ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 19, April 2016

Mode 1 Fracture analysis of Treated and Untreated Banana-Jute-Glass Composite with NaOH

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Abstract—

This project titled Mode 1 Fracture analysis of Treated and Untreated Banana-Jute-Glass Composite with NaOH has been conceived having studied the utilization of natural fibres in polymer composites.Due to the establishment of disposal methods for glass fibre reinforced plastics and their recycling laws are important contemporary subjects because many environment problems have appeared and worsened throughout the world. Due to global warming and other environmental effect, the search for the alternative and environmentally friendly material is a head. Among various natural fibres, banana and jute fibre is of particular interest in that its composites have high tensile strength, high tensile modulus, and low elongation at break beside its low cost and eases of availability. Now the project mainly concentrated on reinforcement of polymer plastics with different combination of banana-jute-glass composite.These composites are subjected to mode 1 fracture analysis. The main objective of the project is to choose the best material out of our compositions.

Keywords—Mode 1 Fracture Analysis; Composites; Reinforcement;

I. INTRODUCTION (*HEADING 1*)

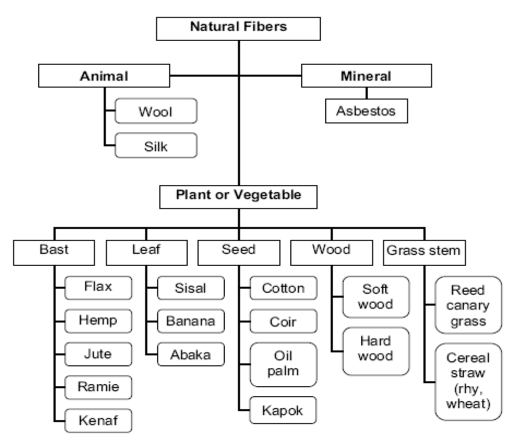
In the past decade, natural-fibers with thermoplastic and thermoset matrices have been embraced by car manufacturers and suppliers for door panels, seat backs, headliners, package trays, dashboards, and interior parts. Earlier FRP's are used in automotives for their light weight, high stiffness and strength for many applications.

Due to the establishment of disposal methods for glass fiber reinforced plastics and their recycling laws are important contemporary subjects because many environment problems have appeared and worsened throughout the world. Due to global warming and other environmental effect, the search for the alternative and environmentally friendly material is a head.

The use of natural fiber reinforced plastics represents attractive and suitable methods for replacing the synthetic fibers. Natural fibers are light and renewable; they are low-cost and high specific strength resource. Among various natural fibers, banana fiber, Jute Fiber is of particular interest in that its composites have high tensile strength, high tensile modulus, and low elongation at break beside its low cost and eases of availability.

Among the various synthetic material that have been explored as an alternate to iron and steel for the use in automotive, plastics claim a major share as substitute. During the last decade, the study of filled plastic composites has simulated immense interest in meeting the shortage of plastic materials Plastics are used for almost everything from the articles of daily use to complicated structures; machine components etc.

Plastics find an extensive application as they are less weight, low water absorption, high stiffness and strength. In fact synthetic fibers like nylon, rayon, aramid, glass, polyester and carbon are extensively used as a reinforcement of plastics. At present due uncertain condition in the shortage and the cost of petroleum and it's by products there is a need to search for its alternate, which is nothing but natural. In recent years the vegetable/plant fibers proves itself as an alternative fibre to its synthetic counterpart.



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Objective

To Fabricate Banana-Jute-Glass Polyester Composite in Mat Form

To find the stress intensity factor of mode 1 facture analysis of Banana-Jute-Glass Fiber Composite Treated and Untreated With NaOH Alkali and to Compare with Combinations of Banana-Jute-Glass Fiber

Introduction to natural fiber composites

Although fiber-reinforced polymers (FRP) have until now been largely applied to various fields of engineering, these materials have also been used in many technical applications, especially where high strength and stiffness are required, but with low component weight. The good specific (i.e., weight-related) properties are due to the low density of the applied matrix systems (unsaturated polyesters, polyurethanes, phenolic or epoxy resins) and to the embedded fibers that provide the high strength and stiffness (glass, aramid, and carbon fibers). Furthermore, great use is made of the fact that composite parts can be tailor-made during production specifically by orientating the reinforcing fibers in the directions of the applied load. In this way, the compound material is itself a direct result of structural manufacture and many different technologies have been developed in order to achieve the required property.

