JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

MECHANICAL CHARACTERIZATION OF LUFFA ACUTANGULA AND SUGARCANE BAGASSE REINFORCED HYBRID COMPOSITE

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Abstract : The fibre-reinforced polymer composite are widely used in engineering applications and there is an increasing need to understand the mechanical and tribological behavior of such composites. Due to increase in environmental awareness, the world attracts towards the utilization of natural materials. The natural/renewable fibres are widely used for the fabrication of fibre-reinforced polymer composites. The *Luffa acutangula* and Sugarcane Bagasse fiber falls in natural fiber category have low weight. The *Luffa acutangula* Sugarcane Bagasse fibre is a lingo-cellulosic fibre with high strength, light weight, smaller elongation, fire resistance quality, strong moisture absorption quality, great potentialities and biodegradability. The *Luffa acutangula* fibre based composites are extensively used in automobile industries for the production of under floor safety panels in luxurious cars like Mercedes. The study of tribological properties of these composite is necessary due to failure of machine parts. Accordingly, the key objective of this study is to investigate the effect of fibre length, fibre loading % wt on mechanical properties (tensile strength, flexural strength, impact strength and hardness) and erosion behaviour of *Luffa acutangula* and Sugarcane Bagasse fibre reinforced polymer composites. This investigation revealed that variation in length of *Luffa acutangula* and sugarcane Bagasse fibre, and % wt of fibre loading affects the mechanical properties (tensile strength, flexural strength, impact strength and hardness) *Luffa acutangula* and sugarcane Bagasse reinforced composites. The best tensile strength, flexural strength and impact strength of the *Luffa acutangula* fibre reinforced polymer composites is achieved with 10 mm fibre length, fibre loading of 20 % by weight, while maximum hardness is achieved with 10 mm fibre length, fibre loading of 20 % weight.

***Index Terms – Luffa Acutangula* fibre, length of fibre, fibre loading, mechanical properties.**

I. INTRODUCTION

There is a wide range of materials that are available for the manufacturing of different parts or products. These materials are broadly classified as: (a) Metals (b) Polymers (c) Ceramics (d) Composites. In recent days various light weight materials with excellent mechanical and tribological properties are available for various engineering applications. One of the examples in this category is the composite material [1].

Composites can be used in the field of engineering & technology i.e. civil construction, marine, automotive, aerospace, turbine blades, telecom equipments, turbine blades, because of their excellent corrosion resistance and strength to weight ratio [2]. A composite consist a mixture of two or more than two constituents with an interface that separate them. The separate constituent is known as reinforcement while continuous phase is known as matrix. If the reinforcement is fibre then it is named as Fibre Reinforced Polymer (FRP) composites [3].

Due to the outstanding fracture resistance, low electrical resistivity, high wear resistance, vibration damping capacity, good corrosion resistance, light weight, rigidity, low coefficient of friction, high thermal conductivity, and exceptional strength. It is used in the fields of aviation, space exploration, satellites, vehicles, ships, and civic infrastructure, among other things, fiber reinforced polymer composites are frequently employed. [4].

Commonly used Fibres are carbon, aramid glass and natural fibres, while matrix is thermoplastic and thermoset resin. The fibre and the matrix exist together in layers and they perform different functions. The fibre reinforcement is the main load bearing member while the matrix maintains the exact position and orientation of the fibre and it also works as a medium for load transfer and keeps the fibre safe from environmental hazards [5].

II. LITERATURE REVIEW

Baruch et al. [13] examined the crystallinity, crystallite size and lattice distortion of banana fibre (musa velutina) .The degree of crystallinity was obtained as 45%. The result shows that banana species can be used as raw material for the pulp paper and textile industries.

Rawal [14] studied the chemically pre treated cotton, banana and jute fabrics. It has been found that bleaching done with H_2O_2 improve the quality of cotton, cotton/ banana and jute/cotton. It is also been found that addition of silicone softener improves the bending strength to all fabrics.

Joseph et al. [8] made compared phenol formaldehyde (reinforced composites) with glass fibres and banana fibres on the basis of mechanical properties. Banana and glass fibres in different lengthand in different lengthpercentage have been taken for the fabrication of composites. The optimization of fibre loading and lengthof fibre for maximum tensile, flexural and impact strength has also been carried out. It has been revealed that as the fibre loading and lengthof fibre increases, the mechanical properties of both fibres also increases.

