength, young’s modulus and water absorption of polyester composites increased with the increasing polyester content but elongation at break decreased. Morphology studied indicates that the tendency of filler- matrix interaction improved with the increasing filler in polyester matrix.

II.PREPARATION AND PROPERTY EVALUATION

Sisal fiber, jute fiber, banana fiber, epoxy resin and epoxy hardener were the raw materials used for the preparation of the composites. In this research, plain and equal sized (length) fibers were taken for the manufacturing of specimens of a constant diameter. Fibers were used as reinforcement material and the epoxy resin is used as matrix material for the composite. Epoxy resin and hardener used in this manufacturing process in the ratio of 2: 1. These were mixed for two minutes to obtain a clear mixture. Pultrusion was the process used for manufacturing parts with a constant cross-section. It is different from the extrusion process in the form of the reinforcement and in fact the material is pulled through the die rather than being pushed through like extrusion. The use of the die closely controls the resin: fiber ratio and pultrusion process has the ability to manufacture composite with a high fiber ratio.

Fig 1.1

Fig 1.2

Fibers were drawn from the rear of the die. They were guided into position and passed through epoxy resin and hardener compound bath and then through the circular die. Since thermo-set materials require time for getting hardened, a mold of same cross section is then clamped around the material. When this material has hardened, the clamp opens and more material is pulled through. However, long lengths of fiber composites can be made rapidly. The design of pultrusion machines varies. Two often used types are reciprocating (hand-over-hand) and continuous (cat-track).For the radius pultrusion process the layout of the machines has two moving stages similar to the hand over hand pulling unit, but as the process is intermittent with only one puller and the mould mounted on the stage of other one. Whether the stages are moving linear or circular depends on the type of profiles to be manufactured.

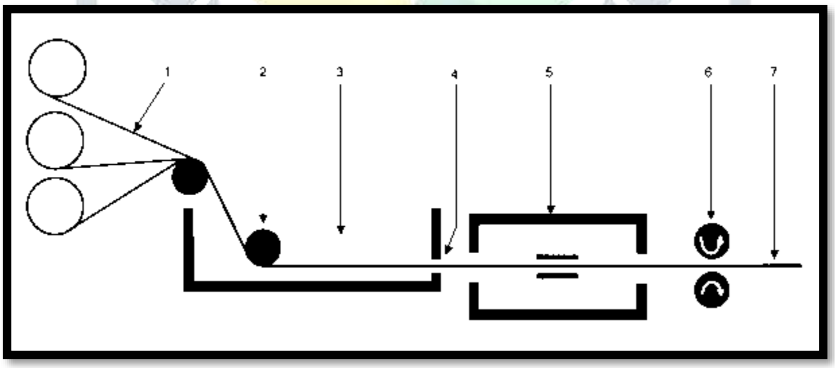

Fig 1.3 Schematic diagram for pultrusion process.

1 - Continuous roll of reinforced fibers/woven fiber mat
2 - Tension roller
3 - Resin Impregnator
4 - Resin soaked fiber
5 - Die and heat source
6 - Pull mechanism
7 - Finished hardened fiber reinforced polymer

Since the fiber composites were made using pultrusion, they has a high proportion of fibers. They has very good mechanical properties in the longitudinal direction when compared to the other directions. Beams and girders are examples of products made using pultrusion. These fiber composites were also made in unidirectional arrangement of fibers.

Table 1

FIBER	PERCENTAGE
SISAL	70%FIBER+30%EPOXY RESIN &HARDENER
JUTE	70%FIBER+30%EPOXY RESIN &HARDENER
BANANA	70%FIBER+30%EPOXY RESIN &HARDENER
COIR	70%FIBER+30%EPOXY RESIN &HARDENER
MIXED	15%SISAL+15%JUTE+15%BANANA+15% COIR+40%EPOXYRESIN &HARDENER

Using this process, the required specimens are made according to the dimensions suitable for the testing machines.

