

Fabrication of Table Tennis Bat Using Pineapple Leaf Fiber

^[1] Prashanth. M, ^[2] Jerome Nithin Gladson G, ^[3] Jithu K Thampi, ^[4] Joshi James

^[1] Assistant Professor, Department of Mechanical Engineering, CSI College of Engineering,
The Nilgiris-643215, India

^{[2][3][4]} Department of Manufacturing Engineering, CSI College of Engineering, The Nilgiris-643215, India

Abstract—The aim of the project is to fabricate a table tennis bat by polymer reinforced composite materials. The bat is made using Epoxy resin reinforced with pineapple leaf fiber. These agricultural wastes can be used to prepare fiber reinforced polymer composites for commercial use. Pineapple fiber can be obtained for industrial purposes without any additional cost. The main advantages of these fibers are their low cost, low density, high specific strength and modulus, renewable nature, and comparatively easy process ability. This project also deals with studying the properties of the composite material made. Various test are carried out to find the mechanical properties of the composite material. Finally the other possible application of the composite material made is found on the bases of the testing and evaluation done.

Keywords—PALF; Fabrication; Tests; Low Density; High specific Strength; Applications

I. INTRODUCTION

Pineapple Leaf Fiber (PALF), is a waste product of pineapple cultivation. Hence, pineapple fiber can be obtained for industrial purposes without any additional cost. Over the past decade, cellulosic fillers have been of greater interest as they give composites improved mechanical properties compared to those containing non-fibrous fillers. Natural fibers are plant based which are lignocellulose in nature and composed of cellulose, hemicelluloses, lignin, pectin and waxy substances. Cellulose gives the strength, stiffness and structural stability of the fiber, and is the major framework components of the fiber. The lignin, hemicelluloses and pectin provides the adhesive to hold the cellulose framework structure of the fiber together. Natural fibers possess mechanical, thermal and electrical properties that can justify their uses in many applications. Study on mechanical, thermal and electrical properties of composites helps to analyze the properties of materials to assess strength, ductility, fatigue, thermal conductivity, specific heat, dielectric constant, dissipation factor, dielectric loss, electrical resistivity, under different conditions such as fiber type and architecture, fiber volume fraction, direction of heat flow, and service temperature, and helps to assists in the evaluation and design of materials and products that are more efficient and less costly because they last longer. Recently, car manufactures have been interested in incorporating natural fiber composites into both interior and exterior parts. This serves a two-fold goal of the companies to lower the overall weight of the vehicle thus

increasing fuel efficiency and to increase the sustainability of their manufacturing process.

Pineapple leaf fiber is a high textile grade commercial fiber, generally extracted by water retting. Pineapple leaf contains only 2.5-3.5% fiber, covered by a hydrophobic waxy layer, which remains beneath the waxy layer. Pineapple leaf fiber is graded in between jute and cotton or jute and ramie. It has all textile properties and is capable of blending with jute, cotton, ramie and some other synthetic fibers. So pineapple leaf fiber can capture an important position among natural fibers as potential commercial grade textile fiber, but there is need of its assured supply to processing industry in sufficient quantities.



Fig. 1 Short Pineapple Leaf Fiber



Fig.2 Pineapple Leaf Fiber

Table: I Properties of Pineapple Leaf Fiber

Property	Value
Density(g/cm ³)	1.526
Softening Point(°C)	104
Tensile Strength(MPa)	170
Young's Modulus (MPa)	6260
Specific Modulus (MPa)	4070
Elongation at Break(%)	3
Moisture regain(%)	12

II. FABRICATION

A. Extraction methods for PALF

Pineapple leaf fiber in nowadays are waste products of pineapple cultivation. A special purpose machine having metal knife scrapper roller and serrated roller used to scrap out the waxy layer and at the same time with retting process the pineapple leaf fiber being extracted.

a) Scrapping of pineapple leaf

The new machine used for scrapping the pineapple leaf has the following modifications, such as the machine has three rollers, (i) feed roller (ii) leaf scratching roller and (iii) serrated roller. The leaves are fed through feed roller and then scratched by other roller to remove the waxy layer followed by serrated roller creating space for retting microbes



Fig.3 scrapping operation through rollers

b) Retting

The scratched pineapple leaves were tied in small bundles and immersed in retting tank containing 1:20 substrate: liquor ratio. 0.5% urea or di-ammonium phosphate (DAP) was added for quick retting. The leaves from retting tanks were regularly checked by pressing them within fingertips to see whether the fibers are loosened and can be extracted. At the end of retting the leaves were taken out and the fibers were mechanically extracted by washing in pond water. The extracted fibers were then dried in air by hanging from bamboo poles

c) Using Ceramic Plate

By implying ceramic plate over the pineapple leaf with pressure and fast movement of it, will give the fiber beneath the leaf. The way how to do the extract the fiber from long leaf done by easy approach.