Behra et al. [3] fabricated two samples of fibre i.e banana-cotton mixture where banana fibre used as weft and another of pure cotton, where fibre used as wrap. It has been found that banana is thicker, stiff filament, stronger, coarser while cotton fibre possess low moisture comparatively. Cotton fibre is more compressible with high flexural rigidity and high bending modules and is more extensible. Cotton banana union fabric is more durable than cotton fabric in the weft direction.

Chen et al. [6] fabricated sandwich composites using natural fibres to study the wet properties, thermal and mechanical properties. The DMA results reveal that the composite is homogeneous, with a higher softening temperature of 140°C and a melting temperature of 160°C ,that shows for manufacturing high performance automotive components it is very important the right selection of bonding fibres.

III. PROBLEM STATEMENT

The glass fibre is widely used fibre for the fabrication of fibre reinforced composites because of its properties like corrosion resistance, good tensile strength and low stiffness light weight. Therefore, glass fiber reinforced composites are widely used in the maritime and chemical industries to build components but at the same time natural fibres are safer to use, cost effective and no side effect on human being therefore these can be better alternative to glass fibres. In the presence of moisture, natural fibres based composites exhibited poor interfacial bonding to the matrix [16]. The objective of present research is to explore the potentials of Luffa acutangula (Ridge Gourd) and cane Bagasse reinforced composites which can be used in many engineering applications like in automobile and construction field.

3.1 METHODOLOGY

To achieve the objectives of present fabrication of composites, the flow chart of the action plan is shown in Fig. 1.1, Initially, review of literature in the field of fibre reinforced composites is to be carried out to find the research gap. Then on the basis of research gap, research objectives of the present research are to be finalized. Then alter, fabrication of different *Luffa* based hybrid composites is to be fabricated using hand-layup technique.

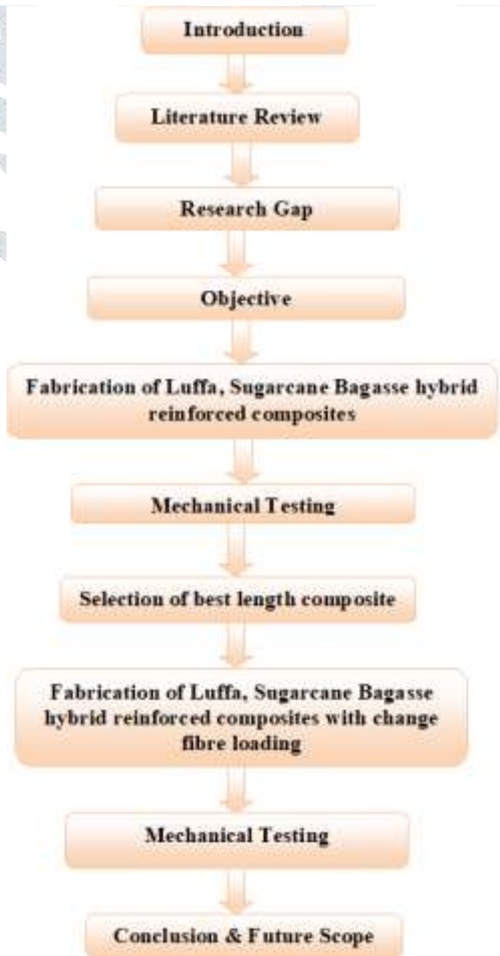

Fig.1 Methodology

3.2 Fabrication and Testing of Fibre Reinforced Composites

The mechanical and tribological properties of *Luffa acutangula* (Ridge Gourd) reinforced, sugarcane Bagasse and hybrid composites depends on the fibre loading, length of fibre, adhesion between fibre and matrix. In the present work, *Luffa acutangula* (Ridge Gourd), sugarcane Bagasse and hybrid composites in different weight %, different fibre loading have been used for this investigation

3.2.1 Luffa acutangula (Ridge Gourd)

For fabrication of fibre reinforced polymer composite, chopped *Luffa acutangula* (Ridge Gourd) is used as reinforced material. Scientifically *Luffa acutangula* (Ridge Gourd) is known as *Luffa* aegyptiaca. The hemi-celluloses, cellulose, pectin, lignin, and some extractives are the main organic constituents of *Luffa acutangula* (Ridge Gourd). The *Luffa acutangula* (Ridge Gourd) has low density as compare to glass fibre. It has high strength, light weight, smaller elongation, fire resistance quality, strong moisture absorption quality, great potentialities and biodegradability. The *Luffa acutangula* (Ridge Gourd) reinforced polymer composites are being employed in automobile companies for the production of under floor safety panels in cars. *Luffa acutangula* (Ridge Gourd) based composite is used for making buildings boards and fire resistance boards. Therefore, in this study, *Luffa acutangula* (Ridge Gourd) is used as reinforced material for the fabrication of composites. The figure 3.1(a) and 3.1(b) shows the pictorial view of uncut and chopped non woven *Luffa acutangula* (Ridge Gourd) respectively.

