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Studies on Material and Mechanical Properties of Natural Fiber Reinforced Composites.

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ABSTRACT

Natural fibers have been used to reinforce materials for over 3,000 years. More recently they have been employed in combination with plastics. Many types of natural fibers have been investigated for use in plastics including Flax, hemp, jute, straw, wood fiber, rice husks, wheat, barley, oats, rye, cane (sugar and bamboo), grass reeds, kenaf, ramie, oil palm empty fruit bunch, sisal, coir, water hyacinth, pennywort, kapok, paper-mulberry, raphia, banana fiber, pineapple leaf fiber and papyrus. Application of composite materials to structures has presented the need for engineering analysis, the present work focuses on the fabrication of polymer matrix composites by using natural fibers like jute, coir, and hay which are abundant in nature in desired shapes by the help of various structures of patterns and calculating the material characteristics (flexural modulus, flexural rigidity, hardness number, % gain of water, wear resistance, bonding structure) by conducting tests like flexural test, hardness test, water absorption test, wear test, SEM analysis and their results are measured on sections of the material and make use of the natural fiber reinforced polymer composite material for automotive seat shell manufacturing

KEYWORDS: *Natural fibers,material,plastics,polymer*

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I. INTRODUCTION

Materials made from two or more constituent materials with significantly different physical or chemical properties which remain separate and distinct at the macroscopic or microscopic scale within the finished structure. Natural fiber composites combine plant-derived fibers with a plastic binder. The natural fiber component may be wood, sisal, hemp, coconut, cotton, kenaf, flax, jute, abaca, banana leaf fibers, bamboo, wheat straw or other fibrous material, and the binder is often recycled plastic (usually PVC or polyethylene). Objective is to choosing proper material as natural fibers to fabrication of natural composite fibers, to create the opportunity to use natural fiber for more (high-tech) applications.[1]

In the literature review **Ever J. Barbero** evaluates the basic concepts on composites design material selection and manufacturing processes are discussed. **Robert S. Fielder** was performed to examine the effects of constructing multilayered thick film inductors using an artificially modulated magnetic composite structure. **K. Van Rijswijk, M.Sc.W.D.** in his report a strategy is introduced to increase the yield of the traditional fibre industry of rural societies. **Erwin Baur** and **Frank Otremba** evaluated an important potential application of natural fibers is their use as reinforcement for plastics. Natural fiber has following properties low shrinkage, low coefficient of thermal expansion, reasonable strength, modulud and elongation, natural fiber combinations made **COIR + JUTE, HAY + COIR, JUTE + HAY.**

Advantages of natural fiber composites include light weight, low-energy production and sequestration of carbon dioxide reducing the "greenhouse effect". Studies on material and mechanical properties of natural fiber reinforced composites of coir, hay, jute with 25% fiber and 75% epoxy resin hardner mixtured has been moulded and flexural test, hardness test, wear test, water absorption test, scanning electron microscope test has been carried out and make use of natural fiber reinforced polymer composite material for automotive seat shell manufacturing.[2,3]

II. PROPERTIES OF NATURAL FIBER

FIBER	DENSITY(g/cm^3)	ELOGNATION (%)	TENSILE STRENGTH(MPa)	YOUNG'S MODULUS(GPa)
Cotton	1.5-1.6	7.0-8.0	287-597	5.5-12.6
Jute	1.3	1.5-1.8	393-773	26.5
Flax	--	2.7-3.2	345-1035	27.6
Hemp	--	1.6	690	--
Ramie	--	3.6-3.8	400-938	61.4-128
Sisal	1.5	2.0-2.5	511-635	9.4-22.0
Coir	1.2	30.0	175	4.0-6.0
E-glass	2.5	2.5	2000-3500	70.0

