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Experimental Investigation on Mechanical and Tribological Analysis of Pineapple Leaf and Sisal Fibers Reinforced Hybrid Epoxy Composites

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ABSTRACT

This work aims to investigate the mechanical and tribological characterization of pineapple leaf and Sisal fiber–reinforced hybrid epoxy composites through experimental studies. The pineapple leaf and Sisal fibers were initially treated with 5% sodium hydroxide. Hybrid composites were fabricated by compression moulding technique with a composition of 0,10,15,20 and 30 wt% Pineapple leaf and Sisal Fibers to the epoxy resin with constant 70% weight ratio. The fabricated hybrid composites were subjected to mechanical studies as per ASTM standards. Composites of various compositions with two different fiber orientations (0° and 90°) are fabricated using Compressible moulding technique. It has been observed that there is a significant effect of fiber loading and orientation on the performance of pineapple leaf & Sisal fibers reinforced epoxy-based hybrid composites. The developed hybrid composites undergo different kinds of tests. The result shows hybrid composites having good strength and stiffness. Application of natural fiber reinforced polymer composites (NFPC) in transportation diligences has become inexorable due to light weight, superior properties, less cost of production and suitability to many products. Interfacial bonding between the fiber and matrix plays a vital role in deciding the mechanical characteristics of composites. The current aerospace and automotive industries are looking to change the conventional materials which are high density material to composite material for reducing the overall weight of the vehicle to increase its performance.

Keywords: Compression moulding, pineapple leaf Fiber, Sisal Fiber and Epoxy Resin

INTRODUCTION

COMPOSITE MATERIALS

A composite material is made by combining two or more materials – often ones that have very different properties. The two materials work together to give the composite unique properties. However, within the composite you can easily tell the different materials apart as they do not dissolve or blend into each other.

Natural composites

Natural composites exist in both animals and plants. Wood is a composite – it is made from long cellulose fibers (a polymer) held together by a much weaker substance called lignin. Cellulose is also found in cotton, but without the lignin to bind it together it is much weaker. The two weak substances – lignin and cellulose – together form a much stronger one.The bone in your body is also a composite. It is made from a hard but brittle material called hydroxyl apatite (which is mainly calcium phosphate) and a soft and flexible material called collagen (which is a protein). Collagen is also found in hair and finger nails. On its own it would not be much use in the skeleton but it can combine with hydroxyl apatite to give bone the properties that are needed to support the body.

Composite in Earlier days

People have been making composites for many thousands of years. One early example is mud bricks. Mud can be dried out into a brick shape to give a building material. It is strong if you try to squash it (it has good compressive strength) but it breaks quite easily if you try to bend it (it has poor tensile strength). Straw seems very strong if you try to stretch it, but you can crumple it up easily. By mixing mud and straw together it is possible to make bricks that are resistant to both squeezing and tearing and make excellent building blocks. Another ancient composite is concrete. Concrete is a mix of aggregate (small stones or gravel), cement and sand. It has good compressive strength (it resists squashing). In more recent times it has been found that adding metal rods or wires to the concrete can increase its tensile (bending) strength. Concrete containing such rods or wires is called reinforced concrete.

LITERATURE REVIEW

James Njuguna (2011). The surface modification of sisal fiber had slightly increased tensile strength of composites and decreased its impact strength. Which suggested that surface treatment improved the compatibility of sisal fiber and PLA matrix and effective stress transferred between fibers and matrix?

M.K. Gupta (2016). Incorporation of two or more fibers into a single polymer matrix leads the development of hybrid composite.

Hybridization can improve the mechanical properties of single fiber reinforced polymer composite.

Yentl Swolfs (2018). Fiber hybrid composites are composed of two or more fiber types in a matrix. Such composites offer more design

freedom than non-hybrid composites. The aim is often to alleviate the drawbacks of one of the other. The hybridization can also lead to synergetic effects or to properties that neither of the constituent's process.

T.P. Mohan (2012). The purpose of fiber treatment is to improve the fiber matrix compatibility, interface strength, mechanical, thermal and water barrier properties. The result shows increased mechanical and thermal properties. The results indicate that interface strength, adhesion, glass transition temperature and tensile properties of composites were improved in treated fiber composites.

Michael Cordin (2018). The young's modulus depends strongly on the fiber orientation which can be described theoretically by the

modified role of mixture. According to the theory reinforcement by fibers is proportional to the fiber volume fraction and angle

of the orientation by fiber.

Krishnan Jayaraman (2003). The composite materials with a fiber length greater than 10 mm and a fiber mass fraction in the range 15% to 35% exhibited excellent tensile and flexural strength.

