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Fabrication and Testing of Fiber Reinforced Composite Material

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ABSTRACT: Nowadays material technologies are playing major role for the development of products in various fields. Many researchers are searching for structural materials of high strength, less weight and low cost. In generally strong materials are relatively dense and light materials have less strength. In order to achieve high strength and less weight, we go for composite materials. In composite material we used glass fiber as a base material. In addition to that we used natural fiber and micro powder for improving the mechanical properties. For determining the effect of additives in composite we go for preparing four different specimens with coconut fiber, banana fiber, sisal fiber and titanium oxide powder respectively. Polyester resin is used as bonding material. Then the tensile strength and impact strength of specimens is determined using ultimate testing machine and impact testing machine. The ^{fin2al} result of the various composite specimens is then compared and optimized.

KEYWORDS: impact testing machine, composite specimens and composite materials.

I. INTRODUCTION

A composite material is formed by combining two or more materials to give a unique combination of properties. Many researchers are searching for structural materials of high strength, less weight and low cost, in general strong materials are relatively dense and light materials have less strength. In order to achieve high strength and less weight, it requires combining two or more distinct materials to get composite materials. The combination results in superior properties not exhibited by the individual materials. Many composite materials are composed of just two phases one is termed as matrix phase, which is continuous and surrounds the other phase often called the dispersed phase or reinforcement phase. The reinforcement is usually much stronger and stiffer than the matrix, and gives the composite good properties.

The interest and development of composites making use of natural fibers, aimed for structural applications, is growing from a long-term sustainable perspective. A prime reason for selecting natural fibers for new products is that the net contribution to the greenhouse effect is minimal. Equally important is their low weight compared to glass fibers. Based on an advantageous cost/performance ratio, natural fiber based composites have been in use for quite a few years in structural and automotive industry applications. Well known examples are panels based on flax/sisal and polymeric binders, thermoplastic or thermo set ones. A problem is that the polymeric binder is based on a non-renewable resource, namely crude oil, and that material recycling is difficult and costly and that energy recovery is not accepted as recycling at the time being.

Natural fiber composites include coir, jute, baggase, cotton, bamboo, hemp. Natural fibers come from plants. These fibers contain lingo cellulose in nature. Natural fibers are eco-friendly; lightweight, strong, renewable, cheap and biodegradable. The natural fibers can be used to reinforce both thermosetting and thermoplastic matrices. Thermosetting resins such as epoxy, polyester, polyurethane, phenolic are commonly used composites requiring higher performance applications. They provide sufficient mechanical properties in particular stiffness and strength at acceptably low price levels. Recent advances in natural fiber development are genetic engineering. The composites science offer significant opportunities for improved materials from renewable resources with enhanced support for global sustainability. Natural fiber composites are attractive to industry because of their low density and ecological



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advantages over conventional composites. These composites are gaining importance due to their non-carcinogenic and bio-degradable nature. Natural fiber composites are very cost effective material especially in building and construction, packaging, automobile and railway coach interiors and storage devices. These composites are potential candidates for replacement of high cost glass fiber for low load bearing applications. Natural fibers have the advantages of low density, low cost and biodegradability. However, the main disadvantages of natural fiber composite are the relative high moisture absorption. Therefore, chemical treatments are done so as to modify the fiber surface properties.

The natural fiber composites can be very cost effective material for following applications: Building and construction industry: panels for partition and false ceiling, partition boards, wall, floor, window and door frames, roof tiles, mobile or pre-fabricated buildings which can be used in times of natural calamities such as floods, cyclones, earthquakes, etc.Storage devices: post-boxes, grain storage silos, bio-gas containers, etc. Furniture: chair, table, shower, bath units, etc. Electric devices: electrical appliances, pipes, etc. Everyday applications: lampshades, suitcases, helmets, etc. Transportation: automobile and railway coach interior, boat, etc. The reasons for the application of natural fibers in the automotive industry include: Low density: which may lead to a weight reduction of 10 to 30% Acceptable mechanical properties, good acoustic properties. Favorable processing properties, for instance low wear on tools, etc. Options for new production technologies and materials. Favorable accident performance, high stability, less splintering. Favorable eco balance for part production. Favorable eco balance during vehicle operation due to weight savings. Occupational health benefits compared to glass fibers during production. No off-gassing of toxic compounds (in contrast to phenol resin bonded wood and recycled Cotton fiber parts). Reduced fogging behavior.Price advantages both for the fibers and the applied technologies.