Fig. 3.1(a) Pictorial view of *Luffa acutangula*

Fig. 3.1(b) Nonwoven *Luffa acutangula*

3.2.2 Sugar Cane Bagasse

Chopped sugarcane bagasse, with dimensions of roughly 5-15 mm in length and 1 mm in width, contains cellulose, lignin, ash, and many extractives that are used to fabricate fiber-reinforced polymer composites. The molecular makeup of bagasse fiber. Natural resource-based fillers and fibers offer excellent particular qualities, low densities, and affordable prices, with a few drawbacks such as inadequate moisture resistance. Agro-industrial leftovers can be economically utilized and a variety of value-added products can be produced using sugarcane bagasse. It has also been discovered that the creation of a composite material with bagasse fiber is appropriate for materials utilized in car interiors. The first applications for bagasse-reinforced epoxy composites were as wooden agglomerate replacements. The figure 3.2(a) and 3.2(b) shows the pictorial view of uncut and chopped sugarcane bagasse.

Fig. 3.2(a) Pictorial view of Sugarcane Bagasse

Fig. 3.2(b) chopped Sugarcane Bagasse

3.2.3 Matrix Material

In the present study, Bisphenol-A-Dig!ycidyl-Ether also called Diglycidyl ether supplied by S M & Sons J341C, RIICO, Industrial Area, Sarna Doonger, moorti zone, Jhotwara, Jaipur is used as a matrix material. It is commonly used thermosetting polymeric epoxy resin. The thermosetting polymeric epoxy resin exhibits superior properties like excellent mechanical, chemical and corrosion resistance properties and low shrinkage during cure. Therefore, thermosetting polymeric epoxy resins are widely used for the fabrication of different composites.

The Hinpoxy C Hardener is supplied by S M & Sons J 341C, RIICO, Industrial Area, Sarna Doonger, moorti zone, Jhotwara, Jaipur, has been used with Bisphenol-A-Diglycidyl-Ether in the required proportion by length i.e. 1:3 ratio. The Hinpoxy C Hardener is a modified amine hardener. Table 3.1 shows the properties of matrix material used in the present work.

Table-1

Ingredients of Matrix Material

Ingredients	Chemical name	Density at 25^0C	Supplier
Epoxy Resin	Bisphenol-A-Diglycidyl-Ether	116-120 (g/cm^3)	S M & Sons J 341C, RIICO, Industrial Area, Sarna Doonger,moorti zone, Jhotwara, Jaipur - 302012, Rajasthan, India
Hardener	Amine	0.94-0.95 (g/ml)	S M & Sons J 341C, RIICO, Industrial Area, Sarna Doonger,moorti zone, Jhotwara, Jaipur - 302012, Rajasthan, India

