Fabrication and Testing of Mechanical Properties on Sisal/Broom Grass Hybrid Natural Fiber Composites

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ABSTRACT - In recent years, natural fiber reinforced polymer composites have received much attention because of their many advantages such as light weight, nonabrasive, nontoxic, low cost and biodegradable properties .A lot of projects has been done all over the world on the use of natural fibers as a reinforced material for the preparation of various types of composites .With this background, and an attempt been made to fabricate and evaluate the different mechanical properties of broom grass/sisal natural fibers reinforced hybrid composites and their effect of hybridization on mechanical properties of broomgrass/sisal natural fiber reinforced hybrid composite in the present project work. The broom grass and sisal fibers were extracted by manual process and developed under similar laboratory conditions. Sisal fiber washybridized with broom grass fiber. The overall fiber weight fraction was fixed as 1Wf. Hybrid composites were prepared using Hand lay-up technique, by considering the properties of sisal/broom grass fiber as 60/40 and 50/50.The hybrid composites for all the Tensile, Flexural, Impact, test samples were prepared by reinforcing sisal/broom grass fibers with different weight percentages according to the ASTM standard.

Keywords. MMC, CNC, ASTM, Fiber.

I-Introduction to Composite Materials

Composite materials for construction, engineering and other similar applications are formed by combining two or more materials in such a way that the constituents of the composite materials are still distinguishable, and not fully blended. One example of a composite material is concrete, which uses cement as a binding material in combination with gravel as a reinforcement. In many cases, concrete uses rebar as a second reinforcement, making it a three-phase composite, because of the three elements involved.

Advanced composites materials are exhibit desirable physical and chemical properties that are High specific stiffness and strength, Dimensional stability, Temperature and chemical resistance, relatively easy processing, light weight, High strength to weight ratio, Good anticorrosion properties.

CLASSIFICATION OF COMPOSITES

There are two classification systems of composite materials. One of them is based on the matrix material (metal, ceramic, and polymer) and the second is based on the reinforcing material structure. Classification of composite**s**. (Based on matrix material)

Metal Matrix Composite**s** (MMC): Metal Matrix Composites are composed of a metallic matrix (aluminum, magnesium, iron, cobalt, copper) and a dispersed ceramic (oxides, carbides) or metallic (lead,tungsten, molybdenum) phase.

Ceramic Matrix Composite**s** (CMC): Matrix Composites are composed of a ceramic matrix and embedded fibers of other ceramic material (dispersed phase).

Polymer Matrix Composite**s** (PMC): Polymer Matrix Composites are composed of a matrix from thermo set (Unsaturated Polyester (UP), Epoxy (EP) or thermoplastic (Polycarbonate (PC), Polyvinylchloride, Nylon, Polystyrene) and embedded glass, carbon, steel or Kevlar fibers (dispersed phase).

CLASSIFICATION OF COMPOSITE MATERIALS

(Based on reinforcing material structure)

Particulate Composites

Particulate Composites consist of a matrix reinforced by a dispersed phase in form of particles. Composite**s** with random orientation of particles**.** Composit**es** with preferred orientation of particles.Dispersed phase of these materials consists of two- dimensional flat platelets (flakes), laid parallel to eachother.

Fibrous Composites

Short-fiber reinforced composites. It consists of a matrix reinforced by a dispersed phase in form ofdiscontinuous fibers (length < 100*diameter).

Composites with preferred orientation of fibers. Long-fiber reinforced composites. It consists of a matrixreinforced by a dispersed phase in form of continuous fibers.

Unidirectional orientation of fibers. Bidirectional orientation of fibers (woven).Laminate Composites:

When a fiber reinforced composite consists of several layers with different fiber orientations, it is calledmultilayer (angle-ply) composite.

INTRODUCTION TO POLYMERS:

A polymer is a large molecule composed of repeating structural units. These subunits are typically connected by covalent chemical bonds. Although the term polymer is sometimes taken to refer to plastics, it actually encompasses a large class of natural and synthetic materials with a wide variety of properties. Because of the extraordinary range of properties of polymeric materials they play an essential and important role in everyday life. This role ranges from familiar synthetic plastics and elastics to natural biopolymers such as nucleic acids and proteins that are essential for life. Natural polymeric materials suchas shellac, amber, and natural rubber have been used for centuries. A variety of other natural polymers exist, such as cellulose, which is the main constituent of wood and paper. Synthetic polymer materials such as nylon, polyethylene, Teflon, and silicone have formed the basis for a burgeoning polymer industry.