U.S.Bongarde, V.D.Shinde [1], has been studied the natural fiber-reinforced polymer composite is rapidly growing both in terms of their industrial applications and fundamental research. These composites are having low density and cost as well as satisfactory mechanical properties make them an attractive due to easy availability and renewability of raw materials. Natural fibers have been proven alternative to synthetic fiber in transportation such as automobiles, railway coaches and aerospace. Other applications include military, building, packaging, consumer products and construction industries for ceiling paneling, partition boards. This paper deals with review of different natural fibers reinforced polymer composite with its manufacturing processes and characterization especially coir and jute fiber. Dieter H. Mueller [2] has been carried out the composite materials and layered structures based on natural plant fibers are increasingly regarded as an alternative to glass fiber reinforced parts. One of their major fields of application can be found in structural components for the automotive industry. Product examples are door trim panels or instrument panels. For such applications utmost impact strength is required in order to implement a maximum of passenger safety by a good crash behavior. The paper describes the effects of several material parameters such as fiber fineness or fleece composition as well as the impact of the process conditions on this important composite characteristic. Dr. Donald F. Adams [3] discusses the impact response of composite materials was of only minor interest prior to the introduction of carbon fiber in the mid-1960s. Before that time, the composites in use were primarily reinforced with glass fibers, which performed well under impact loads. This soon proved not to be true for carbon fibers, which are relatively brittle. But since their static strength and stiffness properties were very attractive, development of carbon fiber reinforcements for structural applications continued. However, by the early 1970s the need to characterize the impact response of carbon fiber composites was evident. Girisha.C, Sanjeevamurthy, Gunti Ranga Srinivas [4] has carried out the project on natural fibers (Sisal and Coconut coir) reinforced Epoxy composites were subjected to water immersion tests in order to study the effects of water absorption on the mechanical properties. Natural fibers like coconut coir (short fibers) and sisal fibers (long fibers) were used in hybrid combination and the fiber weight fraction of 20%, 30% and 40% were used for the fabrication of the composite. Water absorption tests were conducted by immersing specimens in a water bath at 250 C and 1000 C for different time durations. The tensile and flexural properties of water immersed specimens subjected to both aging conditions were evaluated and compared with dry composite specimens. The percentage of moisture uptake increased as the fiber volume fraction increased because of the high cellulose content of the fiber. The tensile and flexural properties of Natural fiber reinforced Epoxy composite specimens were found to decrease with increase in percentage moisture uptake. Moisture induced degradation of composite samples was observed at elevated temperature. The water absorption pattern of these composites at room temperature was found to follow Fickian behavior, whereas the water absorption properties at higher temperature did not follow Fick's law. Ioannis G. Raftoyiannis [5] has been carried out at the National Technical