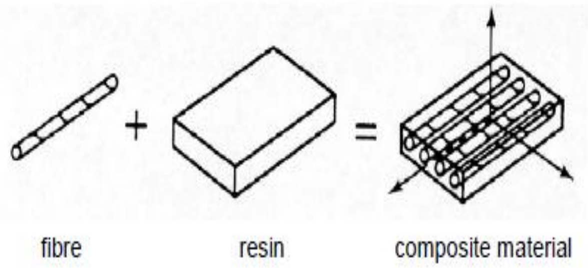
Properties of Natural Fiber

III. PROBLEM DESCRIPTION

It has been already known that if the weight of the vehicle increases the speed as well as the mileage of the vehicle gets reduced. Thus by reducing the weight of the material used conventionally by using the composites materials. The composite materials are usually made with combining glass fibers and resins called matrix. But the use of glass fiber increases the cost. [4]

IV. MOULDING PROCESS

In this project discontinuous fiber is used for fabricate the natural fiber composites. In mould preparation the resin is mixed with hardener in the ratio of 4:1. The mixer is strewed with stirrer for 15 minutes continuously



In this article Hand Laminating Molding is used for fabricate the natural fiber composites.

V. FABRICATED NATURAL FIBER COMPOSITES

- Polymer Coir Matrix Composites
- Polymer Jute Matrix Composites
- Polymer Hay Matrix Composites
- Polymer Coir + Jute Matrix Composites
- Polymer Coir + Hay Matrix Composites
- Polymer Jute + Hay Matrix Composites

Polymer matrix composite

VI. MATERIAL PROPERTIES

The main objective of this project is to determine the material properties (Flexural modulus, flexural rigidity, Hardness number, % gain of water, wear resistance, Bonding structure) of natural fiber reinforced composite material by conducting the following respective tests.[5]

- Flexural test
- Hardness Test
- Water absorption Test
- Wear Test
- SEM analysis

VII. FLEXURAL TEST

The flexural test measures the force required to bend a beam under three point loading conditions. The data is often used to select materials for parts that will support loads without flexing. Flexural modulus is used as an indication of a material's stiffness when flexed. Since the physical properties of many materials (especially thermoplastics) can vary depending on ambient temperature, it is appropriate to test materials at temperatures that simulate the intended end use environment. [6,7]

Flexural Test

FORMULA USED

$E = \frac{F L^3}{48\, y\, I}$ N/mm^2 E – Modulus of elasticity E I – Flexural Rigidity y- Deflection in mm F- load in N

$E\,I = \frac{F L^3}{48\, y}$ N-mm^2

$I = \frac{B H^3}{12}$

MODEL CALCULATION

$E = \frac{F L^3}{48\, y\, I}$ y = 0.75 mm

$I = \frac{B H^3}{12}$ L = 200 mm B = 80 mm y = H/2 H = 10 mm y = 5 mm from natural Axis

$I = \frac{80 \text{ x } 10^3}{12}$

I = 6666.67 mm^4

$E = \frac{61.31\, X\, 200^3}{48\, X\, 0.75\, X\, 6666.67}$

E = 2043.67 N/mm^2

$EI = \frac{F L^3}{48\, y}$ N-mm^2 $= \frac{61.31\, X\, 200^3}{48\, X\, 0.75}$

EI = 13.624 x 10^6 N-mm^2

VIII. FLEXURAL TEST RESULT

S.No	Proving Reading Division	Load F In		Deflection Y in mm	Modulus of Elasticity E in N/mm^2	Flexural Rigidity EI in $N\text{-}mm^2$
		Kg	N			
1	1	6.25	61.31	0.75	2043.67	$13.624X10^6$
2	2	12.5	122.625	1.7	1803.23	$12.021X10^6$
3	3	18.75	183.94	2.9	1585.60	$10.570X10^6$
4	4	25	245.25	3.7	1657.09	$11.047X10^6$

Polymer Hay Matrix Composites

S.No	Proving Reading Division	Load F In		Deflection Y in mm	Modulus of Elasticity E in N/mm^2	Flexural Rigidity EI in $N\text{-}mm^2$
		Kg	N			
1	1	6.25	61.31	7.32	969.40	$1.39X10^6$
2	2	12.5	122.625	9.5	1493.90	$9.95X10^6$
			1231.65	$5.67X10^6$		

