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RESEARCH ARTICLE

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INVESTIGATION OF MECHANICAL PROPERTIES OF HYBRID FIBER COMPOSITES

AJITH MESHACH J[1],SUJITH K V[2],VINEETH MANOJ B[3],BALASARAVANAN K[4], RAMANI RAJ A[5]

[1, 2, 3,4]Student, [5]Assistant Professor

Velammal Institute of technology, Thiruvallur, Tamilnadu

ABSTRACT

The composite materials are replacing the traditional materials, because of its superior properties such as high tensile strength, low thermal expansion, high strength to weight ratio. The developments of newmaterials are on the anvil and are growing day by day. Natural fiber composites such as Flax/Glass/Polyester fiber composites became more attractive due to their high specific strength, lightweight and biodegradability. Mixing of natural fiber with Glass-Fiber Reinforced Polymers (GFRPs) is used to increase the strength of the fiber. In this study, Flax/Glass/Polyester fiber composites are developed and their mechanical properties such as tensile strength, flexural strength and impact strength are evaluated. The results indicated that the incorporation of Flax/Glass/Polyester fiber composites with GFRP can improve the properties and used as an alternate material for glass fiber reinforced polymer composites.

Keywords— Tensile, flexural and impact testing, Hand layup Fabrication Technique

INTRODUCTION

Natural fibres represent an environmentally friendly alternative by virtue of several attractive attributes that include lower density, lower cost, non-toxicity, ease of processing, renewability and recyclability. Biocomposites materials based on biopolymers and natural fibers used as bone implants , Much of natural product obtained from plants having own medicinal values such as biologically active photochemical are normally present in leaves, roots, barks and flowers, Natural fibers present important advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable. Natural fiber reinforced polymer composite materials which are less rigid than metals may be good alternatives because of properties closer to bone mechanical properties.

Natural fibers

Natural fibers are made from plant, animal and mineral sources. Natural fibers can be classified according to their origin. These are Seed fiber, Leaf fiber, Bast fiber, Skin fiber, Stalk fiber, Animal fiber. It allows insulation properties higher than current materials. In automotive technology, it is more economical and technical.

Synthetic fibers

Synthetic fibers are created by forcing, usually through extrusion, fiber forming materials through holes into the air, forming a thread. These are made from synthesized polymers or small molecules. The main raw materials are petroleum based chemicals or petrochemicals. Their main

properties are Heat sensitive, resistant to most chemical, Low moisture absorbency, Easy to wash and maintain, Flame resistant.

Glass fibers

Glass fiber is a material consisting of numerous extremely fine fibers of glass. It is commonly used as an insulating material and reinforcing agent for many polymer products to form a very strong and light fiber reinforced polymer composite materials called glass reinforced plastic. It is much cheaper and significantly less brittle. Glass properties such as tensile strength, Young's modulus, and chemical durability, are measured on the fibers directly. Other properties, such as dielectric constant, dissipation factor, dielectric strength, volume or surface resistivity, and thermal expansion, are measured on glass that has been formed into a bulk sample and annealed (heat treated) to relieve forming stresses. Fiberglass is a lightweight, extremely strong, and robust material.

Table 1.1 Mechanical properties of natural fibers

Fibers	Modulus (GPa)	Strength (MPa)	Density (g/cm3)	Specific Modulus	Specific Strength
Flax	50-70	500-900	1.4-1.5	~ 41	~ 480
Hemp	30-60	300-800	1.48	~ 30	~ 370
Jute	20-55	200-500	1.3-1.5	~ 27	~ 250
Sisal		500-630	1.5		~340

Selection of natural fibers

Recently natural fibers such as flax, hemp and jute have been considered for reinforcing as they need less energy to grow. And they are biodegradable and renewable. Many automotive components already produced in natural composites mainly based on polyester or polypropylene and fibers like flax, sisal or hemp. Flax fibers mainly selected based on the thermal properties, mechanical properties, and chemical properties.

Flax fiber

Vegetable fibers among which flax fibers (Liniumusitatissiumum) are often used in reinforced composite materials have exhibited numerous advantages such as high mechanical properties, low density and biodegradability. It is well known that the mechanical performances of a composite material strongly depend on the nature and orientation of the fibers and the nature of the matrix but also on the quality of the adhesion between the two components. In order to be incorporated in composites, individual flax fibers require further chemical treatments even after long time dew retting in the field.