III.TESTING OF COMPONENTS

i. **Tensile test:** Tensile test was carried out using universal testing machine with circular specimens of sisal fiber, jute fiber, banana fiber and coir were made whose length an diameter were 40cm and 1.3cm and a composite specimen of consisting all the four fibers with the same dimension has been made. These five composite specimens were placed in the grips of universal testing machine and pulled till the failure occurred. The displacement was measured using strain gauge.

ii. **Compression test:** Compression test was carried out using universal testing machine with circular specimens of sisal fiber, jute fiber, banana fiber and coir were made, whose dimensions were 2cm*1.2cm (length*diameter) and a composite specimen consisting of all four fibers with the same dimension has been made accordingly. These specimens were placed between the compression beds and compressed until their failure.

iii. **Impact test:** Impact test was carried out on Izod impact testing machine. Composite specimens of sisal fiber, jute fiber, banana fiber and coir were made with the dimensions of 10mm*10mm*75mm (length*breadth*height) and a composite specimen consisting of all four fibers with the same dimension has been made and placed in vertical position and a hammer was released to make impact with the specimen and CRT reader gives the reading of impact strength.

iv. **Hardness test:** Hardness test was carried out on brinnel hardness testing machine. Composite specimens of sial fiber specimens of sisal fiber, jute fiber, banana fiber and coir were made with the dimensions of 3cm*1.2cm (length*diameter) and a composite specimen consisting of all four fibers with the same dimension has been made accordingly. These specimens were placed on the equipment and a 1/8" ball indenter is used for performing hardness test on the specimens.

RESULTS AND DISCUSSIONS

The results various tests on natural fiber composites are reported here which includes evaluation tensile strength, compression strength, impact strength and hardness test.

i. **Tensile Test Result:** Experimental results of tensile testing of natural fiber composites of different natural fibers. The influence of fiber length as well as the efficiency of bonding between the fiber and the matrix is important to ensure high strength and stiffness to the natural fiber composite. Sisal fiber reinforced epoxy composite have higher tensile strength than banana fiber, jute fiber and coir composites.

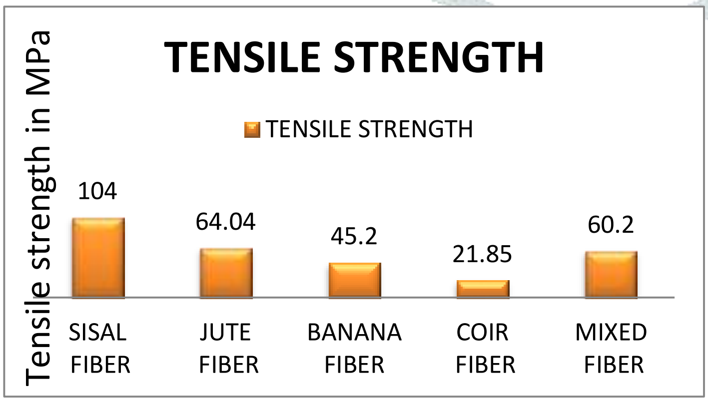

Fig 1.4 Fig 1.5

ii. **Compression Test Result:** The compression strength values from the experimental results of natural fiber composites are potted in the graph. It shows the comparison of compression strength of sisal fibber, jute fiber, banana fiber and coir. Experimental results reveal that sisal fiber has the highest compression strength than jute fiber, banana fiber and coir composites.