Polymer Coir + Jute Matrix Composites

S.No	Proving Reading Division	Load F In		Deflection Y in mm	Modulus of Elasticity E in N/mm^2	Flexural Rigidity EI in $N\text{-}mm^2$
		Kg	N			
1	1	6.25	61.31	1.93	1551.11	$5.29X10^6$
2	2	12.5	122.625	5.55	1078.79	$3.68X10^6$
3	3	18.75	183.94	9.75	921.12	$3.14X10^6$
			1183.67	$4.036X10^6$		

Polymer Coir Matrix Composites

S.No	Proving Reading Division	Load F In		Deflection Y in mm	Modulus of Elasticity E in N/mm^2	Flexural Rigidity EI in $N\text{-}mm^2$
		Kg	N			
1	1	6.25	61.31	2.76	1619.08	$3.70X10^6$
2	2	12.5	122.625	6.32	1414.13	$3.23X10^6$
3	3	18.75	183.94	9.8	1367.96	$3.12X10^6$
			1467.05	$3.35X10^6$		

Polymer Hay + Coir Matrix Composites

S.No	Proving Reading Division	Load F In		Deflection Y in mm	Modulus of Elasticity E in N/mm^2	Flexural Rigidity EI in $N\text{-}mm^2$
		Kg	N			
1	1	6.25	61.31	1.26	1216.46	$8.109X10^6$
2	2	12.5	122.625	2.94	1042.68	$6.95X10^6$
3	3	18.75	183.94	4.62	995.29	$6.66X10^6$
4	4	25	245.25	6.97	879.66	$5.86X10^6$
			1032.02	$6.89X10^6$		

Polymer Hay + Jute Matrix Composites

S.No	Proving Reading Division	Load F In		Deflection Y in mm	Modulus of Elasticity E in N/mm^2	Flexural Rigidity EI in $N\text{-}mm^2$
		Kg	N			
1	1	6.25	61.31	0.8	5685.83	$12.77X10^6$
2	2	12.5	122.625	1.78	5020.97	$11.48X10^6$
3	3	18.75	183.94	3.3	4062.43	$9.28X10^6$
			4923.07	$11.17X10^6$		

Polymer Jute Matrix Composites

IX. HARDNESS TEST

The Rockwell hardness number represents the additional depth to which a test ball or sphere-conical penetrator is driven by a heavy (major) load beyond the depth of a previously applied light (minor) load. High hardness numbers that are obtained from hard materials indicate a shallow indentation while low numbers found with soft materials indicate deep indentation. The increment of penetration depth for each point of hardness on the Rockwell scale is 0.00008 inch. For example, if a piece of steel measures Rockwell C 58 (extremely hard) at same point and C 55 at another, the depth of penetration would have been 0.00024 inch deeper at the softer spot.

Rockwell Hardness Test

Scale	Type of penetrator	Major Load (Kg)Rockwell H
Standard Scales		
B	1/16” Ball	100
C	Brale diamond	150
Special Scales		
A	Brale diamond	60
D	Brale diamond	100
E	1/8” Ball	100
F	1/16” Ball	60
G	1/16” Ball	150
H	1/8” Ball	60
K	1/8” Ball	150

Standard Scales for Rockwell Hardness Test

X. HARDNESS TEST RESULTS

S.No	Polymer matrix composite	Indenter used	Load in Kg	RHN
1	Coir	Diamond Indenter	150	84C
2	Jute			42C
3	Hay			39C
4	Jute + Hay			94C
5	Hay + Coir			32C
6	Jute + Coir			50C
7	Coir	1/16 Ball Indenter	100	73B
8	Jute			79B
9	Hay			95B
10	Jute + Hay			81B
11	Hay + Coir			51B
12	Jute + Coir			80B

Table 4.5.2 Tabulated Readings of Rockwell Hardness Number

XI. WATER ABSORPTION TEST

Water absorption is used to determine the amount of water absorbed under specified conditions. Factors affecting water absorption include: type of plastic, additives used, temperature and length of exposure. The data sheds light on the performance of materials in humid.

