Investigation of Short Hybrid FRC by using Tensile and Wear Test (Sisal and Borassus)

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Abstract— In the modern era of metal-free minimally-invasive dentistry, there is a growing tendency toward using metal-free restorative alternatives that provide not only excellent aesthetics but also enable superior durability. Fiber-reinforced composite (FRC) is one cost-effective alternative that fulfills the requirements of aesthetics and durability. With advancements in the methods of research, the branch of Material science has seen its extremes but there are some areas upon which much attention should be focused. One such area is the natural composites. "Evaluation of Mechanical and Tribological Properties of Composite Materials" advance mechanical properties of composite material and making a new composite material with the help of preparation of specimen and performs various tests. Composite material are used in various place due to their light weight such as aerospace, automotive, smart material and chemical industries. This project works represent the results of mechanical and tribological test of composite. The large family of epoxy resins represents some of the highest performance resins of those available at this time. Epoxies generally out-perform most other resin types in terms of mechanical properties and resistance to environmental degradation, which leads to their almost exclusive use in aircraft components. Hand lay-up is the most common and least expensive open-molding method because it requires the least amount of equipment. Fiber reinforcements are placed by hand in a mold and resin is applied with a brush or roller. This process is used to make both large and small items, including boats, storage tanks, tubs and showers.

Keywords: Hybrid Composites, Mechanical and Tribological Properties, Epoxy, Hand Layup

I. Introduction

Many modern technologies require materials with uncommon combinations of properties not found in the classical ceramics, metals, alloys, and polymeric materials of traditional engineering. This particularly applies to applications used underwater, and in aerospace and transportation. Generally, a composite material consists of a form of reinforcement (particles, flakes, fibers, or fillers) embedded in a matrix (metal, polymer, or ceramic). The matrix holds the reinforcement together to obtain the desired shape while the reinforcement improves the overall mechanical properties of the matrix The natural fiber present important advantages such as low density, appropriate stiffness, mechanical properties with high disposability and renewability.

In this project are used the natural fibre, Nature continues to provide mankind generously with all kinds of rich resources in plentiful abundance, such, In recent years, polymeric based composites materials are being used in many application such as automotive, sporting goods, marine, electrical, industrial, construction, household appliances, etc. Polymeric composites have high strength and stiffness, light weight, and high corrosion resistance. Natural fibres are available in abundance in nature and can be used to reinforce polymers to obtain light and strong materials. The information on the usage of banana fibre in reinforcing polymers is limited in the literature. In dynamic mechanical analysis, have investigated

II. Literature review

Characterization of Natural Fiber Reinforced Composites,[1] P. HemaAditya et al, The science of fiber crops studies the importance, distribution, origin, botany, ecological conditions, agronomy, harvest method, quality determination and processing of different species of fibers. Secondary only food processing plants, fiber-producing plants play a significant role in early and modern civilization. Fiber is an anatomical structure obtained from stems, leaves, roots, fruits and seeds.

Mechanical properties of a hybrid composite material (epoxy-polysulfide rubber) reinforced with fibers[2] A AKarimet al, Fibers are a significant class of reinforcement materials, and the main use of fibers in composite materials is to improve the mechanical and physical properties of the matrix resin with their high strength to weight ratio.

III. Composite material

Composite materials are combination of two or more materials. These materials consist of one or more discontinues phases called reinforcement embedded in a continuous phase called matrix. Their orientation and distribution influence the properties and performance of the composite material.

A. *Types of Composite Materials*

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

1) Metal Matrix Composites(MMC)
2) Ceramic Matrix Composites(CMC)
3) Polymer Matrix Composites(PMC)

1) *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.

2) *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

3) 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.

B. Sisal Fiber

Sisal with the botanical name Agave sisalana, is a species of Agave native to southern Mexico but widely cultivated and naturalized in many other countries. It yields a stiff fiber used in making various products. The term sisal may refer either to the plant's common name or the fiber, depending on the context. It is sometimes referred to as "sisal hemp", because for centuries hempwas a major source for fiber, and other fiber sources were named after it The sisal fiber is traditionally used for rope and twine, and has many other uses, footwear, hats, bags, carpets, and dartboards. Fiber is extracted by a process known as decortication, where leaves are crushed, beaten, and brushed away by a rotating wheel set with blunt knives, so that only fibers remain. Alternatively, in East Africa, where production is typically on large estates, citation needed the leaves are transported to a central decortication plant, where water is used to wash away the waste parts of the leaf. Sisal fiber is fully biodegradable, green composites were fabricated with soy protein resin modified with gelatin. Sisal fiber, modified soy protein resins, and composites were characterized for their mechanical and thermal properties. We used long fiber to analysis the materials. Sisal fiber cute to the length of 80mm. shown in fig1.

