Characterization of a Hybrid Composite using E-Glass, Jute with Coconut Shell Powder as Filler Material

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***Abstract*— In this work an attempt has been made to develop hybrid composite with filler material like coconut ash powder for different weight ratios using hand layup technique. Different mechanical properties such as tensile, bending and hardness were studied by preparing the specimen according to ASTM standards. A comparative study of results for different weight ratio it was found that the tensile and bending strength was maximum for without filler material , but the Young's modulus in tensile found to be maximum for 5% coconut ash powder. There was considerable enhancement in the hardness for 20% coconut ash powder. The tribological behaviour for the above said material has been assessed with a computerized pin disc wear machine by operating in dry condition with varying loads and constant speed, length and time has been done. It was found that for 20% coconut ash powder material the weight loss was minimum and co-efficient of friction is very high. The microstructure analysis is done using Scanning electron microscope.**

***Keywords*— Laminates, Hand lay-up technique, coconut ash powder, E-Glass, Jute.**

I. INTRODUCTION

In recent years, there has been a remarkable increase in interest in biodegradable bio-composite material for application such as packaging, agriculture, medicine, sportswear, insulation, coating and other areas. This effort to develop the bio composites materials will decrease the need for synthetic polymer production at a low cost. The natural fibers are alternately producing a positive effect on both environmental and economical. The availability of coconut shells is increasing every year worldwide, which is hard liginocellulosic Agra waste[1].

Researches all over the world today are focusing on ways of utilizing, either industrial or agricultural wastes as a source of raw materials for the industry. These wastes utilization would not only be economical, but may also result to foreign exchange earning and environmental pollution control[2-3]

Coconut shell is an agricultural waste and is available in very large quantities throughout the tropical countries of the world. Moreover, coconut is becoming an important agricultural product for tropical countries around the world as a new source of energy-biofuel[3]. Previously, coconut shell was burnt as a means of solid waste disposal which contributed significantly to CO2 and methane emissions [3]. However as the cost of fuel oil, natural gas and electricity supply has increased and become erratic, coconut shell has come to be regarded as source of fuel rather than refuse.

Jute is long, soft and shiny, with a length of 1 to 4 m and a diameter of from 17 to 20 microns. Jute fiber are composed primarily of the plant materials cellulose (major component of plant fiber) and lignin (major components of wood fiber). The fiber can be extracted by either biological or chemical retting processes [7].

Numerous research works are carried out on various filler materials that can give good dispersion and interfacial adhesion between the filler and polymer matrices. In this work, we fabricated composite material for general purpose application which is cost effective and can replace conventional materials like wood. Coconut shell ash is agricultural waste and the waste is produced in abundance globally and poses risk to health as well as environment, the idea is to utilise this as a filler material with different proportion (5%,20%) and to compare the results with different weight ratios.

Jute fiber is a long soft and shiny with a length of 1to 4m and diameter of 17 to 20 microns, It is the cheapest natural fiber available abundantly in global. It is a rainy season crop but grow in warm and humid climate conditions.

E-glass known as electrically graded glass was basically developed as stand-off insulators for electrical wiring. Later it was found that they have excellent fibre content capabilities and is now used as basic reinforcement material called as fibre glass [6].

Epoxies are also used in producing fiber-reinforced or composite parts. They are more expensive than polyester resins and vinyl ester resins, but usually produce stronger and more temperature resistant composite parts[5].

Fig 1.1 Mat type Jute fiber

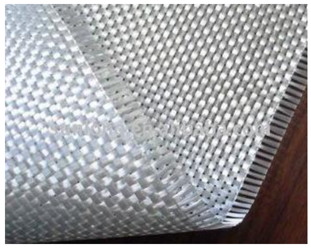


Fig 1.2 E-glass fiber

Fig 1.3 Epoxy Resin Lpox L12

The composite material used in this research was manufactured using plain weave mat of E-glass fabrics of 0.3mm thickness as synthetic reinforcement. Jute fibers were used as natural reinforcement. The matrix material was Epoxy (Lapox L12) resin and hardener (K6) was supplied by Atul Ltd Valsad Gujarat India.