3.3 Specimen Preparation Method

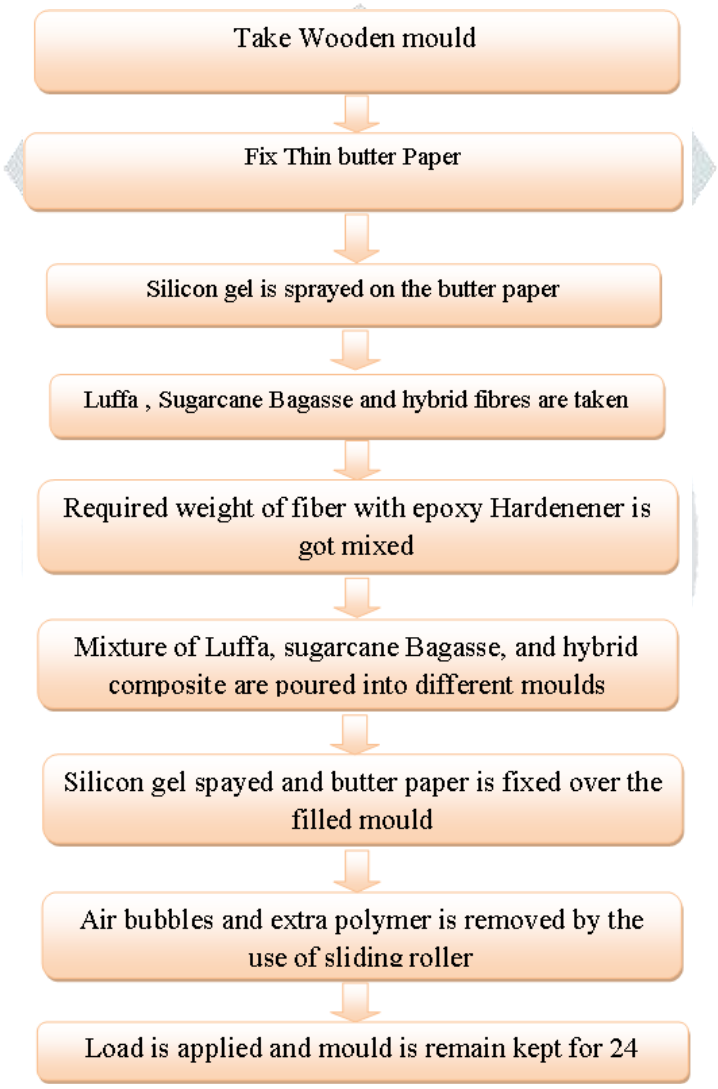

Fig. 2 Specimen Preparation Method

3.4 Testing of Composites

3.4.1 Hardness Test

The resistance to penetration or scratch is called hardness. The Rockwell hardness of all fabricated composites have been carried out on Rockwell Brinell hardness testing machine, which is manufactured by Enkay Enterprises New Delhi-08. The hardness tests have been conducted according to ASTM: E-I8. In this static indentation test, a diamond indenter having diameter 120° diamond cone has been forced into the specimen. The area of indentation and applied load gives the hardness of the specimen. The minor load and major load for measurement of hardness has been taken as 10 kgf and 150 kgf respectively.

3.4.2 Imapact Test

The impact strength of the fabricated *Luffa*, sugarcane and hybrid reinforced polymer composites were done by Izod impact test. All the impact tests were carried out by using impact testing machine manufacturer by Enkay Enterprises New Delhi-08.This equipment contains a pendulum which is used to measure the impact strength of specimen having dimension 65 mm x 10 mm x 10 mm according to ASTM D256 standard. The pendulum hammer hits the specimen at the notch by falling freely and thus releases the energy at the cross section of the specimen. This impact energy is recorded.
The impact strength of the specimen is calculated as:

$$I = \frac{K}{A} \qquad (1)$$

Where,
I = Impact strength, K = Impact energy, A = cross-section area.

IV. RESULTS AND DISCUSSION

The variation in fibre length of of *Luffa acutangula* (Ridge Gourd), sugarcane bagasse and hybrid reinforced composites.), and % weight of fibre loading affects the mechanical properties (tensile strength, flexural strength, impact strength and hardness) of *Luffa acutangula* (Ridge Gourd) ,sugarcane bagasse and hybrid reinforced composites.

- The mechanical properties increase with increase in Fibre length from 5 mm to 10 mm. Further increase in length of fibre beyond 10 mm leads to decrease in mechanical properties. The best mechanical properties of hybrid reinforced polymer composites has been achieved with 10 mm fibre length.
- The mechanical properties of the hybrid reinforced composites increases with increase in fibre loading from 10 % weight. to 20 % weight. Further increase in hybrid loading beyond 20 % weight shows decrement in the mechanical properties. The best mechanical properties of hybrid reinforced composites have been achieved with 20 % weight of fibre loading.
- The poly-propylene reinforced *Luffa acutangula* (Ridge Gourd) based coinposites have a wide application in automobile industries for the production of under floor safety panels in luxurious cars like Mercedes and for making buildings boards and fire resistance boards.
- Now a days the composites can be used in the mudguards of motorcycles ,number plates etc.

IV. Acknowledgment

First of all, I am thankful to Almighty, my Lord and my family for giving me the will power and strength to make it this so far. I am extremely grateful and highly indebted to my guide for his excellent guidance, encouragement, and useful suggestions and providing me every possible help for successful completion of my research work. At the end of work, I am also thankful to all those who have directly or indirectly helped during my research period.

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