Weighing Machine

water absorption test

XII. WATER ABSORPTION TEST RESULT

Polymer matrix composite material	Mass before test (g)	Mass after test (g)	(%) gain of water
HAY	9.823	9.834	0.12
JUTE	8.342	8.348	0.07
COIR	9.141	9.150	0.09
COIR + JUTE	9.143	9.457	0.04
JUTE + HAY	8.563	8.571	0.1
HAY + COIR	8.765	8.789	0.06

Table Water Absorption Test Result

XIII. COMPARISON OF DENSITY OF DIFFERENT REINFORCING POLYMER MATRIX COMPOSITES

Polymer matrix composite material	Mass(m) (g)	Volume(v) (cm^3)	Density(ρ), m/v (g/cm^3)
HAY	9.823	9	1.091
JUTE	8.342	9	0.927
COIR	9.141	9	1.015
COIR + JUTE	9.143	9	1.016
JUTE + HAY	8.563	9	0.951
HAY + COIR	8.765	9	0.974

Table Density Test Result

XI. WEAR TEST

This test method evaluates the performance of materials in rubbing contact under end use type conditions. The contact can be a test material against steel or against itself. The test specification refers to self-lubricating materials

XIV. WEAR TEST RESULT

Sample	Area	Wear	Wear	Wear Rate	Specific Wear Rate	Wear Resistance
	mm^2	Microns	mm^3	mm^3/m	mm^3/Nm	m/mm^3
1	72	493	35.496	0.0355	0.00071	28.172
2	72	628	45.216	0.0452	0.00090	22.116
3	100	346	34.6	0.0346	0.00069	28.902
4	72	420	30.24	0.0302	0.00060	33.069
5	110	369	40.59	0.0406	0.00081	24.637
6	72	592	42.624	0.0426	0.00085	23.461

SAMPLE

1. Polymer Hay + Coir Composite
2. Polymer Jute Composite
3. Polymer Hay Composite
4. Polymer Coir Composite
5. Polymer Jute + Hay Composite
6. Polymer Coir + Jute Composite

Force F = 50 N
Velocity V = 1.5 m/s
Time T = 667 sec
Track Diameter = 0.1 m
Speed N = 287 rpm

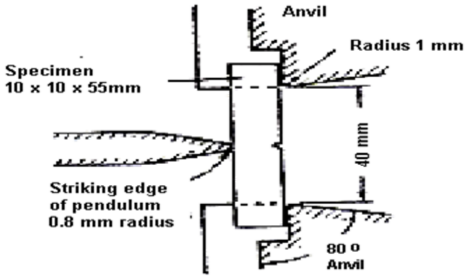
XV. IMPACT TEST

The Charpy impact test, also known as the Charpy v-notch test, is a standardized high strain-rate test which determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent brittle-ductile transition. It is widely applied in industry, since it is easy to prepare and conduct and results can be obtained quickly and cheaply. But a major disadvantage is that all results are only comparative.[8,10]

The apparatus consists of a pendulum axe swinging at a notched sample of material. The energy transferred to the material can be inferred by comparing the difference in the height of the hammer before and after a big fracture.

The notch in the sample affects the results of the impact test, thus it is necessary for the notch to be of regular dimensions and geometry. [9]

Specimen Specification



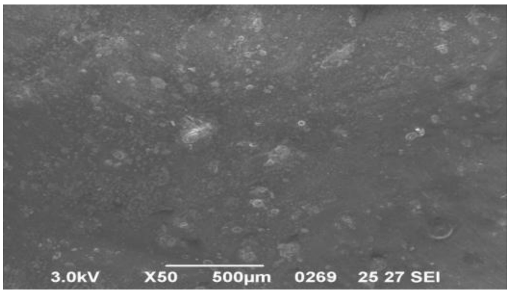
Calculation of Impact Strength

S.NO	NATURAL FIBRE COMPOSITE MATERIAL	IMPACT STRENGTH J/mm^2
1	HAY	0.203
2	COIR	0.205
3	JUTE	0.229
4	HAY& JUTE	0.28
5	COIR & JUTE	0.267
6	COIR & HAY	0.272