Sisal fiber

Sisal fiber is one of the most widely used natural fiber and is very easily cultivated. It is obtain from Sisal plant. The plant, known formally as 'Agave sisalana'. These plants produce rosettes of sword-shaped leaves which start out toothed, and gradually lose their teeth with maturity. The process of fiber removed from the leaf is known as 'Decortication'. Sisal fiber is fully biodegradable, green composites were fabricated with soy protein resin modified with gelatin. Sisal fiber is exceptionally durable and a low maintenance with minimal wear and tear. Its fiber is too tough for textiles and fabrics. The chemical composition of sisal fiber is cellulose (65%), hemicelluloses (12%), lignin (9.9%), waxes (2%). These fiber is commonly used in shipping industry for moving small craft, lashing, and handling cargo.

The process of extraction is of great importance since the quality as well as quantity of extracted fibers is strongly influenced by the method of extraction employed. Extraction is the process of separating the fiber from the cementing substances such as pectin or lignin, wax, resin, fats and other carbohydrates. It is done by the help of either mechanically or chemically. Hand scrapers, Blunt and crescent shaped knives, wooden beater, hand comber has been mainly used for fiber extraction. Here the flax and sisal fibers are extracted from their plants in the following ways

Extraction of flax fiber

Flax fiber is extracted from the Bast or Skin of the stem of the flax plant. Flax fiber is soft, lustrous and flexible. Retting of flax will takes place after the fiber extraction which is mainly used for fiber smoothness. It is done in two ways.

(a) Pond retting (b) Steam retting. After that dressing will takes place. It may include breaking which is used for breaks up the straw into short segments. Scutching is the process of remove of excess straw which is done by knife shaped tool. Heckling is the process of pulled flax fibers into

various sized heckling combs or heckles. By this it will produce required flax fiber without segments.

Extraction of sisal fiber

Sisal is an agave that yields a stiff fiber traditionally used in making twine, rope and also dartboards. Each leaf has an average of around 1000 fibers. The fibers account for only about 4% of the plant by weight. Sisal fiber is extracted from their leaves. The leaves are crushed and beaten by a rotating wheel set with blunt knives, so that only fibers remain. After that the fiber will dry two or four days in the sun. Because fiber quality depends largely on moisture content. The characteristics of the sisal fibers depend on the properties of the individual constituents, the fibrillar structure and the lamellae matrix. The fiber is composed of numerous elongated fusiform fiber cells that taper towards each end. The fiber cells are linked together by means of middle lamellae, which consist of hemicelluloses, lignin and pectin.

Polyester resin

Polyester resin material is a three-component material. However, the manufacturer mixes the two reactive parts. At the time of application, a catalyst is added to start the reaction. Then the material is sprayed onto the roadway. Reflective beads are added using a separate gun located directly behind the paint gun.

Characteristics of polyester resin

The material has the potential to be 100 percent solid. This depends on how fast the reaction takes place. The styrene is volatile prior to the reaction. Heat is not typically added to the system except when cure time is expected to be long, such as on cool spring or fall days. The catalyst is added to drive the reaction.

Hand lay-up technique

The fiber piles were cut to size from the Flax fiber cloth. The appropriate numbers of fiber plies were taken: two for each. Then the fibers were weighed and accordingly the resin and hardeners were weighed. Polyester resin and hardener were mixed by using glass rod in a bowl. Care was taken to avoid formation of bubbles. Because the air bubbles were trapped in matrix may result failure in the material. The subsequent fabrication process consisted of first putting a releasing film on the mold surface. Next a polymer coating was applied on the sheets. Then fiber ply of one kind was put and proper rolling was done.

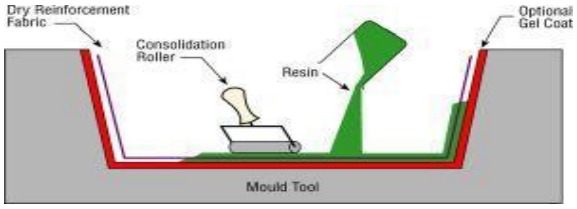

Fig 2.1 Hand lay-up technique

SPECIMEN PREPERATION

Proper preparation of the specimen is a critical process for accurate material characterization. An appropriate preparation of the specimen as well as adequate notching will affect the final test results by generating reliable outcomes in the finish product performances. This can be accomplished by several specimen preparation techniques which abide by the main ISO and ASTM international standards.

