Modeling and influence of mechanical properties of natural fiber composite materials

N.Sathiseelan
Department of Mechanical Engineering
Sri Eshwar College of Engineering
Coimbatore, India

S.Baskaran
Department of Mechanical Engineering
Sri Eshwar College of Engineering
Coimbatore,India

Abstract **-Considerable research in the field of material science has been directed towards the development like composite. Attention has been focused in the development of natural fiber composite due to their low cost and biodegradability. Composite specimens using coir fibres as reinforcement in a polymer matrix are fabricated by compression moulding process. Two types of specimens are prepared, one by reinforcing untreated coir fiber and the other by reinforcing alkali treated fibres with different fiber length and with different weight percentage. The mechanical property of the composites like tensile strength is determined as per ASTM standards. The regression models for tensile strength property were developed using Minitab 14. The optimum fiber parameters for maximum mechanical properties were determined. The results showed that the fiber weight percentage is playing major role than the fiber length on the improvement of mechanical propertiesof new, light weight, high performance engineering materials.**

***Keywords*-Fibers, Composites, Tensile strength, Polymer matrix**

I.INTRODUCTION

Coir is a versatile fiber obtained from coconut trees (cocos nucifera) which grow extensively in tropical countries. The limitations of using lingo cellulosic fibers as reinforcement in polymer matrix composites is the poor interfacial strength developed between the hydrophilic fibers and the hydrophilic matrices. To overcome this several physical and or chemical treatments were developed in order to ensure a better fiber-matrix interaction [1]. Composite products have good mechanical properties per unit weight, durable and their technologies allow manufacturing of complex and large shapes [2]. Jeyabal et al. [1] said that the fiber length also plays a main role and they obtained higher value of mechanical property using continuous coir fiber and optimized using statistical package software. Sree Kumar et al. [2] treated sisal fibers with various chemicals and examined the mechanical properties. They concluded that surface treatment improves the properties of fibers. Herrera–franco [3] examined continuous henequen fibers by surface Modifications using alkaline treatment together with a silane coupling agent. He found that the tensile strength did not improve due to use of silane concentrations. Sinha et al. [4] made an effort by varying the treatment time using jute fiber and find as the treatment time improves the flexural properties. Velumani et al. [5] experimented alkali treated coir polyester composites. The surface treatment improves the adhesion between fiber and matrix. He observed the fiber length and weight plays a significance role in mechanical properties. Velmurugan et al. [6] reported addition of glass fiber with Palmyra fiber gives a better result in tensile, flexural and shear strength. Tharanitharan et al. [7] examined coir sisal hybrid composites. He used vinyl ester resin and samples made by hand layup process. The different combinations are carried using design of experiments and mathematical models also developed to optimize the fibers. Athijayamani et al. [8] used roselle and sisal fibers to produce hybrid composites also glass fiber composite is produced to compare the properties. This investigation also reports that increasing fiber length and content will increase the mechanical properties. Since most literature cover only a specific work on fibers, this work was aimed at analyzing of tensile strength of treated coir fiber composites covering a large range of fiber length and fiber content. The mathematical model was developed using Minitab to find the optimum fiber parameters and their influence on maximum tensile strength was studied in this work.

II.EXPERIMENTAL

A. *Fiber preparation*

The coir fibers are mechanically extracted from the green husk of coconut after soaking the husk in water. The green husk fiber bales are soaked in water for 3–7 days to remove the colouring matter and to make the fibers soft. The fibers were cut for the dimensions of 50, 100, 150 and fiber content in weight percentage of 15, 25, and 35 respectively. The properties of treated coir fiber shown in table I

Table I Properties of treated coir fiber

Properties	**coir**
Cellulose (wt %)	34-47
Hemi cellulose	0.15-0.25
Young's modulus (Gpa)	4-7
Tensile strength (Mpa)	129-182
Lignin (wt %)	0.4-0.29
Density (gm/cm³)	1.28
Fiber diameter (mm)	0.072-0.212

B. Surface modification of fibers

The coir fibers were treated with 5% NAOH solution for 30 min. The fibers were then washed with very dilute hydrochloric acid to remove the traces of alkali. The fibers were washed many times using water were they are free from alkali. The fibers were dried in an air oven at 70°c to remove moistures.