II. COMPOSITE MANUFACTURING TECHNIQUE

There are many techniques available in industries for manufacturing of composites such as compression molding, vacuum molding, pultruding etc. The hand lay-up process of manufacturing is one of the simplest and easiest methods for manufacturing composites. A primary advantage of the hand lay-up technique is to fabricate very large, complex parts with reduced manufacturing times. All composite specimens were manufactured using hand lay-up process.

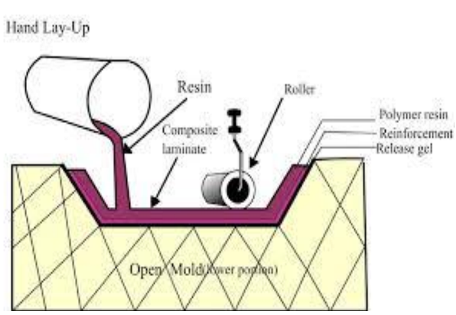


Fig. 1 Hand Lay -up Technique

Fig. 2 Hybrid composite material using coconut ash

2.1 Experimental work

All experimental tests were carried out at Brakes India Pvt Ltd Mysore India and Ducom India Pvt Ltd Bangalore, Indian Institute of Science Bangalore. All experimental tests were repeated three times to generate the data.

2.1.2 Tensile Test

Tensile testing, also known as tension testing, is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces[10].

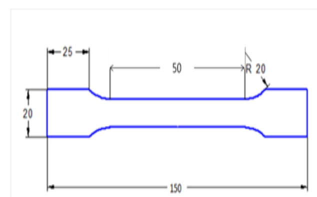


Fig. 3 Tensile Test specimen

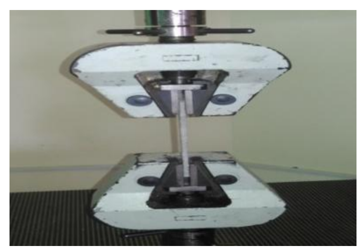


Fig. 4 Tensile specimen in UTM

2.1.3. Flexural Test

The transverse bending test is most frequently employed, in which a specimen having either a circular or rectangular cross-section is bent until fracture or yielding using a three point flexural test technique.

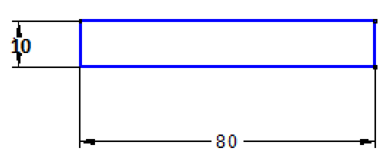


Fig. 5 Flexural specimen.

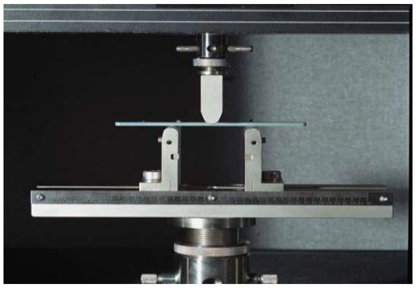


Fig.6 Flexural specimen in UTM

2.1.4 Hardness Test

The Rockwell scale is a hardness scale based on indentation hardness of a material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload.

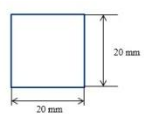


Fig.7 Hardness test specimen.

2.2 Wear Test

Wear is known as the progressive loss of substance from surface of a body due to relative motion with respect to another body. Thus it is termed as the removal of material from the surface of a body which is in relative motion due to mechanical or chemical action. Wear test is done at DUCOM instruments pvt ltd, Bangalore with a computerized pin disc wear machine by operating in dry condition with varying loads and constant speed, length and time has been done.

