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Effect of Fiber Length and Weight on Tensile Response of Natural Fiber Reinforced Composite

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***Abstract* - Fiber reinforced polymer composites have been used in a variety of applications because of their many advantages such as relatively low cost of production, easy fabrication etc., . Reinforcement in polymer is either synthetic or natural. Synthetic fiber such as glass, carbon etc. have high specific strength but their fields of application are limited due to higher cost of production, and due to their non biodegradability. Recently there has been an increased interest in natural fiber based composites due to their many advantages, like biodegradability. Coir & banana fibre are used in the present work for making natural fiber reinforced composite. The objective of the present research work is to study the mechanical behavior of coir& banana fiber reinforced polyester based hybrid composites and comparison of properties like young's modulus. The optimum percentage of banana fiber and coir are found by conducting response surface Methodology.**

Keywords- Coir Fiber ,Banana Fiber,Response Surface Methodoldogy

I) INTRODUCTION

Progressions in the use of laminated composite materials for structure of aircraft and automobile industries were increased significantly over the past decade. This was motivated by the need for improved performance requirements in stipulations of payload, range, stability and simultaneously, a reduction in costs in terms of maintenance, operation and construction. Much experience in the use of hybrid composites in the aerospace industries were achieved from the design of composite airplanes, which were designed using high stiffness requirements and not for all the parts of the current body of airplanes being planned. The stiffness of composites can be determined equitably accurately using the particular tests and material properties from standard material characterization tests. However, with more demanding requirements, this was changed and the minimization of damage is something that is now required in order to satisfy higher-performance demands. This is not as simple as optimizing the elastic stiffness of the structure due to the complex damage modes that can occur in hybrid composites.

Tensile strength is an important topic as it is one of the design drivers for composite structures.

According to Verma D., Gope P.C [1] at all. A composite material made from two or more constituent materials like reinforcement (fibres, particles, flakes, and/ or fillers) and matrix (polymers, metals, or ceramics). One or more discontinuous phases are, therefore, embedded in a continuous phase to form a composite. The discontinuous phase is usually harder and stronger than the continuous phase and is called the reinforcement, whereas, the continuous phase is termed as the matrix.

Kelly [2] defined that the composites should not be regarded simply as a combination of two materials. It clearly states that; the combination has its own unique properties. In terms of strength or resistance to heat or some other desirable quality, it is better to attain properties that the individual components by themselves cannot attain. The composite materials have advantages over other conventional materials due to their higher specific properties such as tensile, flexural and impact strengths, stiffness and fatigue properties, which enable the structural design to be more versatile. Due to their many advantages they are widely used in aerospace industry, mechanical engineering applications (internal combustion engines, thermal engineering, controls and machine components), electronic packaging, automobile, and aircraft structures and mechanical components (brakes, drive shafts, tanks, flywheels, and pressure vessels), process industries equipment requiring resistance to high-temperature corrosion, dimensionally stable components, resistance to oxidation and wear, offshore and onshore oil exploration and production, marine structures, sports, leisure equipment and biomedical devices [3, 4]. Malik P. K. [5] stated that According to the type of matrix materials, composite materials are classified into three categories, such as metal matrix composites (MMCs), ceramic matrix composites (CMCs) and polymer matrix composites (PMCs). Each type of composites is suitable for different applications. Among various types of composites, PMC are the most commonly used composites, due to its advantages such as simple manufacturing principle, low cost and high strength. When the matrix material is polymer, the composite is called polymer matrix composites. The reinforcing material can be either fibrous or non-fibrous (particulates) in nature. There are two major classes of polymers used as matrix materials such as thermoplastic and thermosetting. Thermoplastic (e.g. nylons, acrylic, polyethylene, polystyrene etc.) are reversible and can be resized by application of heat and pressure.

However, thermosetting (e.g. epoxies, phenolic, polyimides, polyesters etc.) materials that undergo a curing process through part fabrication, after which they are fixed and cannot be transformed or resized. Epoxy resin is the most commonly used polymer matrix with reinforcing fibres for advanced composites applications. Epoxy resin possesses so many advantages such as very good mechanical properties, and electrical characteristics, chemical resistance and environmental resistance etc.

Among all reinforcing fibres, natural fibres have gained substantial importance as reinforcements in polymer matrix composites. The benefits accompanying with the usage of natural fibres as reinforcement in polymers are their availability, biodegradability, low energy consumption, non-abrasive nature and low cost. In addition, natural fibres have low density and high specific properties. The specific mechanical properties of natural fibres are equivalent to those of synthetic reinforcements. A great deal of work has been carried out to assess the prospects of natural fibres as reinforcement in polymers. Studies on cerments and plastics reinforced with natural fibres such as coir, sisal, bamboo, jute, banana and wood fibres have been reported [8-12].

