Development and Fabrication of Bagasse & Palmyra Fibers Reinforced Epoxy Composite Material Spur Gear for Sugar Cane Juice Machine

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Abstract- *Gears are machine element that transmits motion by means of successively engaging teeth. The stress is developed when two gears are mated. However it is observed that performance of the spur gear is not satisfactory in certain applications and therefore it is required to explore some alternate materials to improve the performance of the spur gears. Composite materials provide adequate strength with weight reduction and they are emerging as a better alternative for replacing metallic gears. For the purpose of two different types of composite materials were considered namely Epoxy and bagasse fibre and their viability are checked with their counterpart metallic gear (Cast iron).*

Based on the impact test and hardness testing, the best composite material is recommended for the purpose. Keeping this in view the present work has been undertaken to develop a polymer matrix composite (epoxy resin) using bagasse fiber as reinforcement and to study its mechanical properties and environmental performance. The composites are prepared with different volume fraction of bagasse fibers. Experiments have been conducted under laboratory conditions to assess the effect of different environment such as sub-zero, steam, saline water and natural conditions on the mechanical properties of the composites. The change in weight, volume and dimensions are studied for various treatments.

I. INTRODUCTION

The gear materials used for the manufacture of gears depend upon the strength and service conditions like wear and noise etc. The gears maybe manufactured from metallic or non – metallic materials. The cast iron is widely used for the manufacture of gears due to its good wearing properties, excellent machine ability and ease of producing complicated shapes by casting method.

The non – metallic materials like wood, rawhide, compressed paper and plastics like Nylon, Acrylic and Polycarbonate etc are used for gears, especially for reducing weight and noise. Weight reduction can be achieved primarily by the introduction of better material, design optimization and better manufacturing processes.

Fabrication specification

Raw materials used in this experimental work are listed below:
1. Natural fibre.(Bagasse)
2. Epoxy resin .
3. Hardener.

Material Properties for Epoxy

- Hardness Rockwell 80-120m
- Elongation 1-10
- Dimensional Stability Excellent
- Heat Resistance Excellent
- Chemical Resistance Excellent
- Processing CMR

3. Hardener

In the present work hardener (HY951) is used. This has a viscosity of 10-20 MPa at 25ºc.

Table.1.1 Average Bagasse Composition

ITEM	% of content
Moisture	49.0
Soluble Solids	2.3
Fiber	48.7
Cellulose	41.8
Hemicelluloses	28
Lignin	21.8

Preparation of Composites

(a) Bagasse fiber preparation:-

Fresh bagasse fibers were collected after they were crushed for extracting juice by using a hand crushing machine. These fibers were then spread on a water proof sheet to reduce the moisture content. After approximately two weeks, the long bagasse fibers were shortened into a length of 10mm, breadth of 1mm and width of 1mm with a pair of scissors. Small size fibers were selected in order to design a composite with consistent properties. Due to the low moisture content of the bagasse samples, no fungi grew during the storage. The bagasse samples were then cleaned via pressurized water for about one hour. This procedure removes fine bagasse particles, sugar residues and organic materials from the samples. Then the fibers were dried with compressed air.

(b) Composite preparation:-

A wooden mold of dimension (120x100x6) mm was used for casting the composite sheet. The first group of samples were manufactured with 5, 10, 20 % volume fraction of fibers**.** For different volume fraction of fibers, a calculated amount of epoxy resin and hardener (ratio of 10:1 by weight) was thoroughly mixed with gentle stirring to minimize air entrapment. For quick and easy removal of composite sheets, mold release sheet was put over the glass plate and a mold release spray was applied at the inner surface of the mold. After keeping the mold on a glass sheet a thin layer (≈ 2 mm thickness) of the mixture was poured. Then the required amount of fibers was distributed on the mixture. The remainder of the mixture was then poured into the mold. Care was taken to avoid formation of air bubbles. Pressure was then applied from the top and the mold was allowed to cure at room temperature for 72 hrs. This procedure was adopted for preparation of 5, 10 and 20% fiber volume fractions of composites. After 72 hrs the samples were taken out of the mold, cut into different sizes and kept in air tight container for further experimentation.