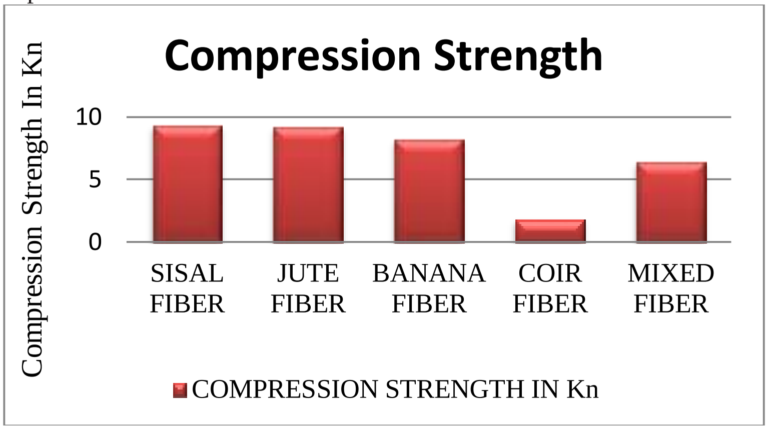

Fig 1.6

Fig 1.7

iii. **Impact Test Result:** The experimental results of impact test of natural fiber composite are plotted in the graph. It shows the comparison of the impact strength of sisal fiber, jute fiber, banana fiber and coir. Experimental results showed that coir has the high impact strength tan the sisal fiber, jute fiber and banana fiber composites.

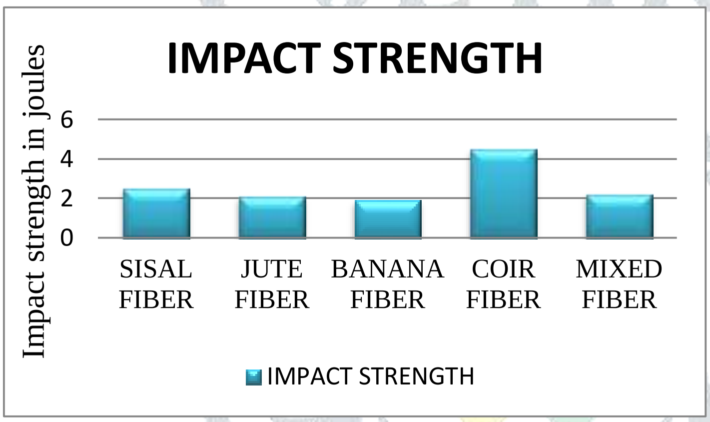

Fig 1.8

Fig 1.9

iv. **Hardness Test:** Hardness values of each natural fiber reinforced composite varies for every fiber. The experimental results of hardness test of natural fiber reinforced composite are plotted in the graph. It shows the comparison of hardness of each natural fiber composite. Experimental results showed that jute natural fiber composite has the highest hardness than the sisal fiber, jute fiber, coir composites.

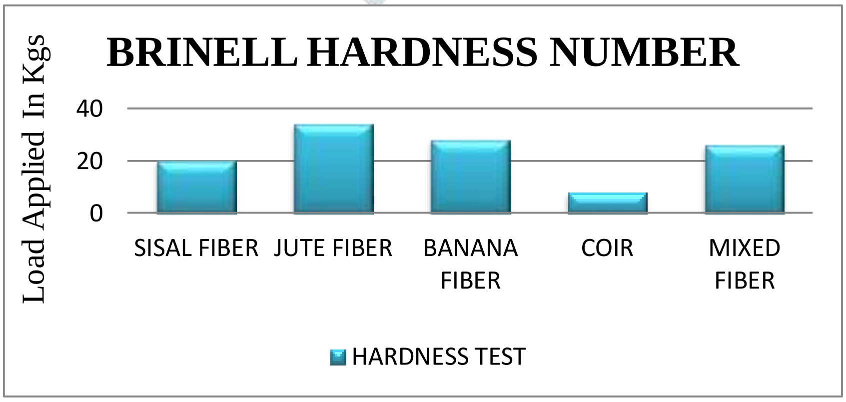

Fig 1.10

CONCLUSION

From the experimental results we found out the mechanical properties like tensile strength, compression strength, impact strength and hardness test of natural fiber reinforced composites at room temperature.

FUTURE SCOPE

1. Mechanical properties can be find by varying the epoxy resin with hardener and fiber ratio in the composite.
2. More number of fibers can be reinforced in one single specimen and testing for various properties.
3. By varying volume fraction of fibers and epoxy resin can enhance the mechanical properties of the specimen.