Nunna S., Chandra P.R at al [13] state that among various natural fibres, coir finds a wide variety of applications around the world. Coir is a natural fibre extracted from the husk of coconut fruit. The husk contains coir fibre and a corky tissue called pith. It is a fibre which is highly available in India, the second highest in the world after Philippines. It consists of water, fibres and small amounts of soluble solids. Because of the high lignin content coir is more long-lasting when compared to other natural fibres. Natural fibres such as coir based composites are enjoying broader applications in automobiles and railway coaches & buses for public transport system. There exists a very good opportunity in fabricating coir based composites towards a wide array of applications in building and construction such as sheets and slabs as reconstructed wood, flooring tiles etc. Coir nets are used to prevent soil destruction during heavy rains and cyclones. However, the main disadvantages of natural fibres and matrix is the relative high moisture absorption. So, a hybrid composite material is preferred, that contains two or more different types of fibre in which one type of fibre could compensate for what are lacking in the other. Hybridization of natural fibre with high corrosion resistance and stronger synthetic fibres like glass, carbon, aramid etc. can improve the various properties such as strength, stiffness etc. It helps us to achieve a better combination of properties than fibre reinforced composites. Uses of hybrid composites are aeronautical applications (pilot's cabin door), marine applications (ship hulls), wind power generation (blades), telecom applications (hybrid aerial, underground cable) [13].

All polymers and polymer based composites absorb moisture in humid atmosphere when immersed in water. In general, moisture diffusion in composites depends on factors such as the volume fraction of fibre, void volume, additives, humidity, and temperature [14- 15].

In the present work with varying percentage of coir and banana fiber composites are fabricated and tested for young’s modulus and optimized using RSM.

II.EXPERIMENTAL PROCEDURE.

Extraction of fibers

Coconut fiber **:**For obtaining natural coir fiber the coconut fruits are taken from the coconut tree and dried until moisture is completely removed from the fruit.

Steps involved in preparation of coir

1.The husk consists of coir fibre and a corky tissue known as pith.
2.The pith and fiber were separated from the husk by means of mechanical process .
3.The resultant fibers were bundle and scrapped with comb until individual fibers were obtained.

3.1 Husk of coconut

3.2 Coconut fiber

Banana Fibre Extraction:

The extraction of the natural banana fiber from the plant required certain care to avoid damage. In the present experiments, initially the banana plant sections were cut from the main stem of the plant and then rolled lightly to remove the excess moisture. Impurities in the rolled fibres such as pigments, broken fibers, coating of cellulose etc., were removed manually by means of comb, and then the fibers were cleaned and dried.

3.3 Banana fiber

After extraction of banana fibers the fibers are made into short fibers of require size (0.5cm, 1cm, 1.5cm, 2cm)

MOULD PREPARATION

The mould is prepared by using the glass of dimensions 350 * 120 * 24 mm thick and a mould cavity of 300 * 80 * 12mm is made by fixing 12mm thick glass plates of width 80mm and thickness 12mm on four sides of the plate using araldite. The mould is solidified in room temperature.

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3.4 Mould cavity

Teflon sheets are attached in the mould cavity for no leakage of matrix & easy removal of samples from mould cavity

SAMPLE PREPARATION

The samples are prepared by hand lay up method which is most common method used to employ for preparation of samples.

1. The polyster resin is choosen in required quantity and suitable proportion of catalyst and accelerator are added to prepare the matrix for the composite
2. Matrix is poured in the mould cavity and spreaded completely over the mould then the fibers are arranged in random manner first the coconut fiber is arranged and again filled with resin for next lamina and the second lamina consists of banana fiber which is oriented randomly and finally filled with resin .
3. Then the entrapped air in the mould cavity is removed by using rollers.
4. The mould is closed with the acrylic sheet and dried at room temperature until it solidifies.
5. By varying the weight and size of coconut & banana fibers samples are prepared in the same procedure.

III) Test Procedure:

In tensile test, an uni axial load is applied from both the ends. Tensile test is performed to evaluate the ultimate tensile strength. A specimen of standard size is cut from the readymade composite plate. Specimens are placed in the grips of a Universal Test Machine(UTM) at a specified grip separation and pulled until failure. As the load increases, fracture occurred in the gauge length portion of the test specimen. The load at fracture is noted from the scale at the time of failure. The same procedure was repeated for remaining specimens cut from the same composite plate. Later, the average load at breaking is noted and tensile strength is calculated on the basis of the following formula.