Details of specimen

The size of the laminate is 290x290x3.From this laminate the specimens are carried out. The commonly used specimen for tensile test is the flat type. During the test a uniaxial load is applied through both the ends of the specimen. The dimension of specimen is (250x25x3) mm typical points of interest when testing a material include: ultimate tensile strength or peak stress; offset yield strength which represents a point just beyond the onset of permanent deformation; and the rupture (R) or fracture point where the specimen separates into pieces. The tensile test is performed in the universal testing machine Instron 1195 and results are analyzed to calculate the tensile strength of composite samples. For flexural test Sample was cut into flat shape 130x13x3 mm, in accordance with ASTM standards. For impact test, the test sample dimension is 60x13x3 mm.

Standard Specimen sizes

- Tensile testing (ASTM D638)
- Flexural testing (ASTM D750)
- Impact testing (ASTM D256)

The laminates of hybrid fibers having various lengths in the range of 2mm, 4mm, 6mm, and 8mm .These size of sisal and flax fibres are added equal in the proportion of 50% with polyester resin. The test specimens are tested and their strengths are calculated. From this, high strength specimens are selected and glass fiber is added to the specimen for increasing their properties.

Mechanical testing

In this project mainly investigating the some of the mechanical properties such as tensile properties, flexural properties, fatigue properties.

Tensile testing

The tensile strength of a material is the maximum amount of tensile stress that it can take before failure. The commonly used specimen for tensile test is the flat type. During the test a uniaxial load is applied through both the ends of the specimen. The dimension of specimen is (250x25x3) mm.

Flexural testing

Flexural strength is defined as a materials ability to resist deformation under load. The short beam shear tests are performed on the composites samples to evaluate the value of inter-laminar shear strength. It is a 3-point bend test, which generally promotes failure by inter-laminar shear. This test is conducted as per ASTM standard using UTM. The loading arrangement is shown in figure. The dimension of the specimen is (130x13x3) mm.

Impact testing

Impact test was carried out on Izod impact tester. The specimens are cut from the fabricated composite plates in accordance with ASTM D-256.The specimen size for impact test is 60x13x3 mm

Mechanical Characteristics of Composites

The characterization of the composites reveals that the fiber length is having significant effect on the mechanical properties of composites. The properties of the composites with different fiber lengths under this investigation are shown below

Table 1.2 Mechanical properties of the composites

Composition	Tensile strength (MPa)	Elongation(%)	Flexural strength (MPa)	Flexural Modulus (GPa)	Impact strength (J)
C_1	21.088	2.373	57.066	3309.14	1.083
C_2	22.9	2.217	55.42	2693.05	1.35
C_3	17.985	1.623	59.037	3587.27	1.1
C_4	21.526	2.93	58.873	1993.25	1.516
C_5	29.224	2	183.83	882.29	2.5

CONCLUSION

The natural fiber composite manufactured by hand lay-up process provides an opportunity of replacing existing materials with a higher strength, low cost, alternative that is environmentally friendly. The tensile, flexural and impact properties of hybrid fiber composites are studied. From this study it has been declared that the fiber length varies the composite mechanical properties with different fiber length. In tensile strength 4mm fiber length is maximum about 22.900 N/mm² and the 6mm shows the minimum value of 17.985 N/mm².In impact testing 8mm withstand the maximum impact load of 1.516J and the minimum is 2 mm which is of about 1.083J.In flexural testing 6mm has the maximum value of 59.037Mpa and 4mm have the minimum value of 55.42Mpa.

Hence when comparing with all tests 4mm and 8mm fiber length are good at all testing. Addition of glass fiber also increases the mechanical properties of the composites. In tensile, it having the value of 29.224 N/mm².In impact testing, it having the value of 3.50J.From this results there is scope for further research to completely characterize the flax and sisal fibers and facilitate proper applications in natural fiber reinforced composites.

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