Fig. 1: sisal fiber

1) Properties of Sisal Fiber

1) Sisal Fiber is exceptionally durable with a low maintenance with minimal wear and tear.
2) It is Recyclable.
3) Sisal fibers are obtained from the outer leaf skin, removing the inner pulp.
4) It is available as plaid, herringbone and twill.
5) Sisal fibers are antistatic, does not attract or trap dust particles and do not absorb moisture or water easily.
6) The fine texture takes dyes easily and offers the largest range of dyed colors of all natural fibers.
7) It exhibits good sound and impact absorbing properties.
8) Its leaves can be treated with natural borax for fire resistance properties.

2) Chemical Composition of Sisal Fiber:

Cellulose	65%
Hemicelluloses	12%
Lignin	9.9%
Waxes	2%
Pectin	10%
Moisture content	7%

C. Borassus Fiber

Borassus (Palmyra Palm) is a genus of six species of fan palms, native of tropical regions of Africa, Asia and New Guinea, economically useful and widely cultivated. It is a long life tree and can live up to 100 years reaching a height of 30 m, with a canopy of leaves and a large trunk resembling that of a coconut tree. The Palmyra palm has been one of the most important trees of Cambodia and India, where it is useful over 800 different ways. The fruits are eaten either roasted or raw, and the young, jellylike seeds are also edible Borassus fine fiber tensile properties and chemical composition. In addition, the morphology and structural, crystallinity and thermal degradation of Borassus fibers were also investigated. To investigated the material at the range of fiber length in 80mm at dry condition. Shown on fig.3

Fig. 2: Borassus fiber

D. Epoxy Resin

Epoxy resins are mostly used in aerospace structures for high performance applications. It is also used in marine structures, rarely though, as cheaper varieties of resins other than epoxy are available. The extensive used of epoxy resins in industry is due to:

1) The ease with which it can be processed,
2) Excellent mechanical properties in composite,
3) High hot and wet strength properties (150^0)

4) Performance of epoxies is superior to polyester resins due to their superior mechanical properties and better resistance to degradation by water and other solvents.

Fig. 4: Epoxy resin

1) *Range of Material*
- 60% of Epoxy resin
- 20% of Sisal fiber
- 20% of borassus fiber

2) *Fiber Range*
- Sisal fiber and borassus fiber length 300mm

3) *Die Size*
- Length 1 feet*1feet
- Width 5mm

IV. EXPERIMENTAL MATERIALS AND METHODS THE MATRIX

The materials used for matrix are epoxy, unsaturated polyester and vinyl ester. Epoxy resins are the most common matrices for high performance advanced polymer composites, but they are also inherently brittle because of their high degree of cross linking. The densely cross linked structures are the basis of superior mechanical properties such as high modulus, high fracture strength, and solvent resistance. However, these materials are irreversively damaged by high stresses due to the formation and propagation of cracks.

A. *Fiber Reinforced Composite*

Fibers are a significant class of reinforcement materials, and the main use of fibers in composite materials is to improve the mechanical and physical properties of the matrix resin with their high strength to weight ratio. Fiber materials are characterized by high tensile and compression strength and high elastic modulus. They impart these properties to the composites to which they are added by being the most subjected to loads, thus improving the stiffness of such composites. The mechanisms of failure of fiber-reinforced composite materials include delaminating, longitudinal matrix splitting, inter laminar matrix cracking, fiber pull-out, and fiber fracture. Fiber reinforcement can include sisal fiber such as borassus fibers, polymeric fiber such as fiber, or natural fiber in the form of material such as sisal and borassus. In this study, epoxy resin was mixed at 60 wt% with sisal and borassus fiber at 40 wt%. The mixing was continuing for 2 hours at room temperature to obtain a homogeneous blend with no bubbles.

1) *Description of Hand Layup Technique*

Matrixes/Resins are impregnated by hand into fibers which are in the form of chopped strand mat woven, knitted, stitched or bonded fabrics. This is usually accomplished by rollers or brushes, with an increasing use of nip-roller type impregnators for forcing resin into the fabrics by means of rotating rollers and a bath of resin. Laminates are left to cure under standard atmospheric conditions. Shown in fig 5

Fig. 5: Fabricated specimens

The epoxy-polysulfide blend was reinforced by cutting and weighting the fibers; using a volumetric friction of 20% and the rules of mixtures, the weight ratio of the fibers could thus be determined from the total weight of the blend. The method used was to pour an amount of the blend into the mould before adding the first layer of fiber, then adding another amount of the blend, continuing this process to develop a composite material reinforced with three layers of fiber. The samples created in this way. The composite materials were left at room temperature for 24 hours before being extracted from the moulds and placed in the drying oven at 60 °C for 8 hours to complete the process of solidification and to eliminate any stresses that may have formed during the process of reinforcement. Finally, the samples were cut according to the standard specifications for each test.

