Performance Analysis of Composite Materials by Hydrostatic Pressure Vessel

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Abstract— For any material to be used in a certain machine the testing of the same is important. This governs the durability of and the robustness of the machine to be used for the prime requirement of the material. For many years different testing procedures have been adopted for the purpose using air pressure, ultrasonic testing etc. but less is carried out using water pressure. This is because water when applied to high pressure does not change its volume hence, the output required is more accurate. So the idea of hydrostatic pressure vessel bought out.

Keywords: Hydrostatic Pressure Vessel, Luffa Fibers

I. Introduction

The use of sponge gourd (Luffa cylindrica) as reinforcement in resin matrix composite materials is evaluated. The morphology of the fibrous vascular system of Luffa's fruit is presented and the advantages of using this natural mat material are highlighted. The use of untreated Luffa does not increase the mechanical properties of the bare resin. Nevertheless, its incorporation produces a change on the fracture mode of the composites from an abrupt one to a controlled and safer one. This result and the values obtained from mechanical tests show that, without any surface treatment, Luffa already has a high potential use as a core material in hybrid composites.

II. Objective

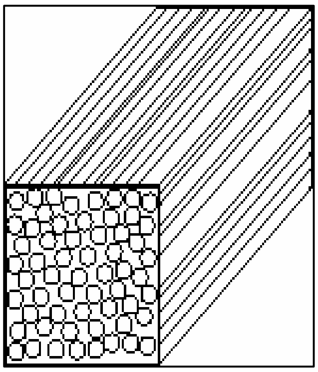
The main objective of this study is to find alternative composite materials that will be used instead of petroleum based materials. luffa sponge has the potential to be used as an alternative sustainable material for various engineering application such as packaging, acoustic and vibration isolation and impact energy absorption.

According to obtained result damping characteristic of Luffa Cylindrica fiber composite materials is higher than glass fiber composites materials. Also the damping properties of Luffa Cylindrica fiber more effective than flax fiber as natural reinforcement. Therefore, this result is significant to find alternative green material. These result demonstrate that plant based fibers can replace petroleum based fibers as a reinforcement in applications that the structures are exposed to vibration excitation, and in application of vibration has major importance,

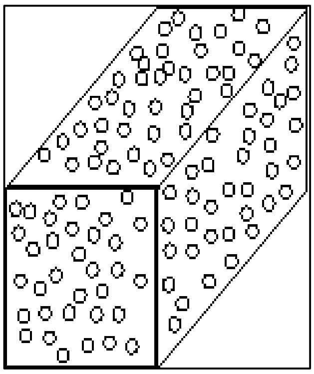
III. Literature review

The purpose of this literature review is to provide background information on the issues to be considered in this thesis and to emphasize the relevance of the present study. This treatise embraces various aspects of natural fiber polymer composites with a special reference to their mechanical and tribological behavior. This projects includes reviews of available research reports. hereby declare that this dissertation entitled "Preparation and Characterization of Luffa Cylindrica Fiber Reinforced Polymer Composite" In recent years, there is increasing environmental concerns, greater attention are being paid towards the use of plant fibers taking the advantages of their abundance and availability as renewable resource and their biodegradability in the environment and economical for their cost effectiveness. Accordingly, a number of review papers have been published on plant fiber-polymer composites. As a matter of fact, interface morphology and surface energy and wetting characteristics are all part of the interfacial phenomena2. Several authors have investigated fiber- matrix adhesion in natural fiber-polyester composites including Luffa fibers through different types of surface treatments. The modification of surface includes both physical treatment (e.g., corona discharge) and chemical (e.g., alkali treatment, benzyl alcohol dewax treatment, acetylation, silane coupling agents, etc.) or thermal treatment. All these treatments as per requirements have usually resulted in changes in the fiber surface structure, their surface energy, crystallinity, chemical composition to influence the mechanical and other properties like water absorption characteristics8-25. It is well known now that due to the surface treatments to the lignocellulosic fibers, good compatibility between fibers and non-polar polymer matrices would be achieved through polymeric chains, which will favour entanglements and interdiffiusion with the matrix. Besides, these surface treatments of the fibers remove some of the materials on the surface ofthe fibers, probably some times leading to defibrilation of individual elementary fibers. Such fibers increase the fiber-matrix interfacial area and also increase the area of load transfer from the fibers to the matrix. It is also reported that some of the chemical treatments such as mercerization removes the lignin and hemicellulose from the lignocellulosic fibers, which affects the chemical composition of the fibers, molecular orientation of the cellulose crystallites in the fibers and degree of polymerization25. Accordingly, various techniques have been used to monitor the treatment carried out by both chemical and physical methods, with the former providing information about the extent of reaction