II. TREATMENT PROCEDURE

Step1: Hybrid fibers were immersed in distilled water with 5% NaOH solution for about 30minutes at room temperature.

Step2: The fibers were then washed many times by using the distilled water.

Step3: The washed fibers were then immersed in distilled water with 2.5% HCL solution for about 30minutes at room temperature.

Step4: The fibers were then washed again many times in distilled water and finally dried at room temperature.

PREPARATION OF COMPOSITES

Composites were fabricated using hybrid fiber and epoxy resins simple hand lay-up technique.
(i). Untreated fibers (with fiber length 5mm)
(ii). 15% alkali treated fibers (with fiber length 5mm)
Hybrid composite with Bagasse fiber, Epoxy resin, Hardener

III. SPECIMEN SEPERATION

The fabrication of the various composite materials is carried out through the hand lay-up technique. For the first plate Bagasse fibers & Palmyra fibers are reinforced with Epoxy LY 556 resin, chemically belonging to the 'epoxide' family is used as the matrix material.

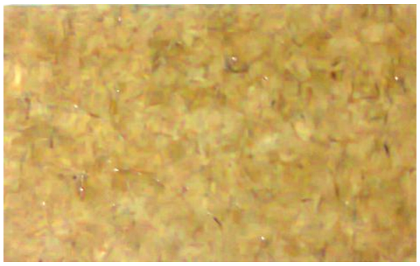

Fig 5.3 Combinations of Bagasse Composites

Its common name is Bisphenol A Diglycidyl Ether. The low temperature curing epoxy resin (Araldite LY 556) and corresponding hardener (HY951) are mixed in a ratio of 10:1 by weight as recommended. The epoxy resin and the hardener are supplied by Ciba Geigy India Ltd.

Two different types of composites have been fabricated with fiber lengths such as 5m. Each composite consisting of 40% of fiber (40% Palmyra fiber) and 130% of epoxy resin & 30% of hardener. The designations of two composites are given in Table 5.1. The mix is stirred manually to disperse the fibers in the matrix. The cast of each composite is cured under a load of about 50 kg for 24 hours before it removed from the mould.

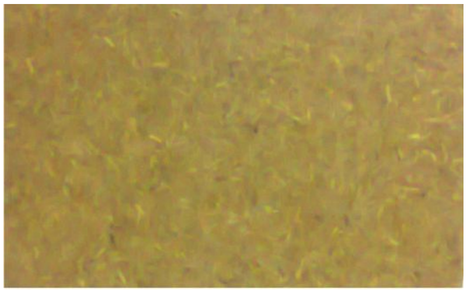

Fig 5.4 Bagasse Composite plate

Then this cast is post cured in the air for another 24 hours after removing out of the mould. Specimens of suitable dimension are cut using a diamond cutter for mechanical testing. This procedure is repeated for another plate by the combination of 20% bagasse and 20% Palmyra, 160% epoxy resin and 40% hardener. Utmost care has been taken to maintain uniformity and homogeneity of the composite.

HAND LAY-UP TECHNIQUE

Hand lay-up is also called contact moulding. It is a production technique suitable for prototypes and low volume production of fiber composite material parts. The composite part will have a smooth surface on one side and a very rough surface on other.

The fibers are manually in to one sided gel coated male or female mould. More layers can be added and, after drying, the composite part can be removed from the mould. Easy to control fiber orientation. Furthermore, the process is very flexible as it can produce from very small, up to very large part of different kinds of geometry. The cycle time per pert is very long, and only small series can be produced.

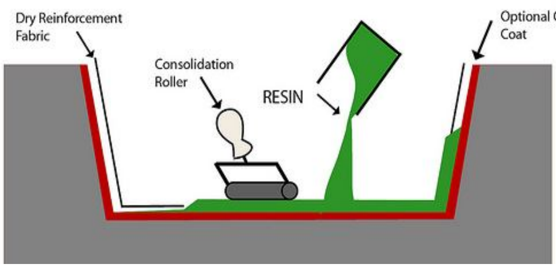

Fig 5.5 Basic process of hand lay-up

Easy to control fiber orientation. Furthermore, the process is very flexible as it can produce from very small, up to very large part of different kinds of geometry. The cycle time per pert is very long, and only small series can be produced.

