Analysis of Mechanical Properties on the Coir Fiber Composite Material

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Abstract— Natural fibres have used to reinforce material for over 3000 years. More currently they have been employed in combination with plastics. Many types of natural fibres have been investigated for use in plastics including flax, jute, coir, seeds, leaf and banana. The agricultural wastes can be used to prepare fibre reinforced polymer composite for commercial use. Application of composite materials to structure has presented the need for the engineering analysis the present work focuses on the fabrication of polymer matrix composite by using the natural fibre like coir. The present study has been undertaken to investigate the effect of reinforcement structure and its surface treatment on the mechanical behaviour of coir fibre reinforced polyester composites. Woven and non-woven coir fibre composites Ire fabricated by compression moulding technique. Treated composites Ire prepared by subjecting the fibres to chemical treatment prior to the moulding process. The study shows that treated woven coir polyester composites exhibit superior mechanical properties compared to the former. Natural fibre composites are emerging as realistic alternatives to glass reinforced composites and metals in various engineering applications).

Key words: Natural fibre; fibre; reinforcement; composite

I. INTRODUCTION

In recent years, there has been growing environmental consciousness and understanding of the need for sustainable development, which has raised interest in using natural fibres as reinforcements in polymer composites to replace synthetic fibres such as glass. The advantages of natural fibres include low price, low density, unlimited, sustainable availability, and low abrasive wear of processing machinery. Further, natural fibres are recyclable, biodegradable and carbon dioxide neutral and their energy can be recovered in an environmentally acceptable way. A number of investigations have been carried out to assess the potential of natural fibres as reinforcement in polymers .The relatively low aggregated value can utilize only small quantity of coir fibres; there are many researches and developing efforts to find new uses with high aggregated value such as a composite reinforcement. However investigations carried out so far have shown that coir fibre is not an effective reinforcement for polymer matrix composites. The water absorbed into the lignocelluloses surface of the hydrophilic coir fibre apparently prevents an efficient adhesion to the hydrophobic polymer matrix, which also happens in other natural fibre composites. In principle, there are ways to reverse this decreasing mechanical properties condition. A strong alkali treatment of coir fibre improves the adhesion to the polyester matrix and thus increases the composites strength by approximately 50 % for a volume fraction of 30 % of coir fibre. Another possibility of effective reinforcement to a polymer matrix could be obtained through the selection of thinner coir fibre.

II. OVERVIEW OF COMPOSITES

A. *Fibre*

The advantage of composite materials over conventional materials stem largely from their higher specific strength, stiffness and fatigue characteristics, which enables structural design to be more versatile. By definition, composite materials consist of two or more constituents with physically separable phases. However, only when the composite phase materials have notably different physical properties it is recognized as being a composite material. Composites are materials that comprise strong load carrying material (known as reinforcement) imbedded in weaker material (known as matrix)

Annual production of natural fibre and sources are tabulated in table.1

FIBRE SOURCE	WORLD PRODUCTION 10^3 TON	ORIGIN
Bamboo	10,000	Stem
Banana	200	Stem
Coir	100	Fruit
Sisal	380	Stem
Flax	810	Stem
Hemp	215	Stem
Jute	2,500	Stem
Ramine	100	Stem
Plam rap	Abundant	Stem
Wood	1,750,000	Stem

Table 1: Annual Production of Natural Fibre and Sources

B. *Classifications of Fibers*

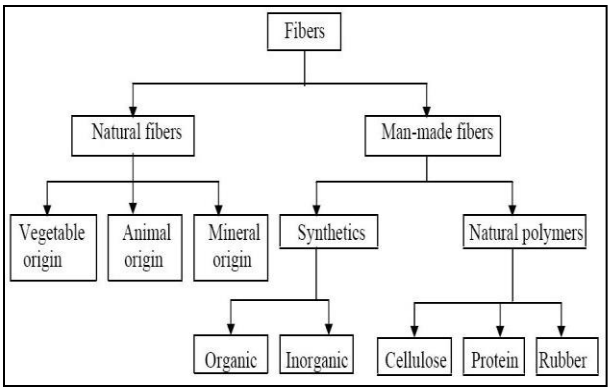

Fig. 1: Classification of Fiber

C. *Natural Fiber*

Natural fibres in the strict meaning of the word are produced through agriculture. Natural fibres are a composite material designed by nature. The fibres are basically a rigid, crystalline cellulose micro fibril-reinforced amorphous lignin and hemicelluloses matrix. Most plant fibres, except for cotton, are composed of cellulose, hemicelluloses, lignin, waxes and some water-soluble compounds, where cellulose, Structural point of view, natural fibres are multicellular in nature, consisting of a number of continuous, mostly cylindrical honeycomb cells which have different sizes, shapes and arrangements for different types of fibres. These cells are cemented together by an intercellular substance which is isotropic, non-cellulosic and ligneous in nature, with a cavity termed the lacuna, whose position and dimensions differ in composition and orientation of cellulosic micro fibrils. There is a central cavity in each cell called the lumen. The micro fibrils in the central walls form a constant angle (microfibrillar or helical angle) for each type of fibre with the fibre axis, so that the crystallites are arranged in a spiral form, the pitch of which varies from one fibre to another