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University of Athens, Greece, to develop composite panels reinforced with cotton fibers. The primary aim of the project is to examine the mechanical properties of such panels for use in secondary structural members such as wall or door systems. The use of natural fibers such as cotton, flax or sisal fibers has the primary advantage of being ecofriendly, low cost and low weight compared to glass fibers on the expense of lower structural properties. This paper presents results from experimental work on composite plates made from polyester resin reinforced with cotton fibers, with special attention given to the effect of the fiber type on the structural properties of the plates. The results from this study showed that the structural performance of cotton fiber composites is satisfactory for structural parts with low requirements, such as wall panels or doors. The present results for cotton fiber composites are also compared to testing results from previous studies on composites with flax/sisal fibers. Madhukiran.J, Dr. S. Srinivasa Rao, Madhusudan.S [6] work has been carried out to investigate the flexural properties of composites made by reinforcing banana and pineapple as the new natural fibers into epoxy resin matrix. The natural fibers were extracted by retting and manual process. The composites are fabricated using banana and pineapple fiber reinforcements. Hybrid composites were prepared using banana/pineapple fibers of 0/40, 15/25, 20/20, 25/15, and 40/0 Weight fraction ratios, while overall fiber weight fraction was fixed as 0.4Wf. It has been observed that the flexural properties increase with the increase in the weight fraction of fibers to certain extent. The hybridization of the reinforcement in the composite shows greater flexural strength when compared to individual type of natural fibers reinforced composites. All the composites shows increase in flexural strength in longitudinal direction. Similar trends have been observed for flexural modulus, inter laminar shear strength and break load values. Onuegbu T. U., Umoh E.T. & Okoroh N. C. [7] investigating the effect of alkali treatment and fibre load on the tensile properties and hardness of coconut fibre ortho unsaturated polyester composites. The short length fibers were incorporated into ortho unsaturated polyester resin. The treated and untreated fibre composite samples were subjected to tensile tests according to ASTM D638 using Instron model 3369. The tensile tests include tensile strength, modulus, and load at break, tensile strain at break and extension at break. The Microhardness test was carried out by forcing a diamond cone indenter into the surface of the hardness specimen to create an indentation. The significant findings of the research showed that alkali treatment improved the tensile properties and hardness of the composite. The tensile properties at 10% fibre load where greatly enhanced while 15% fibre load is best for micro hardness. Vasanta V Cholachagudda, Udayakumar P A, Ramalingaiah [8] investigating the polymer matrix composites is gaining more importance compare to monolithically materials as being more reliable and cheaply available. Polymer matrix composites finding application from household to engineering approach. With the advancement of PMC"s their properties have been increased by one the addition of one more fiber made as hybrid composite which boost the property of PMC where a single fiber composite lags. In our project we have chosen coir fiber as the major reinforcement and rice husk as an additional fiber to improve the mechanical property of polymer composite with vinyl ester as the base material prepared by hand layup process according to ASTM standards. Test specimens are prepared with different weight fractions of coir fiber at the optimization point of tensile test a small percentage of rice husks are added and tests were conducted and the improvement in mechanical properties (tensile strength and flexural strength) of the hybrid composite material is observed. With the SEM analysis the conclusion of the project is made for compatibility of coir and rice husk with Vinyl ester and the interfacial bonding between matrix and reinforcement is observed.

II. FABRICATION PROCEDURE

Select the suitable work table, which should be smooth and clean. The required amount fiber mat was taken. Then the fiber mat was cut according to the required size. The required amount of the polyester resin was taken. Then the cobalt was mixed in the proportion of 20 to30 ml per kg of polyester resin. The catalyst was used for the quick drying of the mixture. Then the resin was applied on the surface of the table by using a brush. Then the glass fiber mat was placed on the resin. Again the resin was applied on the surface of the glass fiber mat. Then the sisal fiber was placed on the resin. Again the glass fiber mat was placed on the table. Finally the resin was applied on the surface of the glass fiber mat. Then the fabricated material was dried in the presence of sun light and atmosphere.

Similarly, the same working procedure was repeated for the other specimen composition. Banana fiber, coconut fiber and titanium powder were placed between the glass fiber mats instead of a sisal fiber. The fabricated specimens were dried in the presence of sun light and the atmosphere up to 24 hours.



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SPECIMEN COMPOSITION

- A. Glass fiber + resin
- B. Glass fiber + sisal fiber + resin
- C. Glass fiber + banana fiber + resin
- $D. \quad Glass \ fiber + coconut \ fiber + resin$
- E. Glass fiber + tungsten fiber + resin

RESIN ACCELERA	: TER :	Polyester Cobalt	
MATERIAL	RESIN	GLASS FIBER	ADDITIVE MATERIAL
А	70%	30%	-
В	70%	20%	10%
С	70%	20%	10%
D	70%	20%	10%
E	70%	20%	10%

Table 1 variation of material in different combinations of resin and glass fiber and additive material



All dimensions are in mm.

Tab length:56 mm,

- Gauge length : 138 mm
- ➢ Total length : 250mm
- ➤ Tab thickness : 1.5 to 4mm
- ➢ Gauge thickness : 1.5 to 4mm
- Width : 15mm.



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IMPACT TEST WORK PIECE DIMENSIONS



All dimensions are in mm

- Length : 120 mm
- > Thickness : 7 to 10 mm
- ➢ Width : 7 to 10 mm

III. ANALYSIS OF SPECIMEN PROPERTIES

To analyze the mechanical properties we have conducted three tests for our specimens.