Currently, polymeric based composite materials are being used for many life applications, such as, automotive, sporting goods, marine, electrical, industrial, construction, household appliances etc. because of their unique properties with high strength and stiffness, light weight, economical and corrosion resistance. In past decade, the research work on polymer based composite materials has been devoted as the use of these materials has been increased tremendously in many applications. As a reinforcement material, the natural fibers are free resource to reinforce into polymer matrix in order to develop a light and strong material. Recently, natural fibers (such as, flax, jute, cotton, coconut etc.) are being used as a reinforce material into polymeric based matrix for enhancing the mechanical properties of the basic polymer.

The possible advantages of such natural fiber composites (NFC) could be

- Natural fibers are renewable resources.
- Lower pollution level during production.
- Energy necessary for fiber production is lower than that of glass.
- CO2 neutral: amount of CO2 neutralized during fiber plant.
- Growth is comparable with that emitted during processing.
- Lower cost.
- Less abrasive to the processing equipment.
- Low density is the main point why NFC is interesting in automotive sector.

Using biodegradable polymers as matrix, we can have totally recyclable materials.ent. Please do not revise any of the current designations.

Types of composite materials

Broadly, composite materials can be classified into three groups on the basis of matrix material. They are

i. Metal Matrix Composites (MMC)

ii. Ceramic Matrix Composites (CMC)

iii. Polymer Matrix Composites (PMC)

Metal matrix composites

Higher specific modulus, higher specific strength, better properties at elevated temperatures and lower coefficient of thermal expansion are the advantages of metal Matrix Composites over monolithic metals. Because of these attributes metal matrix composites are under consideration for wide range of applications viz. combustion chamber nozzle (in rocket, space shuttle), housings, tubing, cables, heat exchangers, structural members etc.

ii. Ceramic matrix Composites

One of the main objectives in producing ceramic matrix composites is to increase the toughness. Naturally it is hoped and indeed often found that there is a concomitant improvement in strength and stiffness of ceramic matrix composites.

iii. Polymer Matrix Composites

Polymeric matrix composites are the most commonly used matrix materials. The reasons for this are two-fold. In general the mechanical properties of polymers are inadequate for many structural purposes. In particular their strength and stiffness are low compared to metals and ceramics. By reinforcing other materials with polymers these difficulties can be overcome. Secondly high pressure and high temperature are not required in the processing of polymer matrix composites. For this reason polymer composites developed rapidly and became popular for structural applications with no time. Polymer composites are used because overall properties of the composites are superior to those of the individual polymers.

Materials

HARDENER

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A substance of mixture added to a plastic composition to take part in and promote or control the curing action, also a substance added to control the degree of hardness of the cured film. See also curing agents, catalyst and cross-linking All working times (pot life) are based upon an optimum working temperature of about 80 degrees F. temperatures variations will greatly affect curing times, and when below 65F can sometimes double curing times. Other factors that affect epoxy curing can be moisture and humidity, as well as the thickness of lamination.

GLASS FIBERS

The most common reinforcement for the polymer matrix composites is a glass fiber. Most of the fibers are based on silica (sio2), with addition of oxides of ca, b, na, fe, and al. the glass fibers are divided into three classes -- e-glass, sglass and c-glass. the e-glass is designated for electrical use and the s-glass for high strength

JUTE FIBERS

Jute is an agricultural product and chemically known as ligno-cellulosic fiber. The fibres are arranged in the bast or phloem region of the jute plant consisting of pyramidal wedges, fibre bundles in each wedge are further arranged in large number (8 to 12) layers. The ultimate cells of individual fibres are formed by the alpha-cellulose where as the presence of hemi-cellulose and lignin cements the ultimate fibres. As a result jute fibres form a mesh or network in which the individual fibres or strands have no identity.

Jute is mainly composed of polysaccharides and lignin but it also contains smaller amount of fats and waxes, pectin, nitrogenous, coloring and inorganic matters. The polysaccharides or glucose units are of two types such as alpha-cellulose (C6H10O6)n and hemi-cellulose.

BANANA FIBER

Banana plants are now found in most tropical regions. In Tamilnadu, they are extensively grove in Theni. The banana plant has a tree-like appearance and a trunk-like stalk, although h contains no woody material and can grow from 3.0 m to 9.0 m.