V. TENSILE TEST

Tensile properties fabricated composite was cut to get the desired dimension of specimen for mechanical testing. For the tensile test, the specimen size was 250 × 25mm^2 and thickness is 3mm. Tensile strength was tested in UTM machine. The specimen with desired dimension was fixed in the grips of the UTM machine with 150 mm gauge length.

Tensile strength = P/A
Where P = Maximum load (N),
A = Area of cross section (mm^2).
Tensile strain = dL/L
Where dL = change in length (mm),
L = original length (mm).

A. *Testing Parameters:*

Parameters	Values
CS area	$75mm^2$
Peak load	973.937N
Elongation	1.140%

UTS	12.988N/mm^2
Speed	2 mm/min
Width	25mm
Thickness	3mm
Gauge length	180mm
Load cell	1000 kgf

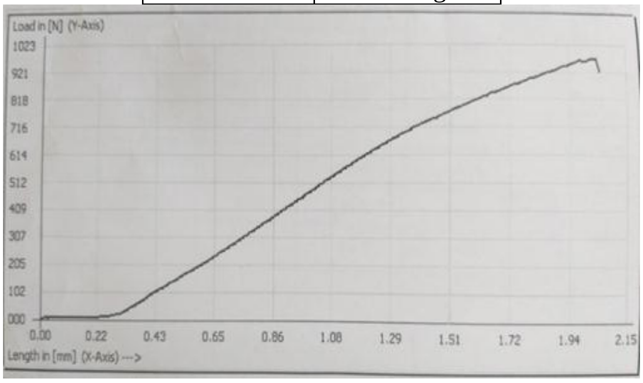

Fig. 6: Elongation of material

VI. Wear Test

The amount of wear in any system will, in general, depend upon the number of system factors such as the applied load, machine characteristics, sliding speed, sliding distance, the environment, and the material properties. The value of any wear test method lies in predicting the relative ranking of material combinations. Since the pin-on-disk test method does not attempt to duplicate all the conditions that may be experienced in service (for example; lubrication, load, pressure, contact geometry, removal of wear debris, and presence of corrosive environment), there is no insurance that the test will predict the wear rate of a given material under conditions differing from those in the test.

A. Testing Parameters:

Parameters	Values
Load	30N
Duration	5min
Speed	250rpm
Pin diameter	4mm
Tracking radius	50mm
Material	Composite(Sisal, borassuas)
Sliding distance	392 m
Velocity	1 m/s

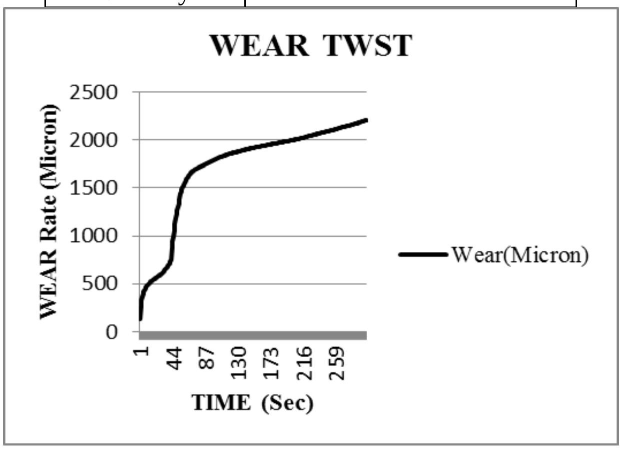

Fig. 7: result on wear test

VII. Result

A. Tensile Test Result on

	CS Area (mm^2)	Peak load(N)	% Elongation	UTS (N/mm^2)
Min	75.000	973.937	1.140	12.988
Max	75.000	973.937	1.140	12.988
Avg	75.000	973.937	1.140	12.988
StdDev	0.000	0.000	0.000	0.000
Variance	0.000	0.000	0.000	0.000
Median	75.000	973.937	1.140	12.988

B. Wear Test Result on

Time	Wear rate (micron)
60	1559.970976
120	1856.40749
180	1962.865404
240	2071.585252
300	2209.764909

C. Advantages

1) Better durability
2) Limitations contraction cracks
3) Improvement of ductility
4) Improvement tensile strength
5) Better fire resistance