Fig. 1 Surface treatment of fibers

C. Fabrication of composites

Initially the treated fibers were spread horizontally and randomly. Polyester resin was used as matrix material. Matrix material consists of unsaturated polyester resin, cobalt naphthalene (accelerator), and MEKP catalyst in the ratio of 1:0.015:0.015. For easier removal of composite sheets from the mold, polyvinyl acetate was sprayed on the mold surfaces before the mould. The fibers and resin were poured in the mold frame of size 200 mm x200 mmx3 mm and pressed by compression moulding process for 6 h. After it the composites were removed from the mold and cured at room temperature for 24 h. The same procedure was followed to fabricate various combinations of fibers. The fabricated plate is shown in figure. 2. After curing, the composite sheets were cut according to ASTM D 638 standards.

Fig. 2 Fabricated composite plate

III. MECHANICAL TESTING

A. Tensile strength test

The tensile strength was determined according to ASTM 638-08. The length, width and thickness of each sample were approximately 165mmx25mmx3mm. For this testing the composites were cut into five identical specimens. The tensile strength for the nine combinations of various fiber parameters are shown in table II. The specimens were tested in Instron tensile testing machine with a cross head speed of 5mm/min. Figure .3 and 4 shows the specimen which is used to find the mechanical strength.

Table II Mechanical property of treated coir composite

Sample Identification	Fiber length (mm)	Fiber content (%)	Tensile strength (Mpa)
50-15	50	15	21.3
50-25	50	25	21.8
50-35	50	35	22.1
100-15	100	15	23.2
100-25	100	25	23.5
100-35	100	35	23.9
150-15	150	15	27.8
150-25	150	25	28.2
150-35	150	35	29.7

Fig. 3 Photograph of specimens before tensile testing

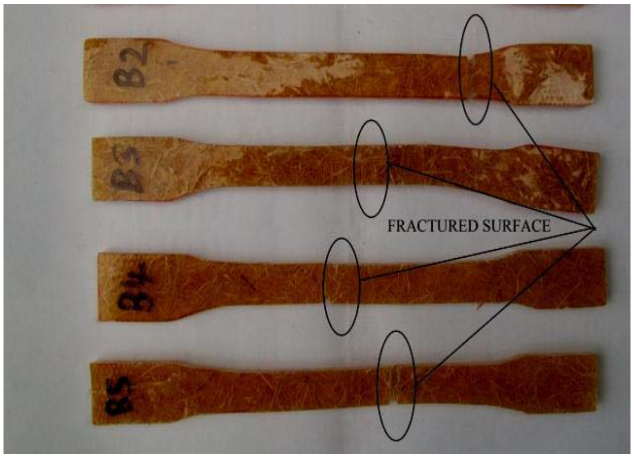

Fig. 4 Photograph of specimens after tensile fracture

IV.NONLINEAR REGRESSION ANALYSIS OF MECHANICAL PROPERTY

The mechanical properties as tensile strength were modelled using Minitab statistical software. In this mathematical model the terms as F1 represents fiber length and F2represents fiber content in weight percentage. The equation 1 is the developed nonlinear regression model of tensile strength (Ts) respectively.

$$Ts = 23.779 - .0721F1 - 0.0655F2 + 0.00055F1\ F2 + 0.000633\ F1^2 + 0.001344\ F2^2 \quad (1)$$

V.RESULTS AND DISCUSSIONS

A. Tensile strength

The composites plates were fabricated using fibers both untreated and alkaline treated fibers. The composite plates were tested for its tensile properties and the treated composites results are shown in table 2. The 50 mm fiber with 35 % yielded the tensile strength of 22.1 Mpa, the 100 mm fiber with 35% yielded 23.9 Mpa and 150 mm fiber with 35 % yielded 29.7 Mpa of tensile strength. It is evident from above results that the treatment of the fibers has increased the tensile properties. This is due to the better fiber matrix adhesion. The effect of fiber parameters are shown in Figure.5.

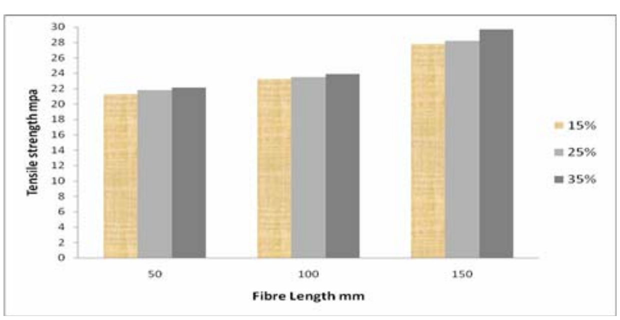

Fig. 5 Effect of fiber parameter on tensile strength

B. Regression Modelling

The values of tensile strength with different lengths and weight percentage were used to develop the regression equation. A two parameters (fiber length and fiber content) and three levels (50, 100,150 mm) factorial design was designed using Minitab. The regression equation for the above factorial design is given below

$$Ts = 23.779 - .0721F1 - 0.0655F2 + 0.00055F1\ F2 + 0.000633\ F1^2 + 0.001344\ F2^2$$

Table.III Tensile strength of various fiber content (wt %)