Polymer synthesis:

Polymerization is the process of combining many small molecules known as monomers into a covalently bonded chain. During the polymerization process, some chemical groups may be lost from each monomer. This is the case, for example, in the polymerization of PET polyester. The monomers are terephthalic acid ($HOOC-C_6H_4-COOH$) and ethylene glycol ($HO-CH_2-CH_2-OH$) but the repeating unit is ($-OC-C_6H_4-COO-CH_2-CH_2-O-$) which corresponds to the combination of the two monomers with the lossof two water molecules.

Polymer degradation:

Polymer degradation is a change in the properties - tensile strength, color, shape, etc. polymer-based product under the influence of one or more environmental factors such as heat, light or chemicals such as acids, alkalis and some salts. These changes are usually undesirable, such as cracking and chemical disintegration of products is more rarely desirable, as in biodegradation. Or deliberately lowering the molecular weight of a polymer for recycling. The changes in properties are often termed "aging". In a finished product such a change is to be prevented or delayed. Degradation can be useful for recycling/reusing the polymer waste to prevent or reduce environmental pollution. Degradation can also be induced deliberately to assist structure determination.

TYPES OF POLYMERS

There are many types of polymers including synthetic and natural polymers.

Classification of Polymers:

Photopolymers – It consist of chains with identical bonding linkages to each monomer unit. This usually implies that the polymer is made from all identical monomer molecules. These may be represented as - [A-A-A- A-A-A]-

Copolymers - Consist of chains with two or more linkages usually implying two or more different types of monomer units. These may be represented as: - [A-B-A-B-A-B] - Polymers are further classified by thereaction mode of polymerization, these include:

Addition Polymers - The monomer molecules bond to each other without the loss of any other atoms. Alkenes monomers are the biggest groups of polymers in this class.

Condensation Polymers- Two different monomer combine with the loss of a small molecule, usually water. Polyesters and polyamides (nylon) are in this class of polymers. Polyurethane Foam in graphic. Classification based upon the physical property related to heating.

Thermoplastic

A thermoplastic also known as a thermo softening plastic is a polymer that turns to a liquid when heated and freezes to a very glassy state when cooled sufficiently. Most thermoplastics are high-molecular- weight polymers whose chains associate through weak Vander Waals forces (polyethylene); stronger dipole-dipole interactions and hydrogen bonding (nylon) or even stacking of aromatic rings (polystyrene). The commercial available thermoplastics are Polyvinyl Chloride (PVC) and Polystyrene, Polymethyl methacrylate

Most Linear polymers and those having branched structures with flexible chains are thermoplastics.

Thermosetting plastic

A thermosetting plastic also known as a thermo set is polymer material that irreversibly cures. The cure may be done through heat through a chemical reaction or irradiation such as electron beam processing. Thermo set materials are usually liquid or malleable prior to curing and designed to be molded into their final form or used as adhesives. Others are solids like that of the molding compound used in semiconductors and integrated circuits.

INTRODUCTION TO NATURAL FIBERS:

The use of natural fiber for the reinforcement of the composites has received increasing attention both by the academic sector and the industry Natural fibers have many significant advantages over synthetic fibers. Currently many types of natural fibers have been investigated for use in plastics including flax, hemp, jute straw, wood, rice husk, wheat, barley, oats, rye, cane (sugar and bamboo), grass, reeds, knead,ramie, oil palm empty fruit bunch, sisal, coir, water, hyacinth, pennywort, kapok, paper mulberry, raphia, banana fiber, pineapple leaf fiber and papyrus. Thermoplastics reinforced with special wood fillers are enjoying rapid growth due to their many advantages; lightweight reasonable strength and stiffness. Some plant proteins are interesting renewable materials, because of their thermoplastic properties. Wheat gluten is unique among cereal and other plant proteins in its ability to form a cohesive blend with viscous elastic properties once plasticized. For these reasons, wheat gluten has been utilized to process edible or biodegradable films or packing materials. Hemp is abast lingo cellulosic fiber. Comes from the plant cannabis sativa and has been used as reinforcement in biodegradable composites

Common natural fibers: Natural fiber reinforced polymer composites have raised great attention and interest among materials scientists and engineers in recent years due to the considerations of developing an environmental friendly material and partly replacing currently used glass or carbon fibers in fiber reinforced composites. They are high specific strength and modulus materials, low priced, recyclable and are easily available. It is known that natural fibers are non-uniform with irregular cross sections which make their structures quite unique and much different with man-made fibers such as glass fibers, carbon fibers etc. Many researchers have been conducted 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 such as sisal, jute and palm fibers and the hydrophobic polymer matrices. Worldwide laboratories have worked on this topic. But reports on composites using bird feathersas reinforcing fibers are rare.