Fig.4 Extraction of fiber using ceramic plate

d) Evaluation of Retting Environmental Parameters

Temperature, pH, redoxpotential(Eh), and conductivity of retting water were determined regularly following the standard procedures using a Eutech pH

meter for determining pH and Eh and a Eutech conductivity meter for determining conductivity after temperature correction, until completion of retting. Strength and fineness of the retted fibers were determined following the standard procedures.

e) Chemical Treatment

Alkali treatment or mercerization using sodium hydroxide (NaOH) is the most commonly used treatment for bleaching and cleaning the surface of natural fibers to produce high-quality fibers. Modifying natural fibers with alkali has greatly improved the mechanical properties of the resultant composites.

The following steps were carried out during chemical Treatment

- 5% NaOH solution was prepared using sodium hydroxide pellets and distilled water.
- Pineapple leaf fibers were then dipped in the solution for 1hour.
- After 1 hour fibers were washed with 1% HCl solution to neutralize the fibers.
- Then it is washed with distilled water.
- It was then kept in hot air oven for 3hours at 65-70°C

Table:II The Effect Of Alkali Treatment Of Short Palf On The Mechanical Properties Of Short Palf

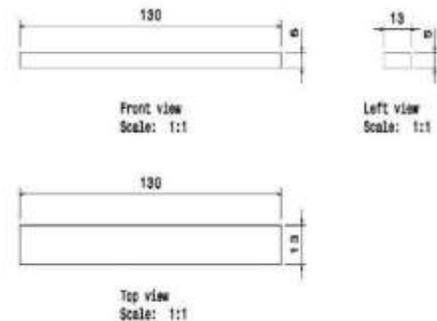
Mechanical Property	NAOH Concentration(%)		
	0	2	4
Tensile strength (MPa)	22.64 (1.25)	25.71 (1.25)	29.95 (1.35)
Tensile modulus (MPa)	824.64 (156.37)	1197.75 (66.43)	1284.84 (133.88)
Flexural strength (MPa)	31.66 (3.25)	34.37 (1.83)	40.78 (2.49)
Flexural modulus (MPa)	4294.02 (399.51)	4464.05 (122.40)	4559.33 (280.98)

Notched impact(J/m)	(1.342) 45.460	(3.187) 64.615	(1.58) 76.95
Unnotched impact(J/m)	45.460 (2.764)	64.615 (1.124)	76.959 (5.535)
Hardness scale L	84.120 (0.614)	89.260 (1.124)	90.820 (0.709)

III. SPECIMEN FOR TESTING

Specimen dimensions for impact and flexural test

SPECIMEN DIMENSION FOR IMPACT TEST AND FLEXURAL TEST



All dimensions are in mm

Fig 5 Specimen dimensions for impact and flexural test

a) Calculation

1. Impact Test and Flexural Test

$$\begin{aligned} \text{Volume of mould} &= \text{Length} \times \text{Breadth} \times \text{Height} \\ &= 130 \times 13 \times 5 \\ &= 8450 \text{ mm}^3 \\ &= 8.45 \text{ cm}^3 \end{aligned}$$

$$\begin{aligned} \text{Density of Epoxy resin} &= 1.4 \text{ g/cm}^3 \\ \text{Density} &= \frac{\text{Mass}}{\text{Volume}} \end{aligned}$$

$$\begin{aligned} \text{Mass} &= \text{Density} \times \text{Volume} \\ &= 1.4 \times 8.45 \\ &= 11.83 \text{ g} \end{aligned}$$

Table:III Composition For Tensile, Impact, Flexural Test

SAMPLE (%)	IMPACT TEST			FLEXURAL TEST		
	FIBER		RESIN	FIBER		RESIN
	TREATED	UNTREATED		TREATED	UNTREATED	
	(g)	(g)	(g)	(g)	(g)	(g)
10	1.183	1.183	10.64	1.183	1.183	10.64
20	2.366	2.366	9.46	2.366	2.366	9.46
30	3.549	8.281	8.281	3.549	3.549	8.281



Fig.8 mixing with pineapple leaf fiber

b) Manufacture of Specimen For Tensile, Impact And Flexural Test

Step 4: The prepared mixture is randomly arranged in the mould without any gap.