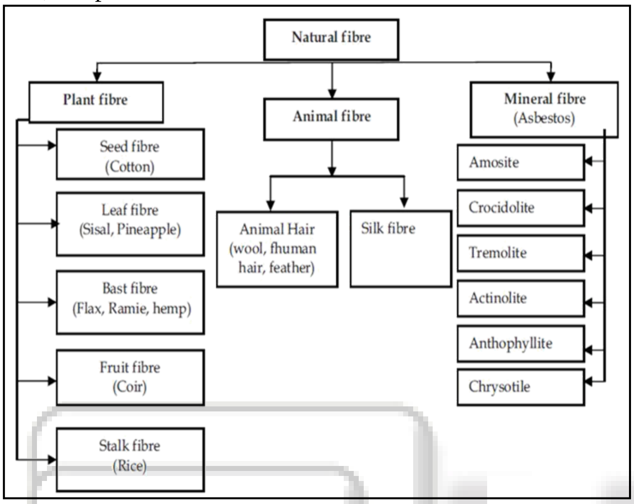

Fig. 2:

Fibre	Density (g/cm^2)	Elaongation (%)	Tensile strength (Mpa)	Young's moduls (Gpa)
Cotton	1.5-1.8	7.0-8.0	287-597	5.5-12.6
Jute	1.3	1.5-1.8	393-773	26.5
Flax	1.5	2.7-3.2	345-1035	27.6
Sisal	1.5	2.0-2.5	511-635	9.4-22.0
Coir	1.2	30.0	175	4.0-6.0
Ramic	…….	11.4	593	1.0
Hemp	……..	1.6	690	………..

Table 2: Mechanical Properties of Natural Fibres to Conventional Reinforcing Fibres

D. Coconut Fibre

Fig. 2: coir fibre

Fibres are collected from the fruit of the plant, e.g. coconut (coir) fibre. The present work includes the processing, characterization of coconut fibre reinforced polyster composites. Samples were subjected to standardized tests such as ash and carbon content, water absorption, moisture content, tensile strength, elemental analysis and chemical analysis.

Coconut fibres are commercial available in three forms, namely bristle (long fibres), mattress (relatively short) and decorticated (mixed fibres). These different types of fibres have different uses depending upon the requirement. In engineering, brown fibres are mostly used. A lot of research has been done on natural fibre reinforced polymer composites but research on coconut based polymer composites is very rare. Against this background, the present research work has been undertaken, with an objective to explore the potential of coconut fibre polymer composites and to study the mechanical and wear characterization of different composites. Fabrication of coconut fibre reinforced polyster based composite. Evaluation of mechanical properties (tensile strength, flexural, hardness, impact strength etc.)

III. LITERATURE SURVEY

A good Interfacial bond is required for effective stress transfer from the matrix to the fibre whereby maximum utilization of the fibre strength in the composite is Achieved Arbelaiz, A. (2005). The Modification to the fibre also improves resistance to moisture induced degradation of the interface and the composite properties Arifuzzaman Khan, G.M. (2009). In addition, factors like processing conditions/techniques have significant influence on the mechanical properties of fibre reinforced composites Alvarez, V.(2006). Mechanical properties of natural fibres, especially flax, hemp, jute and sisal, are very good and may compete with glass fibre in specific strength and modulus Ashori, A.,(2008),Arup Choudary(2007).

IV. METHODOLOGY

There are several methods for making of natural fibre composites. Most of the techniques commonly used for making glass fibre composites are applicable for making natural fibre composites. However, the well-known method for composites making are as followings: Hand Lay-up/Spray up is one of the cheapest and most common processes for making fibre composite products.

In this process, the mold is waxed and sprayed with gel coat and cured in a heated oven. In the spray up process, catalyzed resin is sprayed into the mold, with chopped fibre where secondary spray up layer imbeds the core between the laminates resulting a composite. In hand layup processing, both continuous fibre strand mat and fabrics are manually placed in the mold. Each ply is sprayed with catalyzed resin and with required pressure compact laminate is made.