Fig 5.9 Composite gear

IV. TESTS TO BE CARRIED OUT

THERMAL TEST

Increasing use of composites for various applications emphasizes its importance/significance in the thermal property analysis of an engineering system. Thermal conductivity of a composite (combination of two or more constituents) can be measured by experimental methods. Analytical equations are essential to predict thermal conductivities of a composite material. Information on the thermal properties of composite materials would facilitate the design of an engineering system made of FRPs.

The characterization has been carried out using 'Guarded heat flow meter method' in accordance with ASTM E 1530. The results obtained from this study are useful for the prediction of thermal conductivity of E-glass and Carbon fiber composites with vinyl ester.

EXPERIMENTAL PROCEDURE

The composite test specimen was shaped for the thermal test according to required dimension. Then the specimen is placed in to the muffle furnace and closed the door. The muffle furnace was switched ON and set the temperature. Notice the condition of the specimen at the regular interval of time. Note the temperature, when the test specimen is degraded.

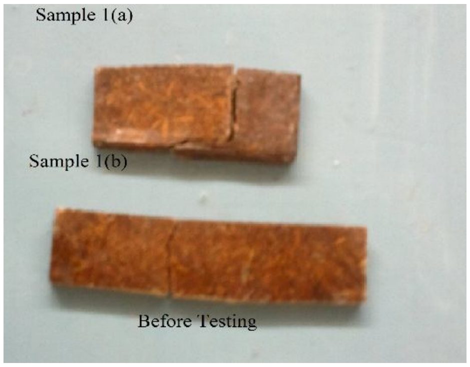

Figure 5.11 sample 1(a & b) before testing

Thermal conductivity of composites is anisotropic in nature. The knowledge of thermal conductivity of composites is needed for accurate design. Data about thermal conductivity of resin facilitates to reduce stresses related to shrinkage of composites during cure and mismatch in thermal expansion coefficients.

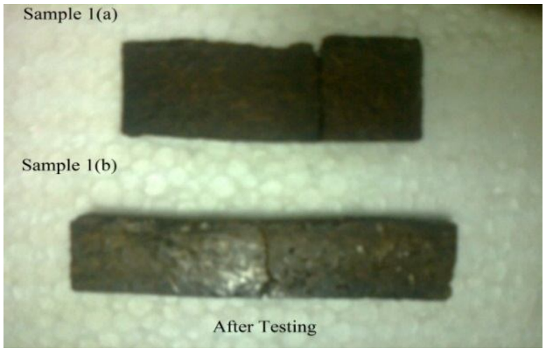

Figure 5.12 sample 1(a & b) after testing

Before conducting experiments to determine thermal conductivity of various composites, knowledge about effect of different parameters influencing thermal conductivity is essential.

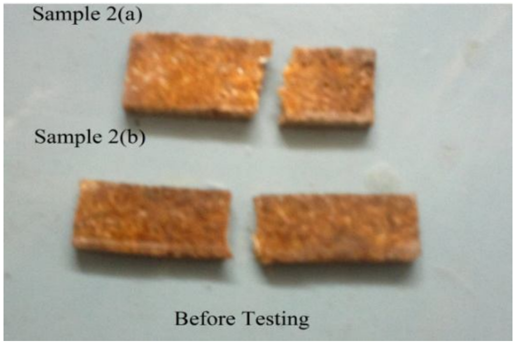

Figure 5.13 sample 2(a & b) before testing

The objective of the research is to attain better understanding of global and local thermal behavior of a composite structural system through fundamental understanding of thermal conductivity properties. The literature reveals that a major focus has been placed on measurements of thermal conductivity in through-the-thickness direction of a FRP composite.

Figure 5.14 sample 2(a & b) after testing

Therefore, current research focus has been on characterization of thermal conductivity in the planar direction (along the direction of fiber and transverse direction of fiber) of a composite laminate.