Step 1: A mould of required size is prepared by OHP sheet.



Fig. 6 Mould Preparation



Fig. 9 Wet/Hand Lay-Up

Step 2: The resin and hardener is mixed in the ratio 10:1.

Step 5: The setup is kept in the dry place for 24 hours



Fig. 7 Resin and Hardener Mixing



Step 3: The resin and hardener is thoroughly mixed with pineapple leaf fiber.



Fig. 10 Curing Process

Step 6: After curing, OHP sheet is removed and the specimen is machined using file for required dimension



Fig. 11 Machining process

c) Finished Specimen Ready for Testing



Fig. 12 Finished Specimen

IV. TESTS

A. Flexural Test



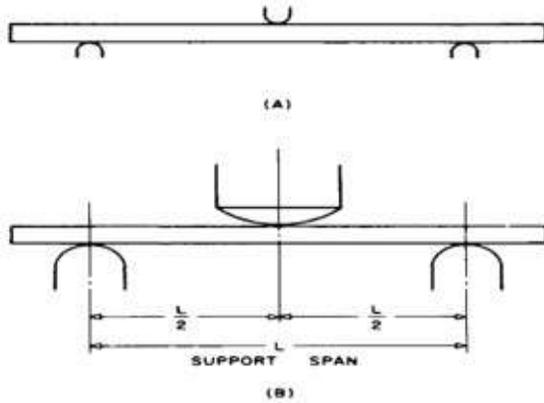


Fig.13 Flexural test

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength, a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. 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 test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress, here given the symbol .

Table: IV Corresponding Values For The Above Graph

Data Pair	Load	Eng. Stress (TS)	True Stress (TS)	Y=log (TS)	Y ²	Extension	Eng. Strain	True Strain (TSR)	X=log (TSR)	X ²	X*Y
1	3544.607	141.78	143.76	4.96815	24.68251	0.349	0.013969	0.01387	-4.27803	18.30154	-21.2339
2	4284.395	171.38	176.17	5.17145	26.7439	0.698	0.027938	0.02755	-3.59175	12.90067	-18.5746
3	4756.95	190.28	198.25	5.28953	27.97913	1.048	0.041907	0.04105	-3.19296	10.19499	-16.8893
4	5043	201.72	212.99	5.36125	28.743	1.397	0.055876	0.05437	-2.91194	8.47939	-15.6116
5	5216.353	208.65	223.22	5.40816	29.24819	1.746	0.069845	0.06751	-2.69548	7.26561	-14.5776
6	5321.291	212.85	230.69	5.44107	29.60524	2.095	0.083814	0.08049	-2.51962	6.34848	-13.7094
7	5383.787	215.35	236.41	5.46557	29.87246	2.445	0.097783	0.09329	-2.37204	5.62657	-12.9646
8	5419.197	216.77	240.99	5.48476	30.08259	2.794	0.111752	0.10594	-2.24488	5.03949	-12.3126
9	5437.521	217.5	244.84	5.5006	30.2566	3.143	0.125721	0.11842	-2.13352	4.55191	-11.7356
10	5443.077	217.72	248.13	5.51395	30.40364	3.492	0.13969	0.13076	-2.03439	4.13874	-11.2175