The stalk, which ranges in diameter from 200 mm to 370 mm, consists of layers of overlapping leafstalk surrounding a hollow core. At the end of each stalk is a dark-green oblong leaf, measuring about 3600 mm by 600 mm. The stalk contains long multi-celled fibres extending length-wise through the pulpy tissues of long leaves or leaf-stems.

Banana fibres are obtained from the pseudo stem of the banana plant. The pseudo stem is called stalk, and is surrounded and supported by leaf sheaths which contain many fibres. A normal stalk is 1.8 m to 3.0 w long and 0.2 m to 0.3 m wide, and each leaf contains fibres in the outer layers. The processes of obtaining banana fibre typically involve manual or mechanical scraping.

MATERIAL PREFERENCES

Resins: Epoxy, polyester, vinyl ester, phenolic and any other resin.

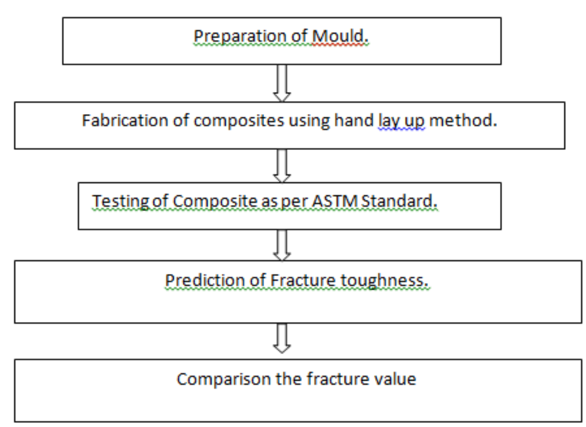
Fibers: Glass,Banana,Jute, Carbon, Aramid and any other reinforcement, although heavy aramid fabrics can be difficult to wet-out by hand.

Cores: Any core materials can be used provided that should be compatible with resin system, i.e. polystyrene core cannot be used with polyester or vinylester resin system.

SELECTED MATERIAL

Banana-Jute-Glass fibre composite:

1. Banana fiber
2. Jute fiber
3. Glass Fiber
4. Polyester Resin
5. Methyl ethyl ketone (Accelerator)
6. Cobalt (Catalyst)
7. Polyvinyl (Separator).



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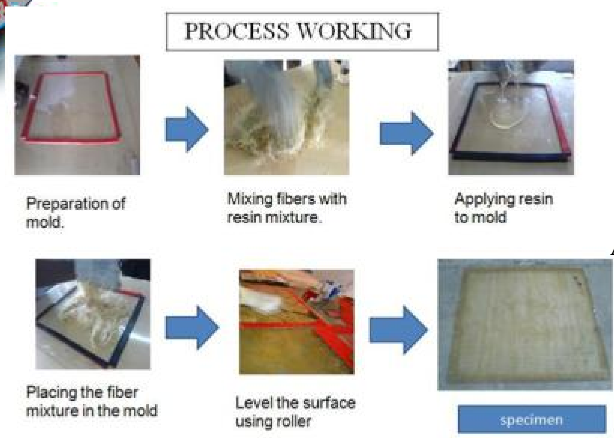


Chemical Treatment on Natural fibers

Alkaline treatment or mercerization is one of the most used chemical treatment of natural fibers when used to reinforce thermoplastics and thermosets. The important

modification done by alkaline treatment is the disruption of hydrogen bonding in the network structure, thereby increasing surface roughness. This treatment removes a certain amount of lignin, wax and oils covering the external surface of the fiber cell wall, depolymerizes cellulose and exposes the short length crystallites . Addition of aqueous sodium hydroxide (NaOH) to natural fiber promotes the ionization of the hydroxyl group to the alkoxide

Thus, alkaline processing directly influences the cellulosic fibril, the degree of polymerization and the extraction of lignin and hemicellulosic compounds. In alkaline treatment, fibers are immersed in NaOH solution for a given period of time. These researchers observed that alkali led to an increase in amorphous cellulose content at the expense of crystalline cellulose. It is reported that alkaline treatment has two effects on the fiber:

(1) it increases surface roughness resulting in better mechanical interlocking; and