Shalwan *et al.* (2013). Alkaline treatment was found to be most effective method to improve interfacial bonding between fiber and matrix, while other treatment methods exhibited either no effect or reduction on the fiber strength.

Layth Mohammed *et al.* (2015). Volkswagen company used natural fibers to make boot lid finish panel, seatback, boot liner and door panel in Passat variant, A4, golf and Bora model.

Georgios Koronis et al. (2013). As per European guidelines 2000/53/EC provided by the European commission, 85% of the weight of products especially automobiles had to be recyclable by 2015. This percentage of recyclable will be increased to 95% by 2025. In order to face balancing sustainability and cost, the automakers are invited to use bio fibers in composites.

J.F. Balart, D. Garcıa-Sanoguera (2016). The results obtained in this study indicate that hazelnut shell flour, a byproduct of the food industry, can optimally be used as reinforcing filler in fully biodegradable compo-sites with poly (lactic acid)–PLA matrix The thermoplastic nature of this materials allows easy processing by conventional extrusion 1 injection moulding processes with high filler content up to 40 wt% and attractive wood-like surface finishing. PLA-based green composites with a hazelnut shell flour content in the 30–40 wt% are the most attracting formulations from an industrial point of view as they offer balanced mechanical properties, full biodegradability and a remarkable decrease in material cost. These formulations could find applications as wood plastic composites (WPCs) in the building industry (fencing, decking, flooring, etc.), automotive interior parts and furniture.

EXTRACTION OF NATURAL FIBERS

The most common methods to separate the plant fibers are dew retting and water retting process. Depending on the fiber category, these methods require approximately 14 to 28 days for the degradation of waxes, pectin, hemicelluloses and lignin. To reduce long processing time, alternative method like **mechanical decortications** has been introduced.

Mechanical Decortications:

The mechanical decorticator consists of a series of components (i.e., rollers, beater and etc.). The space between these rollers is 3 to 8 mm has been maintained for the extraction of the fibers. The outer layers of the fibers such as the gums and the stems skin are eliminated by the continuous feeding of the fibers between the rotating rollers. The decorticated fibers were repeatedly washed with water and dried for 48 hrs in sunlight eliminating the water content from the fibers.

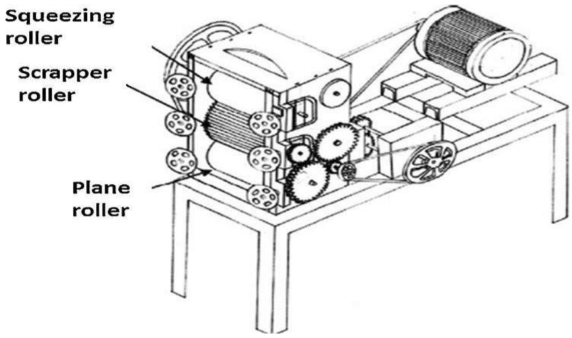


Fig 1. Mechanical Decortications

SELECTION OF FIBERS

FIBERS:

Fiber also known as roughage, is the part of plant-based foods (grains, fruits, vegetables, nuts, and beans) that the body can't break down. It passes through the body undigested, keeping your digestive system clean and healthy, easing bowel movements, and flushing cholesterol and harmful carcinogens out of the body.

SISAL FIBERS:

Common Name **:** Sisal

Tamil Name : Kattukathala

Biological Name **:** Agave sisalana

Fig 2 Sisal Fiber Extraction

Common Name : pineapple leaf

Tamil Name : annachi

Biological Name : ananas comosus

Fig 3. Pineapple leaf Fiber

SELECTION OF RESIN

1. RESIN

A thermosetting resin, or thermoset, is a polymer which cures or sets into a hard shape using curing method such as heat or radiation. The curing process is irreversible as it introduces a polymer network cross linked by covalent chemical bonds. Upon heating, unlike thermoplastics, thermosets remain solid until temperature reaches the point where thermoset begins to degrade.Phenolic resins, amino resins, polyester resins, silicone resins, epoxy resins, and polyurethanes (polyesters, vinyl esters, epoxies, bismaleimides, cyanate esters, polyimides and phenolic) are few examples of thermosetting resins.

Among them epoxies are one of the most common and widely used thermosets today in structural and specialty composites applications. Due to their high strength and rigidity (because of high degree of cross linking), epoxy thermoset resins are adaptable to nearly any application.The term "epoxy", "epoxy resin", or "epoxide" (Europe), α-epoxy, 1,2-epoxy etc. refers to a broad group of reactive compounds that are characterized by the presence of an oxirane or epoxy ring. This is represented by a three-member ring containing an oxygen atom that is bonded with two carbon atoms already united in some other way.