REFERENCES

[1] Shah, et al., (1981) analyzed the mechanical properties of jute reinforces and glass reinforces. The results showed that the jute fibers, when introduced into the resin matrix as reinforcement, considerably improve the mechanical properties, but the improvement is much lower than that obtained by introduction of glass and other high performance fibers.

[2] Rana, et al., (1988) in their work showed that the use of compatibilizer in jute fibers increases its mechanical properties. At 60% by weight of fiber loading, the use of the compatibilizer improved the flexural strength as high as 100%, tensile strength to 120%, and impact strength by 175%. There was a sharp increase in mechanical properties and decrease in water absorption values after addition of the compatibilizer.

[3] Monteiro SN. Rodriquez et al., (1998) utilized the sugar cane bagasse waste as reinforcement to polymeric resins for fabrication of low cost composites. They reported that composites with homogeneous microstructures could be fabricated and mechanical properties similar to wooden agglomerates can be achieved.

[4] Gassan, et al., (1999) used the coupling methods to improve the properties of composites.

[5] Hassan et al., (2000) converted the bagasse into a thermo formable material through esterification of the fiber matrix. The dimensional stability and mechanical properties of the composites prepared from the esterified fibers were reported in this work.

[6] Joshi, et al., (2001) compared life cycle environmental performance of natural fiber composites with glass fiber reinforced composites and found that natural fiber composites are environmentally superior in the specific applications studied.

[7] Ray, et al., (2001) in their work subjected the jute fibers to alkali treatment with 5% NaOH solution for 0, 2, 4, 6 and 8h at 300^0C. It was found that improvement in properties both for fibers and reinforced composites.

[8] BC Ray (2006) used 3-point flexural test to qualitatively assess such effects for 55, 60 and 65 weight percentages of E-glass fibers reinforced epoxy composites during cryogenic and after thawing conditions. The specimens were tested at a range of 0.5 mm/min to 500 mm/min crosshead speed to evaluate the sensitivity of mechanical response during loading at ambient and sub-ambient (- 80°C temperature). These shear strength values are compared with the testing data of acquired samples.

[9] C Alves et al., (2006) carried out a research study to assess the environmental impact of using jute fiber composites and their necessary technical treatments for automotive design applications to manufacture the enclosures of a buggy vehicle. They thus, compare them with the impacts raised by current enclosures made of glass fiber reinforced plastic (GFRP) composites over the entire life cycle of the buggy. The present paper concerns with the use of MAH-PP copolymers as coupling agents in jute propylene composites. It is found that the flexural strength was increased by 40% and flexural modulus by 90%. SEM investigation showed the improved fiber matrix adhesion which was due to the chemical bonds between fiber and matrix provided by the coupling agent.

[10] El-Tayeb et al., (2006) studied wear and friction features of glass fiber/polyester (GRP) and sugarcane fiber/polyester (SCRP) with different parameters including speed, the time taken for test, and load. The research results concluded SCRP as a competitor of GRP composite.

[11] Li et al., (2008) conducted a research to study the mechanical properties, especially interfacial performances of the composites based on natural fibers due to the poor interfacial bonding between the hydrophilic natural fibers and the hydrophobic polymer matrices. Two types of fiber surface treatment methods, namely chemical bonding and oxidization were used to improve the interfacial bonding properties of natural fiber reinforced polymeric composites.

[12] Chin et al., (2009) used fibers reinforced with epoxy composite for a kind of bearing application, in which they showed an 85% enhancement of wear performance and normal orientation in composites.

[13] Saha, et al. (2010) treated the jute fibers with alkali (NaOH) solution and physic-chemical properties of jute fibers were investigated. The treatments were applied under ambient and elevated temperatures and high pressure steaming conditions.

[14] Van de Weyenberg et al., (2010) have shown that good properties of thin walled elements such as high strength in tension and compression, made of sisal fiber reinforced composite, give it a wide area of application, for instance, structural building members, permanent formwork, tanks, facades, long span roofing elements, and pipes strengthening of existing structures