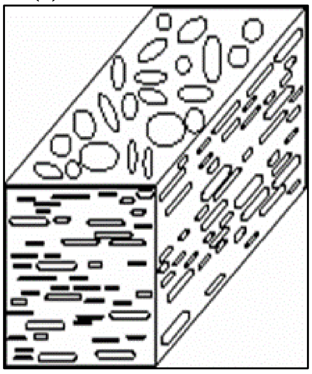
- On natural fibers and natural fiber reinforced composites
- On issues regarding the use of natural cellulose fibers in composites
- On chemical modification of fiber surface
- On hybrid composite
- On wear mechanism and its classification



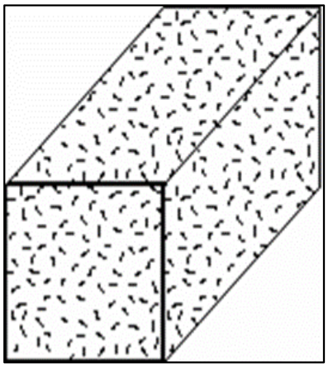
(a) Continuous fiber



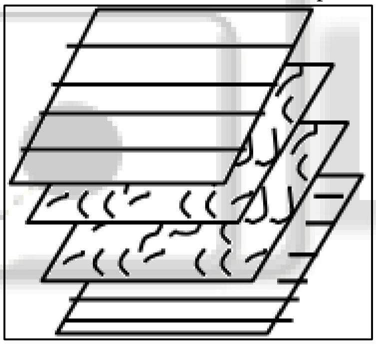
(b) Particulate composites



(c) Flake composites



(d) Random fiber (short fiber) Composite



(e) Laminate Composite

IV. EXPERIMENTAL METHOD

A. *Materials*

Luffa fibers from the Southeast region of Brazil were used as reinforcement in this work. The as received fiber (Fig. 1(a) untreated fiber was ground using a Willy cutter, which showed different fractions with ~ 10% of 40 mesh size, ~ 55% of 60 mesh size, ~18% of 100 mesh size and the remianing more than this. Accordingly, 60 mesh size fibers were used to make mats by compression of either central core, external or internal mat layers. Figures 1(b) and 1(c) show the natural Luffa mat with the outer and the inner structure, respectively, revealing distinct fiber distribution patterns. Unsaturated polyester (ortophthalic) of Araashland, Brazil, was used as the matrix' with PMEK peroxide (Araashland), 3% p/p in relation to the resin. NaOH (analytical grade) and methacrylamide (Aldrich) were used for chemical treatments.

B. *Chemical Treatment to Fibers*

The chemical treatments of the Luffa fibers were carried out as follows: First the ground fibers were washed thoroughly in distilled water followed by drying the fibers in air at room temperature for 24 h. Then the dri90 min or in aqueous methacrylamide solutions of different concentrations - 1, 2 or 3% for different times - 60, 120 and 180 min. Then, both the chemically treated fibers were washed with water until a neutral pH was reached followed by drying them at 60 °C for 24 h. The treatment with methacrylamide may be termed as 'copolymerization' or 'grafting.