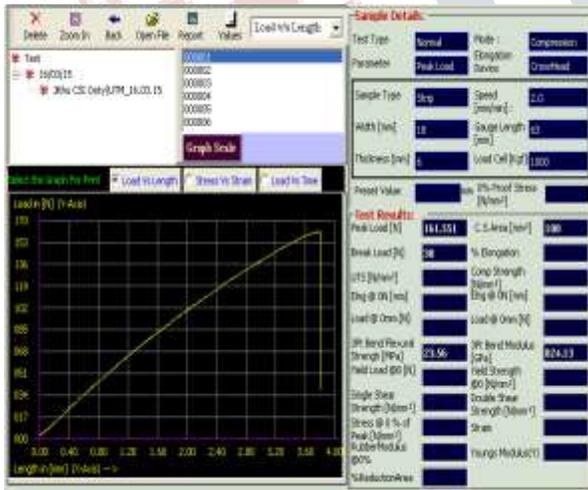


Fig.14 Graph showing Flexural strength of the specimen

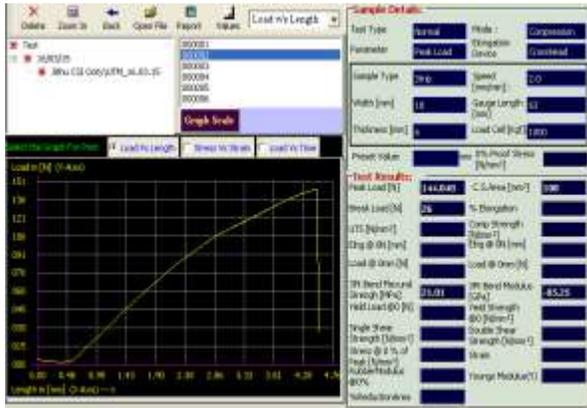


Fig.15 Graph showing Flexural strength of the specimen

Table: V Corresponding Values For The Above Graph

Data Pair	Load	Eng. Stress	True Stress (TS)	Y = log (TS)	Y ²	Extension	Eng. Strain	True Strain (TSR)	X = log (TSR)	X ²	X*Y
1	3544.607	141.78	143.76	4.96815	24.68251	0.349	0.013969	0.01387	-4.27803	18.30154	-21.2539
2	4284.395	171.38	176.17	5.17145	26.7439	0.698	0.027938	0.02755	-3.59175	12.90067	-18.5746
3	4756.95	190.28	198.25	5.28953	27.97913	1.048	0.041907	0.04105	-3.19296	10.19499	-16.8893
4	5043	201.72	212.99	5.36125	28.743	1.397	0.055876	0.05437	-2.91194	8.47939	-15.6116
5	5216.353	208.65	223.22	5.40816	29.24819	1.746	0.069845	0.06751	-2.69548	7.26561	-14.5776
6	5321.291	212.85	230.69	5.44107	29.60324	2.095	0.083814	0.08049	-2.51962	6.34848	-13.7094
7	5383.787	215.35	236.41	5.46557	29.87246	2.445	0.097783	0.09329	-2.37204	5.62657	-12.9646
8	5419.197	216.77	240.99	5.48476	30.08259	2.794	0.111752	0.10594	-2.24488	5.03949	-12.3126
9	5437.521	217.5	244.84	5.5006	30.2566	3.143	0.125721	0.11842	-2.13352	4.55191	-11.7336
10	5443.077	217.72	248.13	5.51395	30.40364	3.492	0.13969	0.13076	-2.03439	4.13874	-11.2175

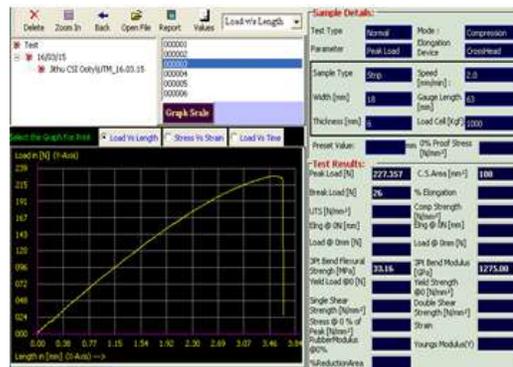
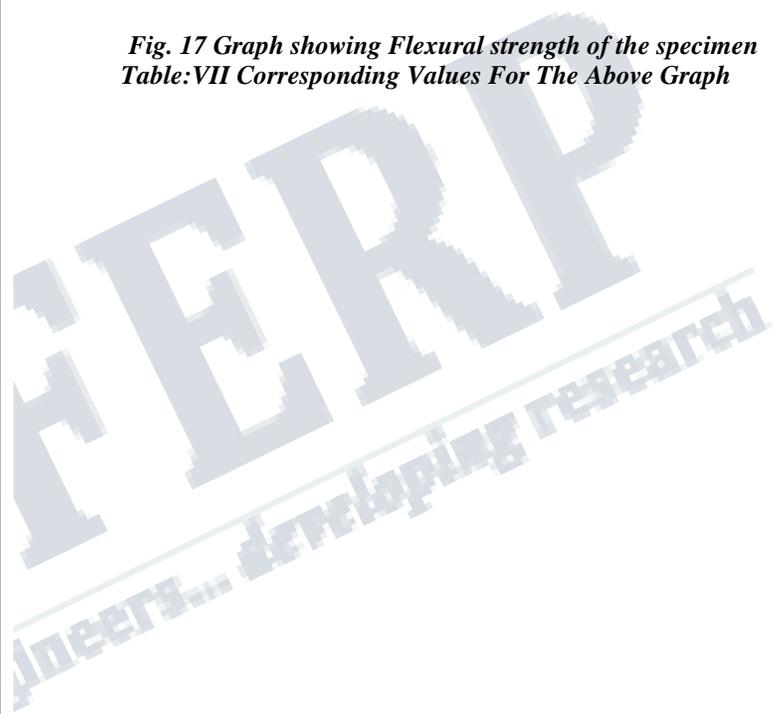