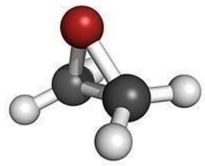


Fig.4. Bond Symbol

Compression Moulding Method:

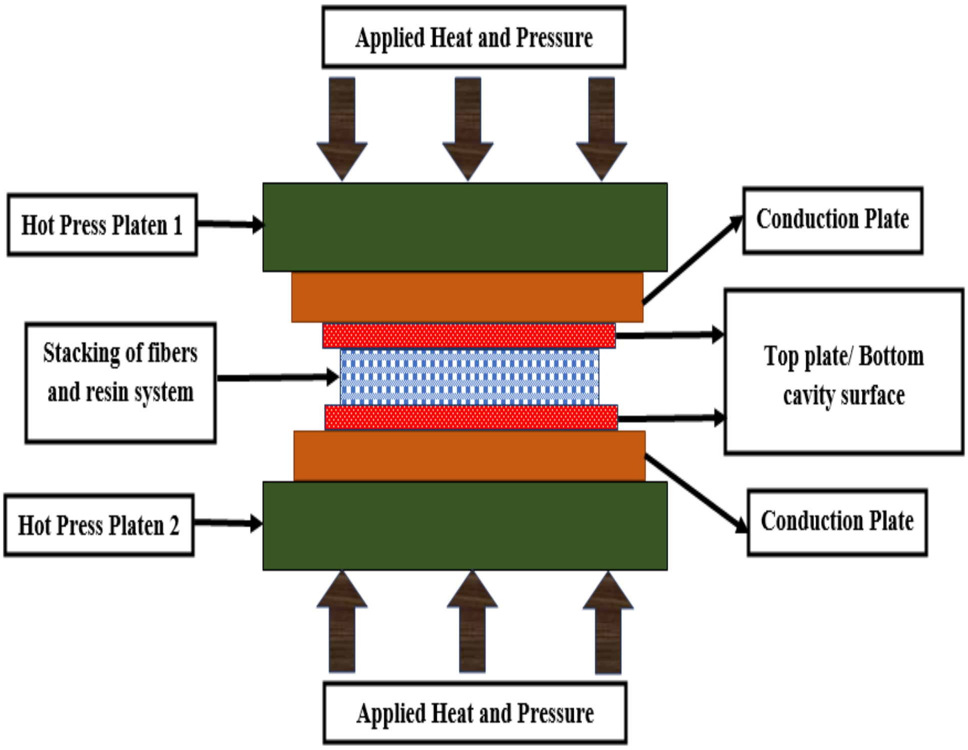


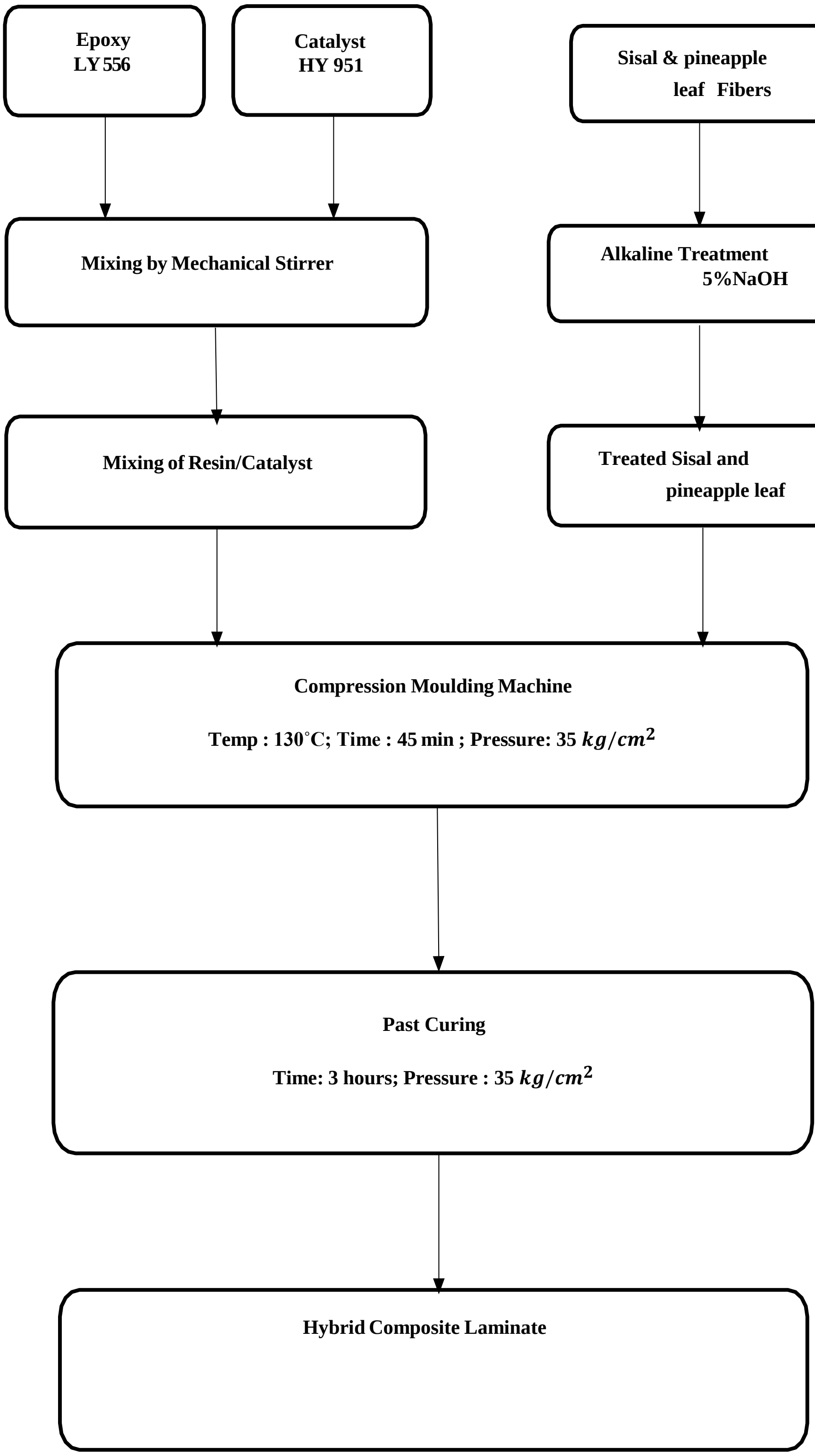
Fig5. Compression moulding method

EXPERIMENTAL PROCEDURE

In this research work, sisal and pineapple leaf fibers are used for fabricating the composite materials. Sisal and Snake grass fibers are extracted by mechanical decortications process. The epoxy resin and hardener were purchased from M/s Covai Seenu Ltd., Coimbatore, India. The physical properties of the sisal and pineapple leaf fibers are presented in table.

Physical Properties of Snake grass and Sisal fibers:

Physical Properties	**Snake Grass Fibre**	**Sisal Fibre**
Density (kg/m3)	887	1.45-1.5
Tensile Strength (MPa)	287-545	350-700
Tensile Modulus (GPa)	9.7	9-22
Elongation (%)	2.87	2-7



Physical Properties of Snake grass and Sisal fibers

The materials used for the experiment were prepared by compression molding techniques. Sisal and Pineapple leaf fibers were cut into 300 mm length to prepare samples. The lamina consists of two layers having sisal and pineapple leaf fibers arranged alternatively. Initially, the epoxy resin was filled over the aluminum foil sheet. The first layer is the sisal fiber, mixture of epoxy resin and hardener was filled over the sisal fiber and then pineapple