Table 1 Test rig specification

Sl.No	Description	Details
1	Speed (rpm)	200 to 2000
2	Normal load (N)	5 to 200
3	Frictional force (N)	0.1 to 200
4	Wear (mm)	± 2
5	Wear track diameter (mm)	10 to 100
6	Sliding speed (m/sec)	0.5 to 10
7	Preset timer (hr/min/sec)	99/59/59
8	pin size (mm)	Ø3,4,5,6,8,10 & 12
9	Wear disc	EN 31 Steel
10	Pin Heating	Ambient to 600 Deg C
11	Software	Winducom 2010
12	Software Interface	Comport RS 232 serial port

Table 2 Instrument used for carrying out this wear test

Sl no	Item	Specifications
1	Test rig	Pin On Disc Tester TR-20-PHM-CHM-600
2	Controller	Electronics controller
4	Software	Winducom 2010
5	Computer	Pentium 4,512MB RAM, 2GB, 17"color monitor

Table 3 Wear test parameters

Test parameters for varying load test
Load 1kg,2kg and 3kg at 300 rpm
Test duration = 15 minutes , Mass measured after completion of all load cases
Wear track dia = 80mm
Test condition = lubricant condition & at Ambient temperature
Environment = open to atmosphere , Humidity = 51.5%Rh, temperature = ambient room temperature

Scanning Electron Microscopy

Microstructures of the abraded composite samples were examined using a scanning electron microscope as shown in Fig 2.9. The composite samples were mounted on stubs with silver paste.

Fig. 9 Scanning electron microscope setup

III. RESULTS AND DISCUSSIONS

All experimental tests were repeated three times to generate the data.

3.1.1 Tensile strength

The following graphs show the relationship between stress and extension of tensile specimen for hybrid composite using Jute and E-glass.

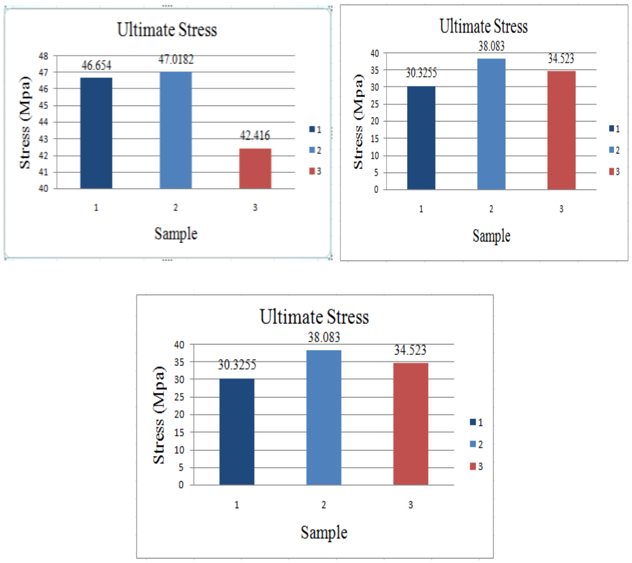


Fig.10 shows the Ultimate stress for different weight ratios of the filler material

3.2.1 Flexural strength

The following graphs show the relationship between stress and extension of bending specimen for hybrid composite using Jute and E-glass.

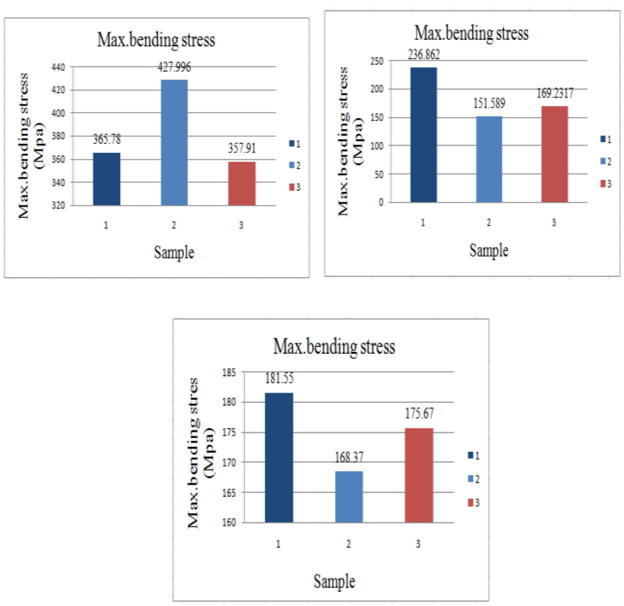


Fig. 11 shows the Flexural strength for different weight ratios of the filler matreial.