Fig.16 Graph showing Flexural strength of the specimen
Table: VI Corresponding Values For The Above Graph

Data Pair	Load	Eng. Stress (TS)	True Stress (TS)	Y=log (TS)	Y ²	Extension	Eng. Strain (TSR)	True Strain (TSR)	X=log (TSR)	X ²	X+Y
1	3544.607	141.78	143.76	4.96815	24.68251	0.349	0.013969	0.01387	-4.27803	18.30154	-21.2539
2	4284.395	171.38	176.17	5.17145	26.7439	0.698	0.027938	0.02755	-3.59175	12.90067	-18.3746
3	4756.95	190.28	198.25	5.28953	27.97913	1.048	0.041907	0.04105	-3.19296	10.19499	-16.8893
4	5043	201.72	212.99	5.36125	28.743	1.397	0.055876	0.05437	-2.91194	8.47939	-15.6116
5	5216.353	208.65	223.22	5.40816	29.24819	1.746	0.069845	0.06751	-2.69548	7.26561	-14.5776
6	5321.291	212.85	230.69	5.44107	29.60524	2.095	0.083814	0.08049	-2.51962	6.34848	-13.7094
7	5383.787	215.35	236.41	5.46557	29.87246	2.445	0.097783	0.09329	-2.37204	5.62657	-12.9646
8	5419.197	216.77	240.99	5.48476	30.08259	2.794	0.111752	0.10594	-2.24488	5.03949	-12.3126
9	5437.521	217.5	244.84	5.5006	30.2566	3.143	0.125721	0.11842	-2.13352	4.55191	-11.7356
10	5443.077	217.72	248.13	5.51395	30.40364	3.492	0.13969	0.13076	-2.03439	4.13874	-11.2175



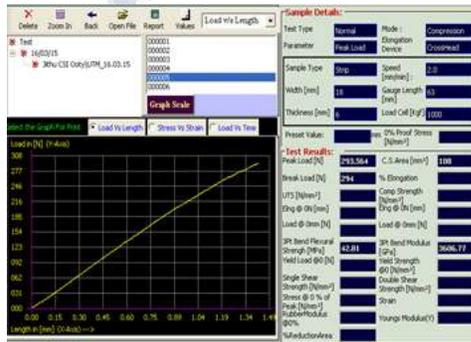
Fig. 17 Graph showing Flexural strength of the specimen
Table:VII Corresponding Values For The Above Graph



Data Pair	Load	Eng. Stress (TS)	True Stress (TS)	Y=log (TS)	Y ²	Extension	Eng. Strain	True Strain (TSR)	X=log (TSR)	X ²	X*Y
1	3544.607	141.78	143.76	4.96815	24.68251	0.349	0.013969	0.01387	-4.27803	18.30154	-21.2539
2	4284.395	171.38	176.17	5.17145	26.7439	0.698	0.027938	0.02755	-3.59175	12.90067	-18.5746
3	4756.95	190.28	198.25	5.28953	27.97913	1.048	0.041907	0.04105	-3.19296	10.19499	-16.8893
4	5043	201.72	212.99	5.36125	28.743	1.397	0.055876	0.05437	-2.91194	8.47939	-15.6116
5	5216.353	208.65	223.22	5.40816	29.24819	1.746	0.069845	0.06751	-2.69548	7.26561	-14.5776
6	5321.291	212.85	230.69	5.44107	29.60524	2.095	0.083814	0.08049	-2.51962	6.34848	-13.7094
7	5383.787	215.35	236.41	5.46557	29.87246	2.445	0.097783	0.09329	-2.37204	5.62657	-12.9646
8	5419.197	216.77	240.99	5.48476	30.08259	2.794	0.111752	0.10594	-2.24488	5.03949	-12.3126
9	5437.521	217.5	244.84	5.5006	30.2566	3.143	0.125721	0.11842	-2.13352	4.55191	-11.7356
10	5443.077	217.72	248.13	5.51395	30.40364	3.492	0.13969	0.13076	-2.03439	4.13874	-11.2175