Sample Identification (mm)	Fiber length (%)	Fiber content (Mpa)	Tensile strength
150-40	150	40	30.3
150-45	150	45	30.6
150-50	150	50	31.4

From Table.III the 40, 45, and 50 weight % of fibers has shown the maximum tensile properties. Conformation experiments were conducted for three sets. The experimental Values and the predicted values obtained from mathematical model were compared

VI.CONCLUSION

Coir fiber reinforced polyester composites were fabricated after treating the fibers with sodium hydroxide with different lengths and weight percentages. The composites were tested for its tensile properties and it was found that the fibers with 150mm length and 35% gave better tensile properties. Regression equation was developed using Minitab 14 software. Further the composites are to be tested for its flexural and impact strength properties and are to be optimized. It is expected that the fiber length and fiber weight Percentage will yield better properties are experimenting the same parameters.

RFERENCES

[1] S.Jeyabal, U.Natarajan, “Influence of fiber parameters on tensile, flexural and impact properties of nonwoven coir-polyester composites’’, Int J Adv Manuf Technol vol. 54, pp.639–648, 2011.

[2] P.A. Sreekumar et al, ‘’ Effect of fiber surface modification on the mechanical and water absorption characteristics of sisal/polyester composites fabricated by resin transfer molding’’, composites: part A40 (2009)1777-1784.

[3] P.J. Herrera-Franco, A. Valadez-Gonza´lez’’Mechanical properties of continuous natural fibre-reinforced polymer composites’’, composites part A35 (2004)339-345.

[4] E. Sinha, S. K. Rout ‘’ influence of fiber surface treatment on structural thermal and mechanical properties of jute fibre and its composite’’, Bull mater. Sci, vol.32, No.1 Feb2009, PP65-76.

[5] S. Velumani, P.Navaneethakrishnan, S.Jayabal’’Surface treatment of coir fiber and its effect on mechanical properties of coir-polyester composite ‘’ Advances in plastic composites, CIPET, TN, 2010

[6] R.Velmurugan, V.Manikandan ‘’ Mechanical properties of Palmyra/ glass fiber hybrid composites’’, composite: part A 38(2007)2216-2226.

[7] G.Tharanitharan, S.Velumani and P.Navaneethakrishnan’’ Regression model and influence of fiber parameter on tensile, flexural and impact properties of coir-sisal hybrid-vinyl ester composite’’ Advances in plastic composites, CIPET, TN, 2010.

[8] A.Athijayamani, B.Phalanivel, M.Thiruchitrambalam,V. Manikandan’’Mechanical properties of natural fibers reinforced polyester hybrid composite’’,Int J plast technol(2010014:104-116.

[9] Llingyu sun, Ronald f. Gibson, Faramarz gordaninejad , Jonghwan suhr,’’ Energy absorption capability of nanocomposites: a review’’, composites science and technology 69 (2009) 2392–2409.

[10] Gewen Yi , Fengyuan Yan,’’ Mechanical and tribological properties of phenolic resin-based friction composites filled with several inorganic fillers’’, Wear 262 (2007) 121–129.

[11] K. Murali Mohan Rao, K. Mohana Rao, A.V. Ratna Prasad,’’ Fabrication and testing of natural fibre composites: Vakka, sisal, bamboo and banana’’, Materials and Design 31 (2010) 508–513.

[12] H. Savastano, S.F. Santos, M. Radonjic, W.O. Soboyejo,’’ Fracture and fatigue of natural fiber-reinforced cementitious composites’’, Cement & Concrete Composites 31 (2009) 232–243.

AUTHORS PROFILE

N.Sathiseelan is currently working as Assistant Professor in Department of Mechanical Engineering at Sri Eshwar College of Engineering,Coimbatore, Tamilnadu.Mobile:(0)9500304444 Email: nsathiseelan@gmail.com

S.Baskaran is currently working as Assistant Professor in Department of Mechanical Engineering at Sri Eshwar College of Engineering,Coimbatore, Tamilnadu.Mobile:(0)9790489152Email: baski.349@gmail.com @gmail.com