HARDNESS TEST

Hardness is a measure of how resistant solid matter is to various kinds of permanent shape change when a force is applied. Macroscopic hardness is generally characterized by strong intermolecular bonds, but the behaviour of solid materials under force is complex; therefore, there are different measurements of hardness: scratch hardness, indentation hardness, and rebound hardness.Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness, viscoelasticity, and viscosity.

FLEXURAL TEST

The flexure test method measures behavior of materials subjected to simple beam loading. It is also called a transverse beam test with some materials. Maximum fiber stress and maximum strain are calculated for increments of load. Results are plotted in a stress-strain diagram. Flexural strength is defined as the maximum stress in the outermost fiber. This is calculated at the surface of the specimen on the convex or tension side. Flexural modulus is calculated from the slope of the stress vs. deflection curve. If the curve has no linear region, a secant line is fitted to the curve to determine slope.

FLEXURAL TESTING OF COMPOSITES

Figure 5.15 sample 1(a & b) before testing

The flexural properties of the composites were determined in three-point bending. At least five rectangular beam specimens were tested for each composite at a support span-to-depth ratio of 16:1 according to ASTM, D790M. Tests were conducted at 22±20C, using aInstron 6025 testing machine.

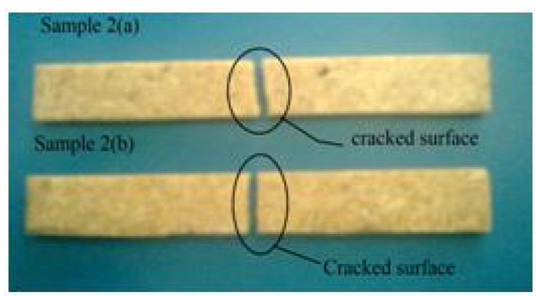

Figure 5.16 sample 1(a & b) after testing

Specimens were center loaded in three-point bending as a simply supported beam, using 3 mm diameter supports and loading bar. The damage developed was monitored on the side of each polished beam using an optical microscope. The maximum tensile stress in the outer fibers was calculated according to,

$sm = 3FL / 2bd^2$……………(reference 18)

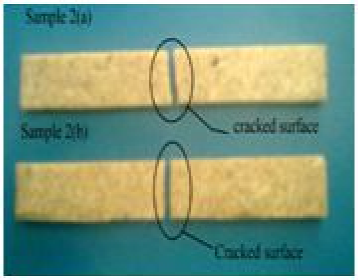

Figure 5.17 sample 2(a & b)

Where F is the force at a given point on the Force deflection curve, L is the support span and b and d are the width and depth of the beam, respectively. The modulus of elasticity was calculated according to;

$E = L^3m / 4 bd^3$……………(reference 18)

Figure 5.18 sample 2(a & b) after testing

Where m is the slope of the tangent to the initial straight-line portion of the force-deflection curve. The maximum tensile strain in the outer fibres was calculated according to;

$e = 6Dd / L^2$……………(reference 18)

Where D is the deflection of the beam at a given point on the load-deflection curve.

IMPACT STRENGTH

The Impact modulus of the Bagasse and epoxy composite material in zero degree angle ply orientation is shows the high impact strength.Results are plotted in a stress-strain diagram. Flexural strength is defined as the maximum stress in the outermost fiber. This is calculated at the surface of the specimen on the convex or tension side. Flexural modulus is calculated from the slope of the stress vs. deflection curve. If the curve has no linear region, a secant line is fitted to the curve to determine slope.

V. RESULTS AND DISCUSSION

Thermal Test

We have manufactured the specimens of hybrid composite material with different fibers. These specimens are undergone the thermal test and the results are listed below.