C. *Preparation of Composites*

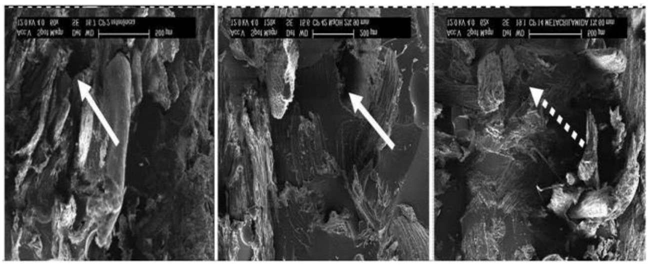


Fig. 4: SEM fractographs of the fractured surface of polyester short-Luffa fiber composites: (a) untreatead Luffa fiber; (b) Luffa fiber treated with NaOH (2 % - 90 min) and (c) Luffa fiber treated with metacrylamide (1% - 60 min).

mold was allowed to cool for 1 h and the composite

Composites were compression molded in a steel mould with an inner cavity of 150 × 150 × 5 (+ 1.5 mm). Alternate layers of dried fibers (70 °C for 2 h) and resin (with the initiator) were placed in the mold until the intended amount of material had been used. The mold was closed, placed in a press and subjected to 3.6 MPa pressure for 2 h at 70°C. There was retrieved. Fiber volume fraction (% Vf) in the composites was kept at 42.6 % and 24.5-35.2 % for the short-fiber and fiber mat composites, respectively. The amount of the fibers in the mats used in accordance with the convenience of molding for the fabrication of the composite.

V. CONCLUSIONS

It was possible to prepare composites with both short fibers and mats of Luffa cylindrica with polyester matrix by compression molding. Surface treatment of Luffa fibers with 2% NaOH for 90 min was found to be the best treatment with reference to highest fracture energy. However, no significant increase in tensile strength of the composites wasobserved compared to untreated fiber composites.

These composites presented water absorption similar to those of other plant fiber like sisal-, jute- or rami-polyester composites.

Nevertheless, fiber treatment with methacrylamide was efficient in decreasing water absorption of the composites. The composites containing 35.3% volume fraction of Luffa mats treated for 90 min with 2% NaOH aqueous solution exhibited the best tensile properties although still lower than those of other plant fiber composites. In view of the good appearance of Luffa/polyester composites prepared with short fibers, their use as ornamental panels, linings and products without structural function may be envisaged available in China, Japan, India and other countries in Asia as well as in Central and South America. The sponge guard are being used as component of shock absorbers, sound proof linings, utensils cleaning sponge, packing materials, for making crafts, filters in factories and part of soles of shoes.

Very limited scientific information available on this fruit in literature specially related to its structure and properties.

The importance of the luffa sponge material is growing in our society because of the search for sustainable solutions using new materials. In a recent study the authors discovered that under quasi-static loading the luffa sponge material exhibits remarkable stiffness, strength and energy absorption capacities that are comparable to those of a variety of metallic cellular materials. It is interesting to note that this fiber contains cellulose 55-90%, hemicelluloses 8-22%, lignin 10-23%, and extractives 3.2 % and ash 0.4%. This makes it suitable for reinforcing material in polymer matrix Very limited research has been conducted in the past on this (luffa sponge) fibre as a potential reinforcement in bio composite. Those research findings indicate that it is a potential alternative material for packaging, water absorption and waste water treatment The luffa fibers were also used as reinforce-cement fiber for other materials and cell immobilization for biotechnology. From these findings it can be conclude that the full potential of luffa fiber is yet to be explored. Hence in the present work the main focus is to prepare a polymer matrix composite (PMC) using epoxy resin as matrix material and luffa cylindrica fiber as reinforcement material.

(a) (b) (c)

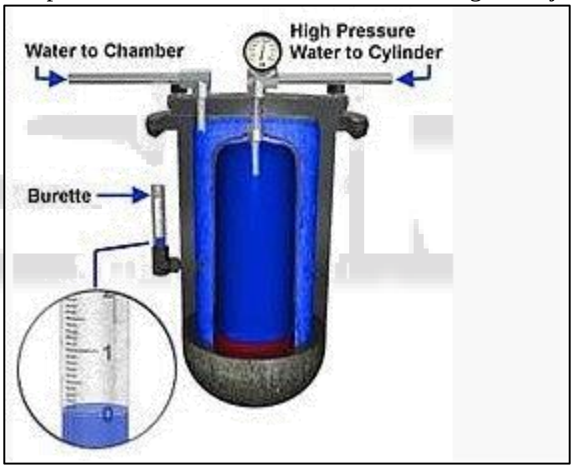
Fig. 5: Photograph of (a) Luffa cylindrica as-received and natural Luffa mat-(b) the outer structure and (c) the inner structure