- 1. Tensile test
- 2. Impact test

TENSILE TEST

- 1) It is one of the most widely used mechanical tests.
- 2) A tensile test helps determining tensile properties such as tensile strength, yield point or yield strength, % elongation, % reduction in area and modulus of elasticity.
- 3) Fig shows a specimen for tensile test. Since mechanical properties to some extent are influenced by the size and the shape of the test specimen, it is customary to use standardized specimen.
- 4) Tensile test is carried out by gripping the ends E, E of the specimen in a tensile testing machine, fig a, and applying and increasing pull [fig b] on the specimen till it fractures.
- 5) During the test, the tensile load as well as the elongation of a previously marked gauge length in the specimen is measured with the help of load dial of the machine and extensometer respectively. These readings help plotting stress strain curve.
- 6) After fracture, the two pieces of the broken specimen are placed as fixed together and the distance L_f between two gauge marks and the diameter D_f at the place of fracture are measured.

IMPACT TEST

- 1) Impact testing becomes essential in order to study the behavior of materials under dynamic loading.
- 2) An impact test determines the behavior of materials when subjected to high rates of loading ,usually in bending, tension or torsion



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- 3) In impact test, a specimen, machined or surface ground and usually notched, is struck and broken by a single blow in a specially designed testing machine. The quantity measured is the energy absorbed in breaking the specimen by a single blow.
- 4) The ideal impact test would be one in which all energy of a blow is transmitted to the test specimen.
- 5) An impact test gives an indication of the relative toughness of the material.
- 6) Two types of specimen are used on an impact testing machine, namely CHARPY and IZOD.

The charpy specimen is placed in the vice so that it is just a simple beam supported at the ends whereas Izod specimen is placed in the vice such that it is a cantilever. Here we have fabricated two testing specimen with different composition as mentioned in table no 1.

TENSILE STRENGTH COMPARISON GRAPH

Extension vs. load graph:

For specimen A:



For specimen B:



For specimen C:



For specimen D:





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For specimen E



Comparison chart of load Vs extension



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IV. IMPACT STRENGTH COMPARISON TABLE

Specimen A:

Table: Results for tensile specimen A

INITIAL READING	FINAL READING	IMPACT STRENGTH
IN JOULES	IN JOULES	IN JOULES
5.6	15.1	9.5
5.6	14.8	9.2
5.6	15.3	9.7

Specimen B:

Table: Results for tensile specimen B

INITIAL READING	FINAL READING	IMPACT STRENGTH
IN JOULES	IN JOULES	IN JOULES
5.6	16.6	11
5.6	16.8	11.2
5.6	16.2	10.6

Specimen C:

Table: Results for tensile specimen C

INITIAL READING	FINAL READING	IMPACT STRENGTH
IN JOULES	IN JOULES	IN JOULES
5.6	17.1	11.5
5.6	18.3	12.2
5.6	17.6	12.0



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Specimen D:

Table: Results for tensile specimen D

INITIAL READING	FINAL READING	IMPACT STRENGTH
IN JOULES	IN JOULES	IN JOULES
5.6	18.1	12.5
5.6	17.3	11.7
5.6	17.9	12.3

Specimen E:

Table: Results for tensile specimen E

INITIAL READING	FINAL READING	IMPACT STRENGTH
IN JOULES	IN JOULES	IN JOULES
5.6	15.6	10.0
5.6	15.8	10.2
5.6	16.2	10.6

COMPARISON OF IMACT STRENGTH





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V. CONCLUSION

The fiber reinforced composite material was fabricated and then its mechanical properties like tensile and impact strength was determined. The result thus obtained was compared with standard specimen (A) that not having any additives. It was proved that the added additives of natural fibers like sisal fiber, banana fiber, coconut fiber in a composite material gives poor tensile strength when compared to the standard specimen (A). But the titanium dioxide as additives in composite material gives high tensile strength. Through this type of works we are optimizing and suggesting that the titanium dioxide used as additives gives excellent mechanical tensile strength. But this is not in the case of impact strength. Impact strength of all the specimens has almost same values and also equivalent values to the standard specimen (A). In addition to that these materials have advantage like less weight, high strength, very cheaper, very easy to fabricate and eco friendly. Therefore titanium dioxide mixed composite materials is used in the area where high strength is needed. In future we will deeply analysis the other mechanical properties of fiber reinforced composite material.

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