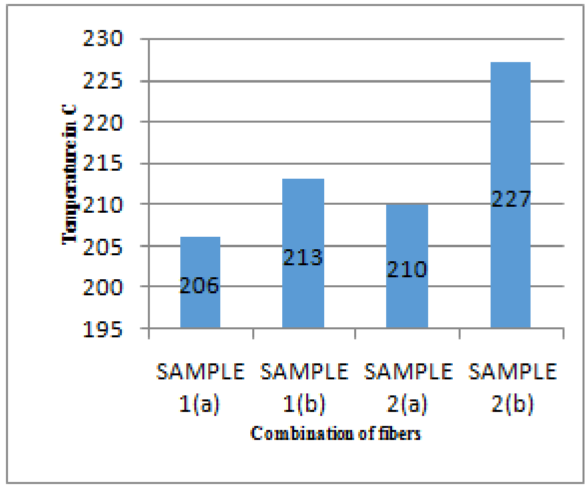

Figure 6.1 Graph for Thermal Test

From the above graph it is understood that 2(b) is the best, because thermal is best produced to with stand on 227° c.

Hardness Test

Hardness is dependent on ductility, elastic stiffness, plasticity, strain, strength, toughness, viscoelasticity, and viscosity.

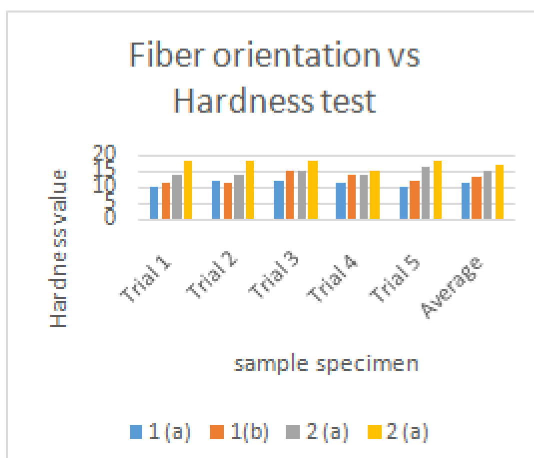

Figure 6.2 Graph for Hardness Test

From the above graph it is understood that 2(b) is the best, because hardness is best produced to with stand on 18 hardness.

FLEXURAL TEST RESULT

Flexural stress value in (Mpa)

Table 1.2 Flexural test

Specimen	Neat LDPE	20 % Bagasse	40 % Bagasse	Neat LDPE	20 % Bagasse	40 % Bagasse
1(a)	8.04	5.98	5.41	60.13	47.54	58.50
2(b)	8.14	7.51	3.28	55.19	59.96	56.03
2(a)	8.14	7.59	3.92	60.97	53.25	59.94
2(b)	8.00	6.09	3.82	56.34	44.51	57.11
Mean	8.09	6.79	4.40	58.16	51.32	57.90
Std.deviation	0.07	0.88	3.50	2.82	6.81	1.90

The following graph were plotted to compare and visualize the experimental results.

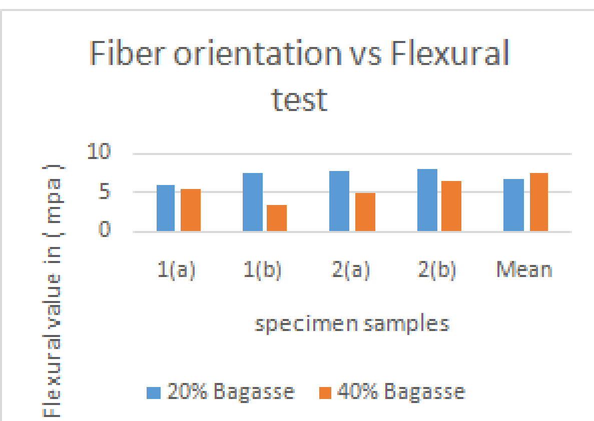

Figure 6.3 Graph for Flexural Test

From the above graph it is understood that 2(b) is the best, because flexural is best produced to wind stand on

IMPACT STRENGTH

The Impact modulus of the Bagasse and epoxy composite material in zero degree angle ply orientation is shows the high impact strength 0.48 J and it is shown in the figure 6.4.

The following graph were plotted to compare and visualize the experimental results.