HYBRID COMPOSITES, The word "hybrid" is of Greek–Latin origin and can be found in numerous scientific fields. In the case of polymer composites, hybrid composites are these systems in which one kind of reinforcing material is incorporated in a mixture of different matrices (blends) or two or more reinforcing and filling materials are present in a single matrix. Or both approaches are combined. The incorporation of two or more lignocelluloses fibers into a single matrix has led to development of hybrid composites. The behavior of hybrid composites is a weighed sum of the individual components in which there is more favorable balance between the inherent advantages and disadvantages.

II- LITERATURE REVIEW

Literature survey is carried out to get the background information on the issues to be considered in the present project work and to focus the relevance in the present study. The purpose is also to present a thorough understanding of the various aspects of mechanical properties on Hybrid natural fiber reinforcedcomposites like coir/broom grass fibers. The mechanical property of a natural fiber-reinforced composite depends on many parameters like fiber strength, fiber length and orientation, modulus, and fiber-matrix interfacial bond strength. A strong fiber-matrix interface bond is critical for high mechanical property of composites. A good interfacial bond is needed for effective stress transfer for effective stress transfer fromthe matrix to the fiber whereby maximum utilization of the fiber strength in the composites is achieved. Modification to the fiber also improves resistance to moisture induced degradation of the interface and the composites properties. In addition, factors like processing techniques/conditions have significant influence on the mechanical properties of fiber reinforced composites. Mechanical properties of natural fibers such as flax, hemp, jute and coir, are very good and may replace the glass fiber in case of specific strength and modulus. A number of investigations have been conducted on several natural fibers.

To study the effect of fibers such as knead, hemp, flax, bamboo, and jute on the mechanical properties of composites of composites materials. Mansur and Aziz studied bamboo-mesh reinforced cement composites, and found that this material reinforcing material could enhance the ductility and toughness of the cement matrix, and significantly increase its tensile, flexural, and impact strength. On the other case, jute fabric-reinforced polyester composites were tested for the evaluation of mechanical properties and compared with wood composites, and it was found that the jute fiber composite has better strengths than wood composites.

OBJECTIVES OF THE PRESENT PROJECT WORK

- The objective is to develop a new hybrid natural fiber reinforced composite by incorporatingSisal/broom grass/ fibers.
- The present work is expected to satisfy the need of light weight engineering materials.
- Fabrication of sisal/broom grass Hybrid Natural Fiber reinforced epoxy based composite by usinghand layup technique.
- Evaluation of mechanical properties (Tensile strength, flexural strength, hardness and impactstrength etc.).

III- FABRICATION AND TESTING:

The following section will elaborate in detail, the fabrication and experimental procedures carried out during the course of the present work.

The steps involved are:

Specimen Fabrication (Fabrication of HNFC) by using Hand Lay-Up method.

Tensile Test Flexural TestImpact Test.

RAW MATERIALS:

Raw materials used in this experimental work are:Natural fibers Sisal/Broom Grass

Epoxy resin

Sisal and Broom grass

Epoxy resin

FABRICATION OF COMPOSITE

Hand Lay-up Technique: The appropriate numbers of fiber plies were taken: four 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 bubbleswere 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. Thenfiber 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 four alternating fibers have been laid. On the top of the last ply a polymer coating is done which serves to ensure a good surface finish. Finally a releasing sheet was put on the top; a light rolling was carried out. Then a 20 kg weight was applied on the composite. It was left for 72 hrs to allow sufficient time for curing and subsequent hardening.

Table 1, Composition and designation:

S.NO	Sisal(%)	Broom grass(%)	Epoxy (%)matrix	Fiber(%)
1	60	40	60	40
2	50	50	60	40

EXPERIMENTAL PROCEDURE

Preparation of test specimens: A jig saw machine was used to cut each laminate into smaller pieces, for Tensile, Flexural and impact test specimens. The characterization of the composites reveals that the % weight of fibers is having significant effect on the mechanical properties of composites. All the mechanical testing methods that were carried out were based on American Standard Testing Methods (ASTM). There are four tests performed, namely Tensile Test (ASTM D638),

Table 2, Final composite plates with various weight fraction ratios

S.No	Test Name	Astm Standard	Dimensions
1	Tensile test	D638-03	168X12.5X4
2	Flexural test	D256	100 X12.7X4
3	Impact test	D790	65X12.7X4

Tensile Test: Tensile modulus and modulus of elasticity was determined as: $E = FL/A\Delta L$ where F is the maximum load; L is the distance between the supports; A is the area of the specimen, and ΔL is the deflection (in mm) corresponding to the load F. Typical points of interest when testing a material include: ultimate tensile strength (UTS) or peak stress; offset yield strength (OYS) which represents a point just beyond the onset of permanent deformation; and the rupture (R) or fracture point where the specimen separates in to pieces.