Fig. 18 Graph showing Flexural strength of the specimen Table:VIII Corresponding Values For The Above Graph

Data Pair	Load	Eng. Stress (TS)	True Stress (TS)	Y=log (TS)	Y ²	Extension	Eng. Strain	True Strain (TSR)	X=log (TSR)	X ²	X*Y
1	3544.607	141.78	143.76	4.96815	24.68251	0.349	0.013969	0.01387	-4.27803	18.30154	-21.2539
2	4284.395	171.38	176.17	5.17145	26.7439	0.698	0.027938	0.02755	-3.59175	12.90067	-18.5746
3	4756.95	190.28	198.25	5.28953	27.97913	1.048	0.041907	0.04105	-3.19296	10.19499	-16.8893
4	5043	201.72	212.99	5.36125	28.743	1.397	0.055876	0.05437	-2.91194	8.47939	-15.6116
5	5216.353	208.65	223.22	5.40816	29.24819	1.746	0.069845	0.06751	-2.69548	7.26561	-14.5776
6	5321.291	212.85	230.69	5.44107	29.60524	2.095	0.083814	0.08049	-2.51962	6.34848	-13.7094
7	5383.787	215.35	236.41	5.46557	29.87246	2.445	0.097783	0.09329	-2.37204	5.62657	-12.9646
8	5419.197	216.77	240.99	5.48476	30.08259	2.794	0.111752	0.10594	-2.24488	5.03949	-12.3126
9	5437.521	217.5	244.84	5.5006	30.2566	3.143	0.125721	0.11842	-2.13352	4.55191	-11.7356
10	5443.077	217.72	248.13	5.51395	30.40364	3.492	0.13969	0.13076	-2.03439	4.13874	-11.2175



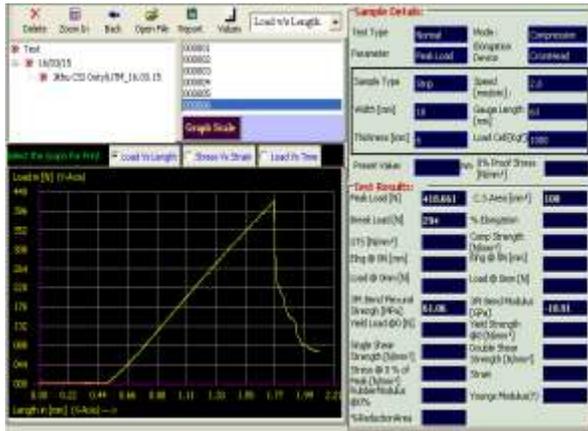


Fig. 19 Graph showing Flexural strength of the specimen

Table: IX Corresponding Values For The Above Graph

Data Pair	Load	Eng. Stress	True Stress (TS)	Y=log (TS)	Y ²	Extension	Eng. Strain	True Strain (TSR)	X=log (TSR)	X ²	X*Y
1	3544.607	141.78	143.76	4.96815	24.68251	0.349	0.013969	0.01387	-4.27803	18.30154	-21.2539
2	4284.395	171.38	176.17	5.17145	26.7439	0.698	0.027938	0.02755	-3.59175	12.90067	-18.5746
3	4756.95	190.28	198.25	5.28953	27.97913	1.048	0.041907	0.04105	-3.19296	10.19499	-16.8893
4	5043	201.72	212.99	5.36125	28.743	1.397	0.055876	0.05437	-2.91194	8.47939	-15.6116
5	5216.353	208.65	223.22	5.40816	29.24819	1.746	0.069845	0.06751	-2.69548	7.26561	-14.5776
6	5321.291	212.85	230.69	5.44107	29.60324	2.095	0.083814	0.08049	-2.51962	6.34848	-13.7094
7	5383.787	215.35	236.41	5.46557	29.87246	2.445	0.097783	0.09329	-2.37204	5.62657	-12.9646
8	5419.197	216.77	240.99	5.48476	30.08259	2.794	0.111752	0.10594	-2.24488	5.03949	-12.3126
9	5437.521	217.5	244.84	5.5006	30.2566	3.143	0.125721	0.11842	-2.13352	4.55191	-11.7356
10	5443.077	217.72	248.13	5.51395	30.40364	3.492	0.13969	0.13076	-2.03439	4.13874	-11.2175