VIII. Conclusion

In order to optimize flexural strength of a FRC construction with low fiber volume fraction, the fibers should be placed on the tension side of the specimen. In order to optimize stiffness of the construction, the fiber rich layer should be spread vertically. Light polymerization of the polymer matrix of FRC at an elevated temperature decreased the quantity of leachable residual monomers and increased the flexural strength and modulus of elasticity

References

[1] P. HemaAditya, K. Siva Kishore, D.V.V. Krishna Prasad,Characterization of Natural Fiber Reinforced Composites. International Journal of Engineering and Applied Sciences (IJEAS) ISSN: 2394-3661, Volume-4, Issue-6, June 2017

[2] A AKarim, E E Kader, A AHamod, A J Abdulrahman, Mechanical properties of a hybrid composite material (epoxypolysulfiderubber) reinforced with fibres, Materials Science and Engineering 433(2018) 012050

[3] N A and M S 2013 Environmental Benefits of ecofriendly natural fiber reinforced polymeric composite materials Environmental Benefits of Ecofriendly Natural Fiber Reinforced Polymeric Composite Materials vol 1

[4] P. Sudhakara, K. Obi Reddy, C. Venkata Prasad, Dani. Jagadeesh, H.S. Kim, B.S. Kim,S.I. Bae, and J.I. SongStudies on Borassus fruit fiber and its composites with Polypropylene. Composites Research, 26(1), 48-53(2013), pISSN: 1598-6934

[5] D Bachtiar, SM Sapuan, MMHamdan - The effect of alkaline treatment on tensile properties of sugar palm

fiber reinforced epoxy composites- Materials & Design, 2008- Elsevier

[6] HL Bos, MJA Van Den Oever, O Peters - Tensile and compressive properties of flax fibers for natural fiber reinforced composites- Journal of Materials science, 2012- Springer

[7] HL Bos, MJA Van Den Oever, O Peters - Tensile and compressive properties of flax fibers for natural fiber reinforced composites- Journal of Materials science, 2012- Springer

[8] U Riedel, J Nickel - Applications of natural fiber composites for constructive parts in aerospace, automobiles, and other areas - Biopolymers online,2005 – Wiley online Library.

[9] Chandramohan, D. and J. Bharanichandar - Natural Fiber Reinforced Polymer Composites for Automobile Accessories - American Journal of Environmental Science 9 (6): 494-504, 2013

[10] Ramakrishna Malkapuram, Vivek Kumar and Yuvraj Singh Negi - Recent Development in Natural Fiber Reinforced Polypropylene Composites – Vol 28 -2008 –

[11] Journal of Reinforced Plastics and CompositesMorton, J.F., “Notes on distribution, propagation, and productsof Borassuspalms (arecaceae),” Economic Botany, Vol.42, No. 3, 1988, pp. 420-441.

[12] Mallick P K 2007 Fiber-Reinforced Composites: Materials, Manufacturing, and Design (ThirdEdition, CRC Press)

[13] Satyanarayana K. G, Sukumaran K, Mukherjee P. S, Pavithran C and Pillai S. G. K, “Natural-Poymer Fiber Composites”,nd Concrete Journal of Composites, 12(2), 1990, pp.117-136.

[14] Yang G. C, Zeng H. M, Jian, N. B and Li, J. J. Properties of banana/ glass fiber reinforced PVC hybrid composites. Plastics Industry, 1: (1996), pp79-81.

[15] Kalaprasad G, Joseph K. and Thomas S. Influence of short glass fiber addition on the mechan’ical properties of banana reinforced LDPE composites, J. Comp. Matter, 31: (1997), pp 509-526.

[16] Chawla K. K. Composite Materials: Science and Engineering: Springer,1998.

[17] Kutz M. Mechanical Engineers Handbook, Third Edition, John Wiley and Sons Inc., Hoboken, New Jersey,2000.

[18] NabiSaheibD, Jog J. P, natural fiber polymer composites: A review, Advances in polymer technology, 18(4), (2004), pp 351-363.

[19] Satyanarayana K. G, Sukumaran K, Mukherjee P. S, Pavithran C and Pillai S. G. K, “Natural-Poymer Fiber Composites”,nd Concrete Journal of Composites, 12(2), 1990, pp.117-136.

[20] .Yang G. C, Zeng H. M, Jian, N. B and Li, J. J. Properties of banana/ glass fiber reinforced PVC hybrid composites. Plastics Industry, 1: (1996), pp79-81.

[21] Kalaprasad G, Joseph K. and Thomas S. Influence of short glass fiber addition on the mechanical properties of banana reinforced LDPE composites, J. Comp. Matter, 31: (1997), pp 509-526.

[22] Chawla K. K. Composite Materials: Science and Engineering: Springer,1998