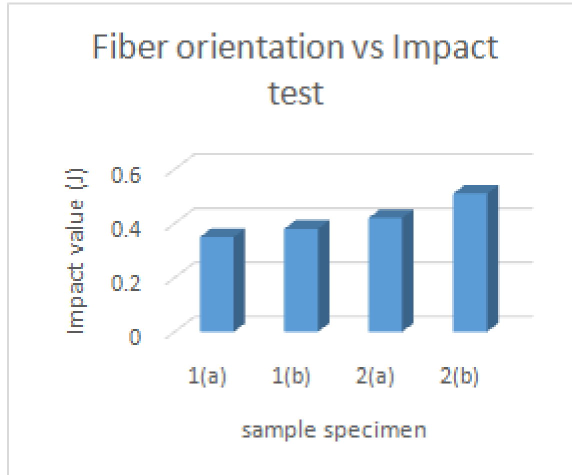

Figure 6.4 Graph for Impact Test

From the above graph it is understood that 2(b) is the best, because impact is best produced to with stand on 0.51J.

VI. CONCLUSION

To find the suitable design gears with less weight and less cost, corrosion resistance, frictionless also. To design and manufacture a sugarcane juice for a common people. With less cost, self-lubricating neat and clean hygienic juice. With more material removal of deflection and stress are increased. Therefore this work is concerned with the replacement of existing metallic gear with composite material gear in order to make it lighter and increasing the efficiency of mechanical machines. So for safe operation of my design is more appropriate under limited load conditions for composite gear. The sugar cane residue bagasse an underutilized renewable agricultural material can successfully be utilized to produce composite by suitably bonding with resin for value added product.

REFERENCES

[1] Bisanda ETN. "The effect of alkali treatment on the adhesion characteristic of sisal fibres." Appl Comp Mater; Volume 7, (2000): p. 331–339.

[2] Budynas, Richard G., J. Keith. Nisbett, and Joseph Edward. Shigley. Shigley's Mechanical Engineering Design. 8th ed. Boston: McGraw-Hill, 2008. Print.

[3] Cao, Shibata S. and Fukumoto. I. "Mechanical properties of biodegradable composites reinforced with bagasse fibre before and after alkali treatments." Composites part A: Applied science and Manufacturing, Volume 37, (2006): p. 423-429.

[4] Design data book compiled by PSG College of Technology,2009, COIMBATORE

[5] Gassan J, Bledzki A.K. "Possibilities for improving the mechanical properties of jute/epoxy composites by alkali treatment of fibres." Compos SciTechnol.;Volume 59, (1999): p. 1303–1309.

[6] Hassan M.L., Rowell R.M., Fadl N.A., Yacoub S.F. and ChrisainsenA.W."Thermo plasticization of Bagasse. I. Preparation and Characterization of Esterified Bagasse Fibers." Journal of applied polymer science, Volume 76,(2000): p. 561-574.

[7] Hassan M.L., Rowell R.M., Fadl N.A., Yacoub S.F. and ChrisainsenA.W."Thermo plasticization of Bagasse. II. Dimensional Stability and Mechanical Properties of Esterified Bagasse Composite." Journal of applied polymer science,Volume 76, (2000): p. 575-586.

[8] K. Mao, A new approach for polyamide composite gear design, Wear 262 (2007) 432-441.

[9] Li XH, Meng YZ, Wang SJ, Rajulu AV, Tjong SC. "Completely biodegradable composites of poly (propylene carbonate) and short, lignocellulose fabric hildegardiapopulifolia." J PolymSci: Part B; Volume 42, (2004): p. 666–675.

[10] Luo S, Netravali A.N., "Interfacial and mechanical properties of environment friendly 'green' composites made from pineapple fibers and poly(hydyoxybutyrate-co-valerate) resin." J Mater Sci; Volume 34, (1999): p. 3709-3719.

[11] Mohanty A.K, Khan M.A, Hinrichsen G. "Influence of chemical surfacemodification on the properties of biodegradable jute fabrics-polyester amide composite." Composites: Part A; Volume 31, (2000): p. 143–150.

[12] Mohanty A.K., Khan M.A., Hinrichsen G. "Surface modification of jute and its influence on performance of biodegradable jute-fabric/Biopolcomposites." Compos Sci Technol; Volume 60, (2000): p. 1115–1124.