Flexural Test Result

Table: X Flexural Test Result

Sl. No.	Fiber type	Volume fractions (%)	Cross section area [mm ²]	Peak Load [N]	Flexural Strength (MPa)	Flexural Modulus (GPa)
1	Treated	10%	108.000	161.551	23.560	61.055
2	Treated	20%	108.000	144.040	21.006	85.246
3	Treated	30%	108.000	227.357	33.156	1274.995
4	Untreated	10%	108.000	229.564	33.478	2689.758
5	Untreated	20%	108.000	293.564	42.811	3606.774
6	Untreated	30%	108.000	418.661	61.055	18.908

The purpose of impact testing is to measure an object's ability to resist high-rate loading. It is usually thought of in terms of two objects striking each other at high relative speeds. A part, or material's ability to resist impact often is one of the determining factors in the service life of a part, or in the suitability of a designated material for a particular application.

Table: XI Izod Impact Value For 6 Mm Thick Specimen

Sample Number	Izod Impact Value for 6mm Thick Specimen in J
1	0.50
2	0.90
3	0.50
4	0.60
5	0.50
6	0.75

Impact Test Result

Table: XII Impact Test Result

Sl. No.	Fiber type	Volume fractions (%)	Cross section area [mm ²]	Izod Impact Value (J)
1	Treated	10%	108.000	0.50
2	Treated	20%	108.000	0.90
3	Treated	30%	108.000	0.50
4	Untreated	10%	108.000	0.60
5	Untreated	20%	108.000	0.50
6	Untreated	30%	108.000	0.75

B. Impact Test:

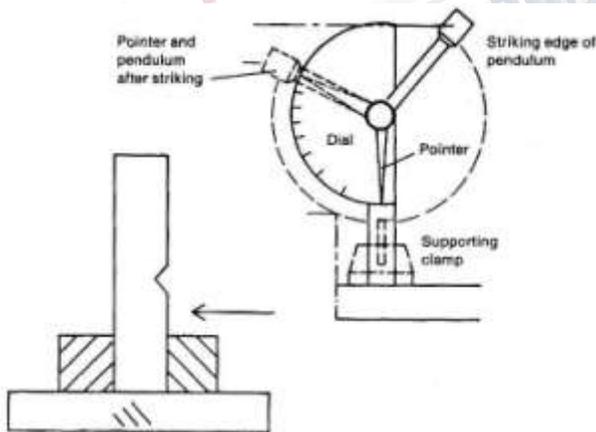


Fig.20 Impact test

V. DESIGNING

a) Design Formula

- Volume of table tennis bat = (volume of face of bat) + (volume of handle of bat)
- Density = Mass / Volume
- Mass = Density X Volume

b) Design

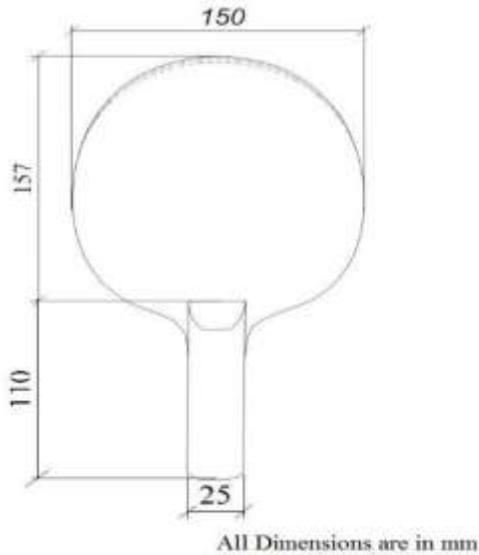


Fig.21 Specimen Dimensions for Table Tennis Bat

c) Calculation

Volume of table tennis bat = (volume of face of bat) + (volume of handle of bat)
 = (Length X Breadth X Height) + (Length X Breadth X Height)
 = {(157 x 150 x 5) - 5% total volume} + (110 x 25 x 5) - 5% total volume
 = 111.86 + 13.062 mm³
 = 123.94 cm³
 Density of Epoxy resin = 1.4 g/cm³ Density = Mass / Volume
 Mass = Density X Volume
 = 1.4 X 132.94
 = 173.4936 g

d) Tabulation

Table: XIII Composition For Table Tennis Bat

PART	SAMPLE (%)	FIBER (g)	RESIN (g)	TOTAL (g)
TABLE TENNIS BAT	15	26.024	147.46	173.4936

e) Manufacturing of Table Tennis Bat

Step 1: A mould of required size is prepared by using Clay & OHP sheet.