Fig 5: UTM with digital out put

Fig 6: After test specimens

IV) Tensile Properties:

The tensile stress and tensile strain of the composites were determined by substituting the load and elongation values in below formulae

Tensile stress $\sigma_t = P/bd$ MPa

Tensile strain $\varepsilon_t = \frac{L}{l}$

Tensile modulus $= \sigma_t / \varepsilon_t$ MPa

Following are the notations used in above formulae

P=Load, (N)

l=Support span, (mm)

b=Width of test beam, (mm)

d=Depth of test beam, (mm)

L=change in the length

Young's modulus values are obtained by using of stress and strain which are already calculated from the above formulae.The table shows the young's modulus for different lengths of fiber and at different weight compositions.

Table 1

Fiber length	Youngs modulas in Mpa				
	4B+4C	3B+4C	2B+4C	4B+3C	4B+2C
0.5	1553.7	1216.2	1386.6	1831.7	1487.5
1	1229.3	1564.4	1699.0	1357.5	1378.8
1.5	1229.3	1719.1	1940.5	2080	1569.8
2	1621.3	1870.4	1868.6	1885.7	1829.7

V)RESULTS AND DISCUSSIONS:

The results obtained from the experiment which are shown above. The discussion includes the comparison of elongation of the hybrid fiber, its Young's modulus. At the end it also found that the better combination of banana and coir combination evolved by conducting response surface Methodology.

Response Surface Methodology (RSM)

Now days, the RSM has become a popular optimization tool used for multi response optimization of process parameters in different applications. RSM is a statistical technique to develop mathematical models or relations between responses and controllable process parameters. These models are also called as prediction models used to predict process variables for required responses. In RSM, the quantitative relationship between input and output variables is presented as follows.

$$y = f(x_1, x_2, x_3, \dots \dots, x_n) \pm e_r$$

Where 'y' is desired response and 'f' is the response function, dependent variable and x_1, x_2, x_3, …..,x_n independent variables and 'e_r' is the fitting error.

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In the present work, sixteen experiments have been planned according to central composite design. The RSM technique is used to analyse the experimental data to identify significant parameters that affect the material property i.e young's Modulus . In addition to that, three dimensional plots are constructed to study the two factor interaction on the responses using Design Expert 8.3 software.

A. Materials

The experimental investigation has been made to identify the optimal combination of banana fiber and coconut coir composition in composite material reinforcement.

Chemical composition of banana fiber and coconut coirs are:

Table 2

Banana fiber	
Cellulose	48.19%
Hemi cellulose	15.91%
Lignin	19.17%
Pectin	3.48%

Table 3

Coconut coir	
Lignin	45.84%
Cellulose	43.44%
Hemi-Cellulose	00.25%
Pectin's and related Compound	03.00%
Water soluble	05.25%
Ash	02.22%

B. Experimentation:

Materials: banana fiber, coconut coir, polyester resin

Mould size: 300*80* 12 mm^3

UTM: digital UTM

The present work 20 different composite materials were prepared with combination of synthetic resin prepared with different proportions of banana fiber and coconut coir along with different lengths of fibers.

Table 4

Factors	Units	Level 1	Level 2	Level 3	Level 4
Banana fiber	gms	4	3	2	--
Coconut coir	gms	4	3	2	--
Length	Cm	0.5	1	1.5	2

C. Results and discussion:

Experimental results of young's modulus for twenty experiments in different lengths and different fibers presented in the Tables 5.

Table5. Design of experiments and experimental results for young's modulus

Sl. no	Banana fiber	Coconut coir	Length cm	Young's modulus KN
1	4	4	0.5	1553.70
2	4	3	0.5	1831.79
3	4	2	0.5	1487.46
4	3	4	0.5	1216.20
5	2	4	0.5	1386.6
6	4	4	1	1229.32
7	4	3	1	1357.47
8	4	2	1	1378.82
9	3	4	1	1564.42
10	2	4	1	1699.02
11	4	4	1.5	1229.32
12	4	3	1.5	2080
13	4	2	1.5	1569.76
14	3	4	1.5	1719.10
15	2	4	1.5	1940.49
16	4	4	2	1621.33
17	4	3	2	1885.71
18	4	2	2	1829.74
19	3	4	2	1870.40
20	2	4	2	1868.57

Analysis of young's modulus:

Table.6 ANOVA for Response Surface for Ra

Source	Sum of Squares	df	Mean Square	F Value	p-value (Prob>F)
Model	1020431	8	127554	3.51	0.017
Linear	610402	3	203467	5.60	0.009
L	337233	1	337233	9.28	0.008
B	264810	1	264810	7.29	0.016
C	66423	1	66423	1.83	0.196
Square	357467	3	119156	3.28	0.505
L*L	93486	1	93486	2.57	0.129
B*B	2045	1	2045	0.06	0.816
C*C	263978	1	263978	7.27	0.017
2-way interaction	101848	2	50924	1.40	0.277
L*B	101489	1	101489	2.79	0.115
L*C	23610	1	23610	0.65	0.433

The experimental data of young's modulus is analyzed with MINITAB the RSM was carried out at 100% confidence level to identify significant process parameters on the response. The P-value of process parameters indicates their significance on the young's modulus. The process parameters in RSM table which are having P-value less than 0.05 are indicated as significant parameters. composite with varying percentage of fibers and varying length of fibers have been analysed for young's modulus using RSM at 100% confidence level for identifying significant parameters. The results are shown in table 6. The model term is having P-value of 0.017 that indicates that the RSM of young's modulus is acceptable. The P- value of banana fiber is 0.016, P-value of length is 0.008, therefore the banana fiber and length are significant parameters which affect the young's modulus.

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Effect of process parameters on young's modulus

Figures (a to c) are the 3-D surface plots for the young's modulus of the composite material. The figures shows 2 factor interaction of length of fiber materials, weight of banana fiber and weight of coconut coir.

Fig a shows that the young's modulus is found to be minimum at 2 grams of banana fiber and 0.5 cm length.

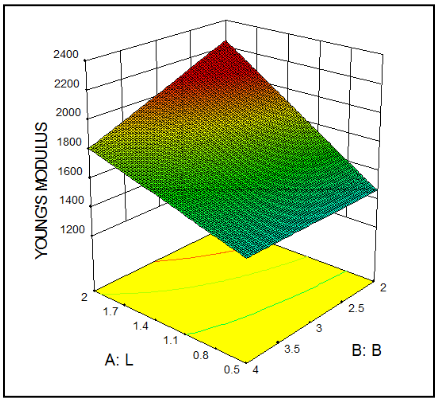

Fig a: Two factor interaction of length of fiber and weight of banana fiber on young's modulus

Fig b shows that the young's modulus is found to be minimum at 2 grams of coconut coir and 0.5 cm length

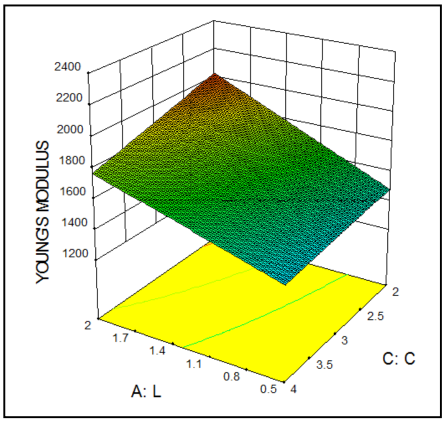

Fig b: Two factor interaction of length of fiber and weight of coconut coir on young's modulus

Fig c shows that the young's modulus is found to be minimum at 4 grams of banana fiber and 4 grams of coconut coir.

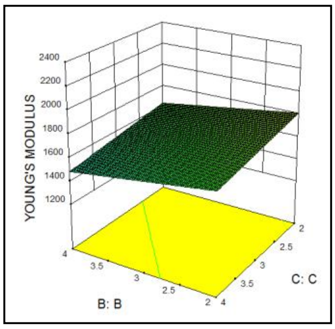

Fig c: Two factor interaction of weight of banana fiber and weight of coconut coir on young's modulus

Empirical relations for young's modulus is formulated with banana fiber, coir, and length as shown below:

Regression Equation in Uncoded Units

$$E = -1312 + 461\,L + 212\,B + 1830\,C + 250\,L*L - 27\,B*B - 301\,C*C - 169\,L*B - 81\,L*C$$

Optimization results:

In the present work single response optimization was carried out for optimization of process parameters using MINITAB17 software. The fig shows the response surface optimizer plotted from the experimental results. Response optimizer is a tool to identify the optimal controlling variables to achieve required responses with concept of desirability. Desirability is a measure of effectiveness of optimization using individual desirability function (d) and composite desirability function (D). The values of D and d are calculated between 0to 1. A larger desirability function indicates that the predicted response value is closer to the desired response.