Tensile strength machine and specimens

Flexural Test

Flexural strength is the ability of the material to withstand bending forces applied perpendicular to its longitudinal axis. Sometime it is referred as cross breaking strength where maximum stress developed when a bar-shaped test piece, acting as a simple beam, is subjected to a bending force perpendicular to the bar. This stress decreased due to the flexural load is a combination of compressive and tensile stresses.

There are two methods that cover the determination of flexural properties of material: three-point loading system and four point loading system. As described in ASTM D790, three-point loading system applied on a supported beam was utilized. Flexural test is important for designer as well as manufacturer in the form of a beam. If the service failure is significant in bending, flexural test is more relevant for design and specification purpose than tensile test. According to ASTM D790, specimens of test pieces were prepared with dimension of 127mm × 12.7mm × 3mm [24]. The test pieces were tested flat wise on a support span resulting span-to-depth ratio of 16. This means the span is 16 times greater the thickness of specimen. Thetest pieces were then placed on two supports and load will be applied. The distance of two supports span

(L) was fixed at 100mm.

Table 3, Dimensions of flexural test specimen

Dimension	Value(mm)
Width	4
Length	12.7
Gauge length	100


Flexural test machine and specimens

Impact Testing

The impact test is the ability of the material to withstand the sudden shock loads. This test is conducted in an Impact testing machine. The machine consists of a loading striker which on releasing possesses fixed kinetic energy. The specimen made as per the specification would be kept in the machine and the loadwill be released. The absorbed energy would be indicated in the dial the impact properties of the material are directly related to the overall toughness which is defined as the ability to absorb applied energy. Area under the stress- strain curve is proportional to the toughness of a material. Nevertheless, impact strength is a measure of toughness. In this last two decades, there are four types of impact tests, for example: the pendulum impact tests, high-rate tension test, falling weight impact test and instrumented impact test.

IV- RESULT AND DISCUSSION

MECHANICAL CHARACTERISTICS OF COMPOSITES

The properties of the Sisal/broom grass fiber reinforced epoxy hybrid composites with different weight fractions of fiber under this investigation are presented in below Tables &figures respectively. Details of processing of these composites and the tests conducted on them have been described in the previous chapter. The mechanical properties of natural fiber reinforced composites are largely depends on the chemical, structural composition, fiber type and soil conditions and also on atmospheric conditions at the time of fabrication of the specimens. The results of various characterization tests are reported here. This includes evaluation of tensile strength, flexural strength, impact strength. Has been studied and discussed Based on the tabulated results, various graphs are plotted and presented in figs

Table 4. The impact properties

Sample Id	% Weightfraction	Impact load(joules)
C1	60/40	1.5
C2	50/50	2.0

Table 5. The Tensile properties

Sample Id	%WeightFraction	Ultimate Tensilestrength (Mpa)	Tensile Modulus(Mpa)
C1	60/40	25	1600
C2	50/50	35	3400

Table 6. The Elongation properties

SampleId	% WeightFraction	Flexuralstrength(Mpa)	FlexuralModulus(Mpa)
C1	60/40	300	35000
C2	50/50	350	45120

Table 7. The flexural properties

Sample Id	% WeightFraction	Elongation(mm)
C1	60/40	1.9
C2	50/50	1.2

V- CONCLUSION

The mechanical behavior of Sisal/Broom grass reinforced hybrid natural fiber composite lead to the following conclusions. The natural fiber reinforced epoxy hybrid composites are successfully fabricated using hand lay-up technique. The sisal/broom grass hybrid composite with weight fraction of 50/50 shows maximum tensile strength and maximum tensile modulus (35 and 3400) Mpa The sisal/broom grass hybridcomposite with weight fraction of 60/40 shows maximum flexural strength and maximum flexural modulus. (350 and 45120)Mpa. The sisal/broom grass hybrid composite with weight fraction of 50/50 shows maximum impact strength. (2 joules). The sisal/broom grass hybrid composite with weight fraction of 60/40 shows maximum elongation and break load. (2.3mm). by increasing the weight percentage of broom grass fiber, the mechanical properties also increase up to certain limit. Further, addition causes them to decrease due to poor interfacial bonding between fiber and matrix. Due to the lowdensity of proposed natural fibers compared to the synthetic fibers (Glass fibers, carbon fibers, etc...), the composites can be regarded as a useful engineering materials in light weight applications.

VI- FUTURE SCOPE OF WORK

There is a wide scope for future scholars to explore this area of research. This work can be further extended to study other aspects of jute/Broom grass hybrid natural fiber reinforced composites. The present investigation is limited to the finding of mechanical properties only. It can be extended to in the present investigation; study of jute/Broom grass fiber weight fraction is limited to 40% only. This can be further enhanced to 50 % fiber content and 50 % matrix through other fabrication techniques, Optimization studies. Water absorption studies, Experimental results can be compared with ANSYS. The work can be extended with various types of alkali treatments of fiber.

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