Fig.22 Mould Preparation

Step 2: The resin and hardener is mixed in the ratio 10:1 and then thoroughly mixed with pineapple leaf fiber.



Figure: 5.4. Resin, Hardener and Pineapple leaf fiber mixing

Step 3: The prepared mixture is randomly arranged in the mould without any gap.

PART	SAMPLE (%)	FIBER (g)	RESIN (g)	TOTAL (g)
TABLE TENNIS BAT	15	26.024	147.46	173.4936
				39



Figure: 5.5. Wet/Hand Lay-Up



Figure: 5.8. Finished product

Step 4: The setup is kept in the dry place for 24 hours.



Figure: 5.6 Curing Process

Step 5: The specimen is machined using file and grinding machine for required dimensions



Figure: 5.7 machining process

Finished Product



CONCLUSION

The fabrication of present study shows that the useful composite with good properties could be successfully developed using PALF as reinforcing agent for the Epoxy matrix. From this, several conclusions can be drawn regarding to mechanical properties of composite to the effect of fiber loadings, namely tensile, flexural and impact properties. The Pineapple Leaf Fiber (PALF) is a waste product of pineapple cultivation. Hence, Pineapple fiber can be obtained for industrial purpose without any additional cost. Over the past decade, cellulosic fillers have been greater interest as they give composites improved mechanical properties compared to those containing non-fibrous fillers. The table tennis bat manufactured by pineapple leaf fiber composite can be used as an alternative for the TT bat made of wood. This reduces the usage of trees and increases the production of useful materials from the waste.

REFERENCE

- [1] Nishar Hameed, P.A. Sreekumar, Bejoy Francis, Weimin Yang and Sabu Thomas (2007) studied Morphology, dynamic mechanical and thermal studies on poly (styrene-co-acrylonitrile) modified epoxy resin/glass fibre composites.
- [2] H.N. Dhakal, Z.Y. Zhang and M.O.W. Richardson (2006) studied the effect of water absorption on the mechanical properties of non-woven hemp fiber reinforced unsaturated polyester composites.
- [3] Darshil U. Shah , Peter J. Schubel , Peter Licence and Mike J. Clifford (2012) studied the effect of fiber volume fraction on aligned PFCs physical properties (porosity and fiber packing arrangement) and tensile properties has been investigated.
- [4] Maries Idicula , S.K. Malhotra, Kuruvilla Joseph, Sabu

Thomas (2008) studied the Static and dynamic mechanical analysis of short randomly oriented intimately mixed banana/sisal hybrid fiber reinforced polyester composites was investigated with special reference to the total volume fraction of the fiber and varying the relative volume fraction of the two fibers.

[5] Sherey Annie Paul , Abderrahim Boudenne , Laurent Ibos, Yves Candau and Kuruvilla Joseph (2007) studied the Short randomly oriented PP/banana fiber commingled composites were prepared from commingled short PP fiber and banana fiber.

[6] W. Wang, M. Sain and P.A. Cooper (2012) studied the moisture absorption in natural fiber plastic composites At high fiber loading when fibers are highly connected, the diffusion process is the dominant mechanism; while at low fiber loading close to and below the percolation threshold, the formation of a continuous network is key and hence percolation is the dominant mechanism.

[7] Nicolas Le Moigne, Martien van den Oever and Tatiana Budtova (2012) performed a careful statistical analysis of composites based on polypropylene mixed with flax, sisal and wheat straw fibers.

[8] N.A. Wright and S.N. Kukureka(2010) studied the Wear testing and measurement techniques for polymer composite gears The co-ordinate measurement technique is capable of providing detailed information on wear rates of gears as a function of roll angle, and hence load, sliding speed and slip ratio.

[9] M.Ramesh, K.Palanikumar and K.Hemachandra reddy (2009) experimented that mechanical property evaluation of sisal-jute- glass fiber reinforced polyester composites.