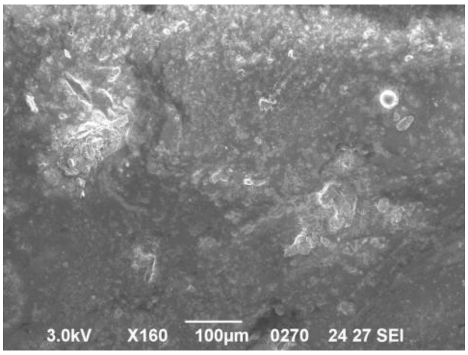
XVI. SEM ANALYSIS

For plastics applications, a scanning electron microscope can be used to examine surface irregularities or fracture areas in a part. A SEM can also be used to measure the depth of thin coatings. Test specimens are sputter coated with gold, then placed in a vacuum chamber for viewing on the computer monitor at up to 10,000x magnification. Polaroid photos are taken for a permanent record.

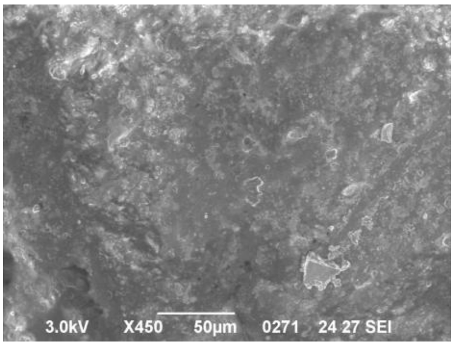
SEM ANALYSIS RESULT



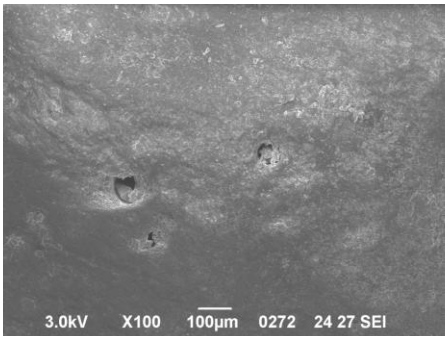
(a) Scanning electron micrograph of Polymer Hay + coir Composite



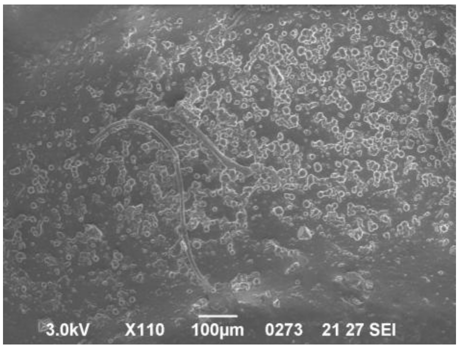
(b) Scanning electron micrograph of Polymer Jute Composite



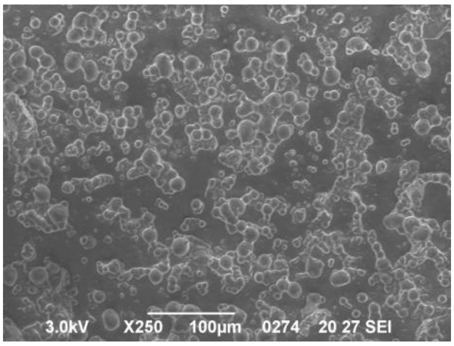
(c) Scanning electron micrograph of Polymer Hay Composites



(d) Scanning electron micrograph of Polymer Coir Composite



(e) Scanning electron micrograph of Polymer Jute + Hay Composite



Scanning electron micrograph of Polymer Coir + Jute Composite

XVII. CONCLUSION

A Polymer matrix composite contains the various natural fibers as the reinforcement phase was successfully fabricated and the homogeneity of natural fibers-matrix combinations and their bonding structures was characterized through SEM analysis.The material properties (young's modulus, poison's ratio, percentage gain of water, wear and hardness) of fabricated natural fiber reinforced composites were observed and it is was found that polymer hay reinforced natural composites is the best natural composites for manufacturing of automotive seat shells among the other natural fiber combination of coir and jute.

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