(2) it increases the amount of cellulose exposed on the fiber surface,

thus increasing the number of possible reaction sites . Consequently, alkaline treatment has a lasting effect on the mechanical behavior of flax fibers, especially on fiber strength and stiffness . Reported that alkaline treatment gave up to a 30% increase in tensile properties (both strength and modulus) for flax fiber–epoxy composites and coincided with the removal of pectin. Alkaline treatment also significantly improved the mechanical,Fracture toughness behaviors of fiber-reinforced composites

SPECIMEN SPECIFICATION:

DESIGN AND MANUFACTURING

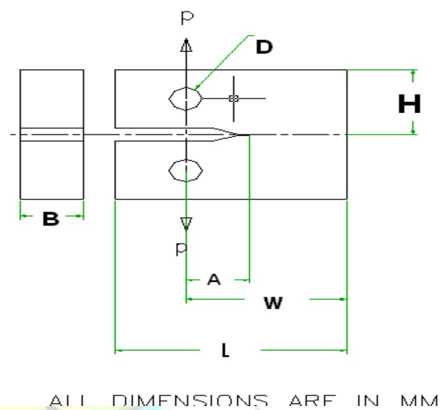
Length: 100 mm

Breath: 90 mm

Thickness: 3 mm

ASTM STANDARD D709 FRACTURE TEST SPECIMENS

The compact tension specimen is a notched sample and is a standard specimen in accordance with ASTM and ISO standards. The crack will begin on the point of the notch and extend through the sample. CT specimens are used extensively in the area of fracture mechanics and corrosion testing, in order to establish fracture toughness values for a material. CT specimens are used for experiments where there is a shortage of material available due to their compact design.



ASTM D709 test specimen for fracture toughness

P- load at which crack propagate

B- Thickness of the test specimen

W- Length of the specimen from the centre of the hole

A- crack length

H- Half height

L–Total length

D- Diameter of the hole

As per ASTM D709 standard dimension in material cutting

ASTM dimension

Mode-I –

Specimen size 90 x 100x 3 mm,

Notch dimension 45 mm

Notch width 3 mm

Holes size Ø8 mm

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Testing Procedure

The machine used for Fracture test is ***Instron 4204*** *Universal Testing Machine*

After finishing the fabrication of specimen, that specimen is fitted on the machine by the procedure mentioned below.

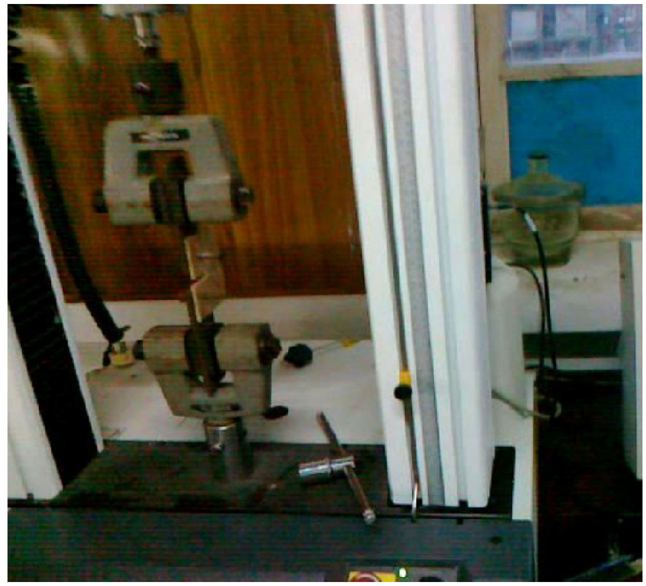
The testing of the specimen is done with the help of **Instron 4204 Universal Testing Machine.**

The 2 bolts is inserted in the 8mm diameter hole.

That 2 bolts are fixed in the testing machine.

Thus the specimen will be fixed in the testing machine for conducting CT test.

The testing machine will be connected with the computer to find out the required results digitally



Now switch ON the machine to find out the crack produced in the specimen.

Note down load which produce the crack in specimen from the computer.

Follow the same procedure for various specimens and find out the load from the computer.

This the testing procedure to find out the crack produced in the CT specimen.