The optimization carried out for obtaining young's modulus. The desirability& composite desirability value for young's modulus is found to be 1. This indicates that optimization is valid. The optimum values of banana fiber, coconut coir and length to be 2.3447gr, 4.0gr & 1.9726 cm respectively.

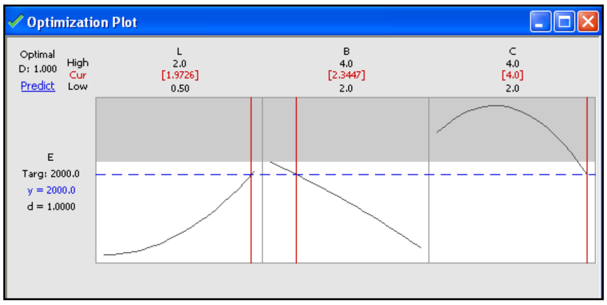

Figure 4. Response optimizer of composite material in length, banana fiber and coconut coir

5. CONCLUSIONS

- A new class of polyster based hybrid composite reinforced with banana and coir fiber has been fabricated.
- The present investigation aims the influence of % of fiber compositions of different lengths on tensile properties of composites.
- It is observed from the experiments that the young's modulus are tested depends on % of fibre composition and fibre length.
- The young's modulus is found to be maximum for banana and coir fibers of length 1.9 cm and with 8% of banana fibre and 4% of coir by weight.
- In order to obtain the optimum combination of banana fiber and coir fiber Response Surface Methodology was used.

REFERENCES

[1] Verma D., Gope P.C., Shandilya A., Gupta A., Maheshwari M.K., (2013). Coir Fibre Reinforcement and Application in Polymer Composites: A Review, J. Mater. Environ. Sci 4(2), pp. 263-276.
[2] Kelly, (1967). A. Sci. American 217 (B), pp.161.
[3] Zweben C., (2006). Mechanical Engineers' Handbook, Materials and Mechanical Design 1, pp.380-414.
[4] Sahib D.N and Jog, J. P., (1999). Natural Fibre Polymer Composites: A Review, Advances in Polymer Technology, 18(4), pp.351-363.
[5] Malik P. K. Fibre reinforced Composites: Materials, Manufacturing and Design.
[6] John M.J., Anandjiwala R.D., (2008). Recent developments in chemical modification and characterization of natural fibre-reinforced composites, Polymer Composites, 29(2), pp. 187-207.
[7] Ronga M.Z., Zhang M.Q., Liu Y., Yang G.C., Zeng H.M., (2001). The effect of fibre treatment on the mechanical properties of unidirectional sisal-reinforced epoxy composites, Composites Science and Technology 61, pp.1437–1447.
[8] Filho R.D.T., Scrivener K., England G.L., Ghavami K., (2000). Durability of alkalisensitive sisal and coconut fibres in cement mortar composites, Cement Concrete Composites 22, pp. 127-143.
[9] Zhong L.X., Fu S.Y., Zhou X.S., Zhan H.Y., (2011). Effect of surface microfibrillation of sisal fibre on the mechanical properties of sisal/aramid fibre hybrid composites, Composites: Part A 42, pp. 244–252.*M.Tech Thesis 2013* Mechanical Engineering Department N.I.T. Rourkela Page 40
[10] Acha B.A., Reboredo M.M., Marcovich N.E., (2007). Creep and dynamic mechanical behavior of PP-jute composites: Effect of the interfacial adhesion, Composites: Part A 38, pp. 1507–1516.
[11] Bledzki A.K., Mamun A.A., Volk J., (2010). Barley husk and coconut shell reinforced polypropylene composites: The effect of fibre physical, chemical, and surface properties, Composite Science and technology 70, pp. 840-846.
[12] Rozman H.D., Tan K.W., Kumar R.N., Ishak Z.A.M., Ismail H., (2000). The effect of lignin as a Compatibilizer on the physical properties of coconut fibre polypropylene composites, European polymer journal 36, pp.1483 –1494.
[13] Nunna S., Chandra P.R., Shrivastava S., Jalan A.K., (2012). A review on mechanical behavior of natural fibre based hybrid composites 31, pp.759-769.
[14] Errajhi, O. A. Z., Osborne, J. R. F., Richardson, M. O. W., & Dhakal, H. N., (2005). Water absorption characteristics of aluminised E-glass fibre reinforced unsaturated polyester composites, Composite structures, 71(3), pp. 333-336
[15] Weitsman, Y. J., (2006). Anomalous fluid sorption in polymeric composites and its relation to fluid-induced damage. Composites Part A: Applied Science and Manufacturing, 37(4), pp.617-623.