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

INVESTIGATION OF MECHANICAL PROPERTIES ON BANANA AND SISAL FIBER REINFORCED POLYMER COMPOSITE

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Abstract: Natural fibers are the emerging reinforcement for synthetic reinforcement. In this research, the polyester matrix is reinforced with banana and sisal fibers in three combinations. Mechanical analysis like impact, compression and hardness are analyzed for the laminates developed from compression molding machines. The water absorbing property of all laminates is also observed. The result showed that the L3 laminate, which was reinforced with a 24 weight percentage of sisal fiber, has a maximum value of impact, compression and hardness. The presence of a high quantity of sisal fiber showed better mechanical properties and also it absorbs very less amount of water, when compared with other laminates. The L3 laminate will be applied in the automobile and manufacturing industry for its better mechanical property.

I.INTRODUCTION

Composites are materials that consist of more than two components that are bound with each other to give various mechanical properties. The components are divided into two phases namely, a matrix phase and reinforcement phase. The matrix phase will be the polymer, which has a long chain of covalent bonds that was not balanced. This is the reason the polymers are in liquid state. It will be balanced by adding hardener, so that it was converted into a hard compound. The matrix is the binding component that binds all the reinforcement and gives the desired shape for the material.

The reinforcement is the components that give shape to the material. It acts like a frame and gives strength to the entire component. The load act over the composite is distributed to the entire structure of the composite and the load is balanced by neglecting the force act in a specific area to avoid fatigue. We all knew about the failure mechanism of a material: when a material is subjected under a cyclic loading there is a formation of fatigue over the material. Then the fatigue developed into a crack. So the reinforcement avoids the crack formation by distributing the load over the composite.

At first Synthetic reinforcement like glass fiber and aramid are used in composite but green reinforcement emerged as promising alternatives to substitute synthetic reinforcement. Natural fiber has advantages such as cost-effectiveness, renewability, light weight, high specific strength and biodegradability. Some plants have grown naturally with fibers, which are long, thin and have more strength. For example fibers are naturally available in banana and coconut herbs. We can use those fibers by treating it with some chemical to eliminate the starch and get only fibers. Usually the different plant fibers have different properties. Even the same plant grown in different regions has some ups and downs in their property. So much research has been undertaken to debut new green fibers to the industry.

To reduce the environmental impact of non-biodegradable materials natural fibers are used. The natural fiber is formed with cellulose, hemicellulose and lignin. The hemicellulose and lignin are covered by cellulose and form an amorphous structure. The amorphous structure is the reason for the cellulose not directly linked with matrix material. Because the hemicellulose and lignin form a weak hydroxyl group and it reacts with atmospheric molecules. This is the reason for the hydrophilic nature of natural fiber, which gives poor adhesion behavior with matrices.

This research focused on obtaining extensive mechanical property by combining the banana and sisal fiber as reinforcement in polymer composite. We try to eliminate the drawbacks in natural fiber by using it as reinforcement at different percentages. Since India has an abundant amount of natural fibers, which were grown as food crops. After collecting the fruits and seeds, the remaining part of the plants and herbs are left as waste. Also when focused on banana cultivation in the area of south tamilnadu have met more disaster. Farmers lost their crops in disaster before it was cultivated. So when we increase usage of banana and sisal fiber in industry, it will help our farmers to get more yields by not only selling fruits and also selling those herbs

II. MATERIALS AND METHODOLOGY

2.1. Materials

Banana fiber is collected from nearby agricultural areas and sisal fiber is bought from the industry named gundur fibers. Both the fibers are treated with NaOH solution for 1 hour. Then it is dried and analyzed for chemical composition and mechanical properties are shown in table 1 and 2.