A. Hand Lay-Up Method

Hand layup is an open contact molding in one-sided molds are the lowest-cost and most common processes for making fibre glass composite products and is the most common method of producing composites parts in the U.S. aircraft industry. In a typical open mold application, the mold is first waxed and sprayed with gel coat. It then may be cured in a heated oven at about 120º F. In the spray-up process, after the gel coat cures, catalyzed resin (usually polyester or vinyl ester at 500 cps to 1000 cps viscosity) is sprayed into the mold, along with chopped fibre glass. A chopper gun chops roving (usually E-glass) directly into the resin spray, so that all materials are simultaneously applied to the mold. Using low-styrene and suppressed-styrene resins, fillers and high-volume/low-pressure spray guns or pressure-fed resin roller applicators helps reduce emissions of volatile organic compounds. In hand lay-up processing, fibre glass (typically E-glass) continuous strand mat and/or other fabrics such as woven roving are manually placed in the mold. The applied vacuum compacts the preform and helps the resin to penetrate and wet-out the fibre preform. Fibre content up to 70 percent has been reported.

Fig. 3: Hand lay-up method

B. *Work Material*

In this research work we chosen the following materials such as polyster as resin and coconut coir as fibre and cobalt catalys as additives.

Fig. 4: fabrication of composite material

C. *Specimen Preparation and Test Machine*

The test specimens for tensile and Impact test, Flexural Test Water Absorption Test were cut as per American standard testing method (ASTM) specifications in table 3. The Instron Universal Testing Machine (UTM) (supplied by Instron Corporation, Series 9, automated testing machine) used for tensile test and Impact testing machine is used for Impact Testing.

S.No	Type of Test	ASTM Standard	Specimen Size (mm)
1	Impact Testing	D 4812	75x10x10
2	Tensile Test	D 3039	100 x 15 x 30
3	Compression Test	D 638	13×13×11
4	Hardness Test	D 570	125x125

Table 3: ASTM Standards for Specimen Preparations

Chemical compositions of coir fibre this work was 25%, within this percentage, the volumetric relation between coir fibre was modified according to the compositions: 100% coir fibre

S.no	Component	Proportions %
1	Cellulose	70
2	Lignin	12
3	Pectin	10
4	Hemicelluloses	8

Table 4: Chemical Composition of Coir Fibre

V. RESULT AND DISCUSSION

A. *Impact Strength of Coir Laminate Hybrid Composite*

The impact strength of coir laminate hybrid composites is presented in table 5 and It is observed that the laminate composite is exhibiting higher impact strength than the sisal and coir fibre reinforced composite. The coir laminate hybrid composite impact strength is higher than sisal reinforced composite but lower than glass fibre reinforced composite. The increase in impact strength of hybrid composite is because of laminated of coir.

S.No	Material	Energy absorbed force in (J)	Energy spend to break the specimen in (J)	Energy absorbed by the specimen in (J)	Impact strength in N/mm
1	*coir fibre*	*60*	*50*	*0.4*	*44*
2	sisal fibre	60	50	0.2	22

Table 5: Impact Strength of Laminate Coir Composite

B. *Tensile Test*

The tensile test was conducted on dried specimens of size of 10cm x 1.5cm x 0.3cm. The tensile strength was found to be slightly greater for treated fibres than untreated fibres. This can be attributed to the increased adhesion at the fibre – polyster interface after the fibre is chemically modified.

S .No	Material	Maximum Stress In (N/mm^2)	Maximum Strain	Maximum Load In (N)
1.	*Coir fibre*	*14*	*0.01*	*$1.2x10^3$*
2.	Sisal fibre	12	0.01	$0.9 x10^3$

Table 5: Tensile Properties of Laminated Coir Composites

C. *Compression Test*

The compression specimen is prepared as per the ASTM D638 standard. A compression test involves mounting the specimen in a machine subjecting it to the compression.

The specimen size for compression test is 13×13×11mm.The generated directly from the machine for compression test with respect to load and displacement for coconut husk.

S.No	*Material*	Minor load	Intender used	Compression Strength(N)

		In no (kg)		
1	Coir Fibre	300	¼ ball	0.8 x10^3
2	Sisal Fibre	300	¼ ball	0.6 x10^3

Table 6: Compression test Observations for Coir Composites

VI. Conclusion

This experimental investigation of mechanical behavior of sisal and coir laminate -polyester composites leads to the following conclusions.

- The characterization of the composites reveals that the hybridization is having significant effect on the mechanical properties of composites.
- The improved properties such as impact strength, tensile strength and compression strength of coir fibres are improved compared with the sisal fibre.

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