Design Calculation

Fracture toughness is a property which describes the ability of a material containing a crack to resist fracture, and is one of the most important properties of any material for virtually all design applications. It is denoted KIc and has the units of pa mm1/2

Modes of Fracture:

Mode I crack – Opening mode (a tensile stress normal to the plane of the crack)

Mode II crack – Sliding mode (a shear stress acting parallel to the plane of the crack and perpendicular to the crack front)

Mixed Mode crack – Tearing mode (a shear stress acting parallel to the plane of the crack and parallel to the crack front)

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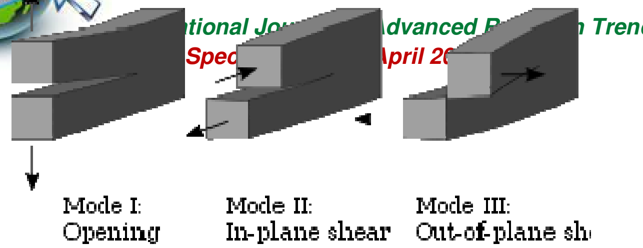


MODE I FRACTURE

Stress intensity factor can be considered as an estimate of fracture toughness. The critical stress intensity factor for mode I is given by the equation. $K_{IC} = (P/BW^{1/2})f(x)$

$f(x) = (2+x)(0.886+4.64x-13.32x^2+14.72x^3-5.6x^4)$ where:

P = Load at which crack propagates in N

B = Specimen thickness in mm

W = Specimen width in mm

a = Crack length in mm

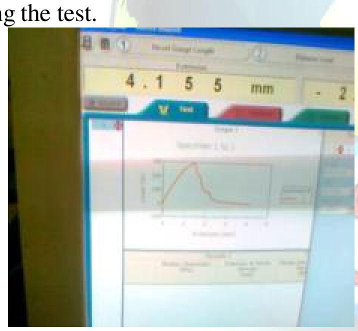
x = a/W

a.

RESULTS AND DISCUSSION

The fracture tests were conducted on three samples for each composite. The fracture test was carried out in universal testing machine. At the end of the test maximum load at crack propagate is observed. The values of Kic were obtained by using equations

P is the corresponding peak load for each type of composites, where B, a, w are geometrical properties. The following results were obtained as shown below. Load value is found from graph obtained during the test.



Composite test specimens (specimen1, specimen 2, specimen 3) for the same fibre composite were tested in the universal machine. The variations in load for the fibre composite were tabulated.

Then average load is calculated from the loads obtained from the each composite. The average load is used for calculating fracture toughness value of composite

Load (N) (Treated/Untreated with NaOH)	Critical stress intensity factor (Mpa mm1/2)
Banana-untreated	
5000	68.89
5400	74.40
5500	75.78
banana-treated	
5300	73.13
5700	78.53
5600	77.40
jute-treated	
3800	52.44
3900	53.73
3800	52.36
banana-jute untreated	
6500	89.56
6600	91.07
6700	92.31
banana-jute treated	
7200	99.20
7300	100.73
7100	97.82
banana-jute-glass untreated	
9200	126.76
9200	126.95
9300	128.13
banana jute-glass treated	
9700	133.64
9600	132.27
9600	132.47

CONCLUSION

India is one of the largest Banana,Jute producing countries in the world the use of its fiber and its wastes for producing useful components would be very attractive on the economic point of view. Banana , Jute fiber and its composites can be further attractive if a suitable cost–effective design method of fiber separation and its composite production may increases its application to a greater extent. Composites based on Glass-banana-jute treated with alkali fibers have very good potential use in the various sectors like construction, automotive, machinery etc.

In this study, the effects of Banana-Jute-Glass fibre is tested for fracture property . Fracture toughness tests were performed on various composites with fibre mate form. It can be concluded that fracture toughness is improved with the reinforcement of glass fibre as well as banana fibre and Jute Fiber (Glass-Banana-Jute) when treated with NaOH alkali

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Contribution of Present Work

The Fracture Toughness of Banana-Jute-Glass Composite when treated with an alkali is more. From this result it is inferred that alkali has its Positive effect on Composite by increasing its Fracture Toughness.

The Combination of Banana Jute Glass Composite has more strength when compared individually. Also implementing banana jute in composite will be eco friendly as when compared with synthetic fiber

Scope of Future Work

This results can be compared with other natural composites like Sisal, Hemp, etc., Those composites could be treated with other alkalies like $KMnO_4$.

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