Table 1: Chemical composition of banana and sisal fiber

Chemical percentage	Cellulose	Hemicellulose	lignin
Banana fiber	52	12	16
Sisal fibre	62	12	9.9

Table 2: Physical properties of banana and sisal fiber

Physical properties	Density	Elongation at break	Tensile strength	Young's modulus
Banana fibre	1.4g/cm²	1.8 %	700 - 800 Mpa	27 - 32 Gpa
Sisal fiber	1.5g/cm²	2.7%	350-700 Mpa	9-72 Gpa

2.2. Preparation of polyester and hardener

The composite was developed by using polyester as matrix material with density of 1.2-1.5 g/cm 3 and by adding the hardener in the ratio of 10:1. Polyester, hardener and catalyst were bought from covai seenu and company in Coimbatore.

2.3. Preparation of mold

An Aluminum frame was prepared, which will occupy a space with dimensions of 300×300×30mm. Both top and bottom plates are also prepared with Aluminium to hold the composite material. This will withstand a high temperature and load when placed in a compression molding machine.

2.4. Fabrication of composite

Compression molding machine is used to fabricate the composite plates. Wax is applied on both the face of top and bottom plates to avoid sticking of composite on the frame. The frame is placed over the bottom plate. Fibers are placed inside the frame in the combination of 1:1, 3:2 and 2:3 as shown in table 3. Those fibers are shortly cut into 3mm long fiber with the help of scissors. Sixty percent of polyester is used in all plates. After placing the fibers inside the frame, a compression is given to settle all those fibers within the frame. Also void and gaps are neglected by giving little compression over the frame. The polyester is measured and taken in a container. The hardener used here is cobalt and it is taken in the amount of 10ml for 1Kg of polyester. The catalyst added in the amount of 15ml for 1Kg of polyester. Polyester, Hardener as cobalt and catalyst are added as per required ratio, it is mixed well and poured inside the frame where the fibers are placed. Resin mixer is widely spread all over the fiber. Then the top plate is placed over the frame. The entire set-up is placed over the compression molding press which was set with a temperature of 90°C. A compression of one ton is given for 15minutes to fabricate the plate.

Table 3: Composition of laminates.

Composite composition	Polyester	Banana fiber	Sisal fiber
L1	60%	20%	20%
L2	60%	24%	16%
L3	60%	16%	24%

III. EXPERIMENTAL ANALYSIS

3.1. Impact test

Impact test helps to evaluate the high impact energy that can be observed by a material. It gives the point of energy that breaks the material. By this value we can conclude that the material can absorb the energy below the point at the break. Izod impact is analyzed for the prepared sample according to the ASTM D256 standard with dimension of 65×14×3mm.

3.2. Compression test

While fabricating polymer composite plates, Shear loading test is the best method for testing the ultimate compressive strength. This method determines the in-plane compressive property by applying the compressive force into the specimen at wedge grip interfaces. The most suitable standard for polymer composite is ASTM D3410, because we have used banana and sisal fiber as reinforcement. The fixture will provide the compressive load to the unsupported center for 12 to 25mm gauge length. The specimen with a dimension of 25×25×3mm was prepared and placed inside the fixture. A fixture is used to align the specimen in the wedge grips and the grips are tightened. The wedges are placed into the compression fixture and then the compression is given until the specimen fails.

3.3. Hardness test

Vickers hardness has the wide advantage of testing polymer composite. Where an indentation is made over the specimen with a diamond indenter, which is in the form of a pyramid with a square base. The inner opposite faces have an angle of 136°. That was subjected to a test, force between 1gf to 100 Kgf. The sample is prepared and polished to get a smooth surface. Then a full load is applied for 10 to 15 seconds. The indenter made an impression over the specimen and the two diagonals of indentation left on the surface of the specimen was measured using microscope and their average is calculated. The Hardness number (HV) is calculated by using a simple formula.