VI. HYDROSTATIC PRESSURE VESSEL

A hydrostatic test is a way in which pressure vessels such as pipelines, plumbing, gas cylinders, boilers and fuel tanks can be tested for strength and leaks. The test involves filling the vessel or pipe system with a liquid, usually water, which may be dyed to aid in visual leak detection, and pressurization of the vessel to the specified test pressure. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss. The location of a leak can be visually identified more easily if the water contains a colorant. Strength is usually tested by measuring permanent deformation of the container. Hydrostatic testing is the most common method employed for testing pipes and pressure vessels. Using this test helps maintain safety standards and durability of a vessel over time. Newly manufactured pieces are initially qualified using the hydrostatic test. They are then re-qualified at regular intervals using the proof pressure test which is also called the modified hydrostatic test. Testing of pressure vessels for transport and storage of gases is very important because such containers can explode if they fail under

A. *Testing Process*

Hydrostatic tests are conducted under the constraints of either the industry's or the customer's specifications, or may be required by law. The vessel is filled with a nearly incompressible liquid - usually water or oil - pressurised to test pressure, and examined for leaks or permanent changes in shape. Red or fluorescent dyesmay be added to the water to make leaks easier to see. The test pressure is always considerably higher than the operating pressure to give a factor of safety. This factor of safety is typically 166.66%, 143% or 150% of the designed working pressure, depending on the regulations that apply. For example, if a cylinder was rated to DOT-2015 PSI (approximately 139 bar), it would be tested at around 3360 PSI (approximately 232 bar). Water is commonly used because it is cheap and easily available, and is usually harmless to the system to be tested. Hydraulic fluids and oils may be specified where contamination with water could cause problems. These fluids are nearly incompressible, therefore requiring relatively little work to develop a high pressure, and is therefore also only able to release a small amount of energy in case of a failure - only a small volume will escape under high pressure if the container fails. If high pressure gas were used, then the gas would expand to V=(nRT)/p with its compressed volume resulting in an explosion, with the attendant risk of damage or injury.



Small pressure vessels are normally tested using a water jacket test. The vessel is visually examined for defects and then placed in a container filled with water, and in which the change in volume of the vessel can be measured, usually by monitoring the water level in a calibrated tube. The vessel is then pressurised for a specified period, usually 30 or more seconds, and if specified, the expansion will be measured by reading off the amount of liquid that has been forced into the measuring tube by the volume increase of the pressurised vessel. The vessel is then depressurised, and the permanent volume increase due to plastic deformation while under pressure is measured by comparing the final volume in the measuring tube with the volume before pressurisation. A leak will give a similar result to permanent set, but will be detectable by holding the volume in the pressurised vessel by closing the inlet valve for a period before depressurising, as the pressure will drop steadily during this period if there is a leak. In most cases a permanent set that exceeds the specified maximum will indicate failure. A leak may also be a failure criterion, but it may be that the leak is due to poor sealing of the test equipment. If the vessel fails, it will normally go through a condemning process marking the cylinder as unsafe.

The information needed to specify the test is stamped onto the cylinder. This includes the design standard, serial number, manufacturer, and manufacture date. After testing, the vessel or its nameplate will usually be stamp marked with the date of the successful test, and the test facility's identification mark.

A simpler test, that is also considered a hydrostatic test but can be performed by anyone who has a garden hose, is to pressurise the vessel by filling it with water and to physically examine the outside for leaks. This type of test is suitable for containers such as boat fuel tanks, which are not pressure vessels but must work under the hydrostatic pressure of the contents. A hydrostatic test head is usually specified as a height above the tank top. The tank is pressurised by filling water to the specified height through a temporary standpipe if necessary. It may be necessary to seal vents and other outlets during the test.

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