3.3 Hardness Test

The hardness test for the above said material has been done using Rockwell hardness tester on a M-scale and the results are shown below.

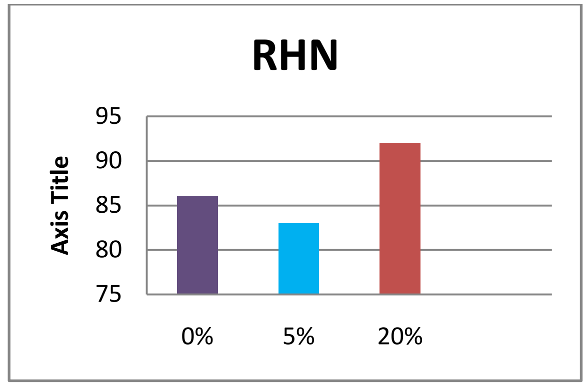


Fig. 12 Rockwell hardness Number.

Table 4 shows average strength of Tensile, Flexural, Young's Modulus and hardness tests

Sl No	% of Filler material	Tensile strength (MPa)	Flexural strength (MPa)	Young's Modulus (MPa)	Hardness (RHN)
1	0	59.8	383.3	5074.15	86
2	5	45.36	184.27	5041.52	83
3	20	34.31	175.19	4470.97	92

It is evident from table 4 that both tensile and flexural strength are more for composites without filler material since the strength of the composite depends on the fibre. As the volume of fibre content is reduced the strength is getting reduced. For composites with 20% filler material it is observed that there is a substantial increase in the hardness due to the reduction of porosity caused by the presence of high coconut shell powder. This material finds applications in the automobile and aerospace areas. The fabrication of this composite is cost effective and is considered to be an eco-friendly bio composite.

3.4 Wear Test

The wear test is carried on a pin on disc with dry condition at room temperature various compositions with applied loads of 10N, 20N, 30N and at a constant speed of 300 rpm and time of 900 secs.

Table 5 shows the weight loss for different loading (Without filler material)

SL NO	LOAD (N)	WEAR TRACK (mm)	SPEED (RPM)	TIME (MIN)	TEMP (°C)	WEAR (microns)	F.F (N)	COF	INITIAL WEIGHT OF TEST SAMPLE (gm)	FINAL WEIGHT TEST SAMPLE (gm)	WEIGHT LOSS (gm)	COMPUTER PATH
25	20	80	300	15	-	391	3.5	0.350	7.38252	7.37456	0.00796	c/data/CSW 2341 TEST 25
26	30	80	300	15	-	339	6.88	0.344	7.28668	7.38407	0.00262	c/data/CSW 2341 TEST 26
27	10	80	300	15	-	606	11.31	0.377	7.39116	7.36293	0.02873	c/data/CSW 2341 TEST 27

Table 6 shows the weight loss for different loading (With 5% filler material)

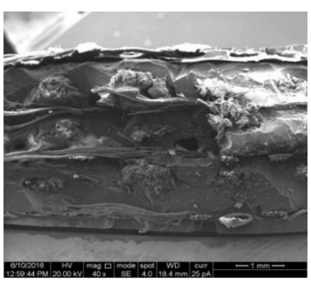
SL NO	LOAD (N)	WEAR TRACK (mm)	SPEED (RPM)	TIME (MIN)	TEMP (°C)	WEAR (microns)	F.F (N)	COF	INITIAL WEIGHT OF TEST SAMPLE (gm)	FINAL WEIGHT TEST SAMPLE (gm)	WEIGHT LOSS (gm)	COMPUTER PATH
1	10	80	300	15	-	160	4.4	0.440	7.84330	7.84229	0.00101	c/data/CSW 2341 TEST 1
2	20	80	300	15	-	385	8.0	0.399	7.398388	7.87988	0.10400	c/data/CSW 2341 TEST 2
3	30	80	300	15	-	398	14.4	0.428	7.87355	7.86097	0.01258	c/data/CSW 2341 TEST 3