$$\text{Vickers hardness (HV)} = \text{Applied Load} / \text{Area of Indentation}$$

$$HV= [2F\sin(136°)]/[2d^2]$$

$$\mathbf{HV=1.854F/d^2}$$

3.4. Water absorption test

Natural fibers have the ability to absorb water, so a water absorption test is recommended for any polymer composite to be reinforced by natural fiber. The ASTM D5229 was a recommended standard for testing. The test was carried out with fresh water and distilled water. The prepared samples were dried in the oven and the initial weight of each sample is noted. Twenty four samples were prepared and then 12 samples were immersed in water and 12 samples were immersed in distilled water. Time period of 6, 12, 18, 24 days immersed samples in fresh water and distilled water was taken and final weight was noted. The amount of water absorbed by the composite was calculated by the equation.

$$\text{Weight percentage} = [(W_i - W_f)/W_f] \times 100$$

Where W_i – weight at initial

W_f – weight at final

IV. RESULTS AND DISCUSSION

Impact tests on each laminate showed that the impact energy of 97.82 KJ/m² is the maximum energy absorbed by the L3 combination. This is due to the presence of 24% of sisal fiber in this laminate. In laminate L2, 88.32 KJ/m² of energy is absorbed and 91.92KJ/m² of energy absorbed by L1 laminate as shown in table 4. So we can conclude that the increase in sisal increases to absorb high impact energy. But when applying for high impact absorbing material L3 combination will be the suitable one.

Table 4: Impact strength, compression strength and Hardness values of each laminates

Laminates	Impact strength in KJ/m²	Compression Strength in MPa	Hardness (HV)
L1	91.91	39.57	56.14
L2	88.32	31.29	49.12
L3	97.82	54.76	62.17

4.2. Compression analysis

The laminate L3 had a high compression energy of 54.76 MPa. As the same Impact analysis, increase in sisal fiber can increase the high compression energy. This can be seen in the value of L2 laminate. Which have a large percentage of banana fiber when compared to other laminates so it has very low compression energy of 31.29 MPa.

4.3. Hardness analysis

It is evident from the hardness strength of the composites varied with different composition of fibers and laminates. The composite laminate L3 has more hardness strength when compared to other two laminates L1 and L2 were shown in the table 4

4.4. Water absorption analysis

The laminates gained weights by absorption of water. The percentage increase of the interval of six days for distilled water and normal water is tabulated in the below tables. The test was done over a period of 24 days. From the test it is found that the maximum water absorption is observed in laminate L2 as shown in the table 5 and 6. This is due to the fact that the banana fiber absorbs more water when compared to sisal fiber. So we can find that 24% of banana fiber is reinforced in L2 laminate when compared to L1 and L3 laminates , banana fiber percentage as 20% and 16%. As increase in banana fiber in laminates increases the water absorption capacity of each laminates.

Table 5: Composite laminates in freshwater

Composite laminate	Initial Weight in (g)	Day 6 Weight in (g)	Day 12 Weight in (g)	Day 18 Weight in (g)	Day 24 Weight in (g)
L1	3.502	3.724	4.765	7.851	10.327
L2	4.489	6.751	8.484	14.252	15.121
L3	4.418	5.131	8.26	10.183	14.562

Table 6: Composite laminates in distilled water

Composite laminate	Initial Weight in (g)	Day 6 Weight in (g)	Day 12 Weight in (g)	Day 18 Weight in (g)	Day 24 Weight in (g)
L1	3.314	3.976	4.358	8.021	10.628
L2	4.412	6.321	8.251	11.452	15.396
L3	3.291	4.685	7.546	10.374	14.157

V. CONCLUSION

Polyester resin was effectively reinforced with banana and sisal fibers at three compositions. The mechanical properties impact strength, compression strength and hardness are analyzed. The water absorption of each composition was observed.

- It is found that an increase in weight percentage of sisal fiber increases its mechanical properties.
- Water absorption of laminates decreased with increase in weight percentage of sisal fiber.
- Banana fiber increases the absorption of water in laminates and also shows very high deviation in mechanical properties.

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