leaf fiber was filled over the resin. Subsequent layers were filled after resin gets dried. Finally, these laminas were kept in frame, for over 45 minutes at 130 °C and pressure of 35 kg/cm2 was applied for 45 minutes before it is removed from the mold. The laminate size is limited to 30x30x0.5 cm. The fabrication route of the hybrid composites is shown in below.

PROCESS FLOW CHART OF HYBRID COMPOSITES

TESTING OF COMPOSITE

1. LIST OF EXPERIMENTS:

i. Water Absorption Test
ii. Shore D Hardness Test
iii. Wear Test
iv. Tensile Test
v. Compression Test
vi. Impact Test
vii. SEM Analysis

FINAL SAMPLE PLATES:

SAMPLE NO	PICTURE	PINEAPPLE LEAF FIBER (wt.%)	SISAL FIBER (wt.%)	RESIN (wt.%)
1		30%	0%	70%
2		20%	10%	70%
3		15%	15%	70%

4		**10%**	**20%**	**70%**
5		**0%**	**30%**	**70%**

CONCLUSION

The pineapple leaf and sisal fibers reinforced hybrid composites are prepared with different volume fractions. Water absorption, tensile, compression, impact, wear, and hardness tests to be conducted in the phase 2.SEM analysis on the hybrid composite materials was performed to analyze the bonding behavior of materials and internal structure of the fractured surface. It can be concluded that the obtained composites will acts as a low cost, lightweight and eco-friendly composites

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