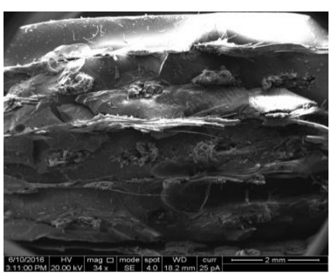
Table 7 shows the weight loss for different loading (With 20% filler material)

SL NO	LOAD (N)	WEAR TRACK (mm)	SPEED (RPM)	TIME (MIN)	TEMP (°C)	WEAR (microns)	F.F (N)	COF	INITIAL WEIGHT OF TEST SAMPLE (gm)	FINAL WEIGHT TEST SAMPLE (gm)	WEIGHT LOSS (gm)	COMPUTER PATH
10	10	80	300	15	-	131	3.87	0.387	7.87209	7.86018	0.01191	c/data/CSW 2341 TEST 10
11	20	80	300	15	-	323	7.56	0.378	7.76304	7.75765	0.00539	c/data/CSW 2341 TEST 11
12	30	80	300	15	-	415	10.23	0.341	7.87972	7.82180	0.05792	c/data/CSW 2341 TEST 12

For hybrid composite with high glass fibre contents shows less CoF the wear rate increases because of the brittle nature the glass fibre. The coefficient of friction is higher for 20% filler material which can be used for brake shoe liner applications. For bearing applications a relatively lesser or negligible CoF is required which is met by without filler material. It is evident from the table hybrid composite with 20% coconut ash powder the wear rate is less because the coconut ash powder acts as a lubricant.

3.5 Micro structure





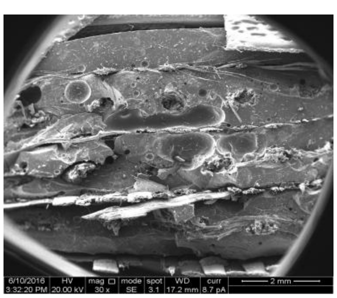


Fig. 13 shows the surface morphology of hybrid composite material using Jute and E-glass with filler material.(0%,5%,20%)

Fig. 13 shows the SEM images of composites without filler material , respectively. The surface morphology shows the presence of micro-cracks and formation of debris The increase in the normal load exhibits that the surface damage is caused by fracture of the fibre and damage of the matrix which results in de bonding of the fibres.SEM images of composites with 5% of coconut ash filler material micro-crack and wear scars are clearly observed over the surface of the abraded composites.

The micrograph of composites with 20% of coconut ash as filler material it is observed that , severe matrix damage, micro cracks and deeper groove at low fibre content. Fine wear debris and scratches are detected on the surface of abraded sample of Composite.

IV. CONCLUSION

The casting and testing on hybrid composite made up of Jute and E-Glass as fibre with, coconut ash as filler material is conducted and the results are analysed and tabulated.

- After analyzing tensile and bending test results graph it is concluded that the average tensile and bending strength is highest for the 0% fly ash but the average tensile young's modulus is highest for 5% coconut ash powder and average bending young's modulus is highest for the 20% coconut ash that means the elastic limit for the 5% and 20% has increased.
- There was considerable enhancement in the Hardness for 20% coconut ash.
- From the wear test results after analyzing the graphs for different load of 10N, 20N and 30N condition it is concluded that the wear is less for the20% coconut ash that means weight loss is less and also the co-efficient of friction is more for 20% coconut ash.
- The morphology of the above said composite material for different weight ratio of the filler material has been analyzed using Scanning Electron Microscope.

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