International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 05, May-2015

Mechanical Characterization of Jute and Glass Reinforced Hybrid Polymer Composites

Mihir I. Patel[1]
[1]P.G. Student,
Department of Mechanical Engineering,
Ipcowala Institute of Engineering & Technology,
Dharmaj, Gujrat, India

Chirag K. Patel[2]
[2]Assistant Professor,
Department of Mechanical Engineering,
Ipcowala Institute of Engineering & Technology,
Dharmaj, Gujrat,India

Nilam S Patel[3]
[3]Research scholar of RAI University & Assistant Professor
Department of Mechanical Engineering,
Ipcowala Institute of Engineering & Technology,
Dharmaj, Gujrat, India

***Abstract*—The use of natural fiber as reinforcement in polymers has gain importance nowadays due to its eco friendly temperament. Natural fibers are very tough, lightweight and also comparatively very cheap. This work concerns the production of hybrid composites by hand lay-up method and predict the effect of process parameter on tensile, flexural and compression strength of jute and glass fiber reinforced polyester-based hybrid composites. The composite plates was prepared using hand lay-up method to the dimension of 300mmx300mmx4mm by means of different weight fraction of natural fiber namely jute (10, 15 and 20 wt %) and glass fiber (10, 15 and 20 wt %) reinforced with polyester resin. The mechanical properties like tensile, flexural and compressive strength were evaluated for the specimen cut from the fabricated composite plates to the dimensions according ASTM standard. The significant effect of fiber content was evaluated by ANOVA.**

Keywords—Hybrid composite, jute fibers, glass fibers, polymer, tensile strength, flexural strength, compressive strength, ANOVA

1. INTRODUCTION

The improvement in the sector of material science results in many novel and superior materials. Hybrid composites are one of them, which are used in various engineering and industrial applications. Hybridization is a generally used procedure to obtain properties which are intermediate between the two originating materials. The properties of hybrid composites were deliberate by many researchers [1–3] and they accomplished that hybrid composite offers better resistance to water absorption, cost saving, weight reduction, and improved properties.

The wide use of hybrid composites in industries is due to their collective properties of resilience, high strength and stiffness to weight ratios, creep resistance, corrosion resistance, and good damping properties. The use of natural fiber as reinforcement had increased a lot of folds in modern era due to novel environmental rules and customer demands can be seen in related studies [4].

Natural fibers are very thin hair like material. They are directly obtained from a vegetable, animal, or mineral resource and convertible into non-woven fabrics like felt or after spinning into yarns, or paper into woven cloth. The increased demand of natural fiber is due to their low cost, renew-ability, low density, bio-degradability, and abundance. The conclusion of this study [5] evaluates that the application of natural fiber can be increased by proper chemical treatment of fibers which produces enhanced mechanical properties than untreated fibers.

According to [6] 1, 3-Benzene dicarboxylic acid, polymer with 1, 4- cyclohexane dim ethanol, 2, 2-dimethyl-1, 3-propanediol and 2, 5-furandione is the chemical name of polyester resin. Its molecular formula is (C8H6O2, C8H16O4, C5H12O2, C4H2O3) n. Unsaturated polyester resins with Ambient temperature cure gives the ability to fabricate high-quality, value added hybrid composite products. Many authors [7–9] stated numerous properties of polymer reinforced plastics which make them suitable for various applications like marine structures, automotive parts, and aerospace structures.

In present work, hybrid composites were fabricated using different weight percentages of dissimilar fibers (reinforcement). These specimens were used to test their properties according to the procedure as per ASTM standards. The effect of jute fiber reinforcement on glass fiber reinforced hybrid composite was evaluated and mechanical properties were analyzed.

2. EXPERIMENTAL

A. Material.

The hybrid composite material used in this research was fabricated using light weight chopped strand mat of E-glass fabrics as synthetic reinforcement. Jute fibers were used as natural reinforcement. Jute fibers and the plant from which they are extracted are shown in figure 1.polyester resins with initiator (Methyl ethyl Kenton Peroxide) and accelerator

(cobalt) were used as matrix materials. Some significant properties of polyester resins are given in table I.

Fig. 1. *Jute plant and fiber*

TABLE I. PROPERTIES OF POLYESTER RESINE

Properties	Polyester
Viscosity at 250μ(cP)	250-350
Tensile Strength (Mpa)	72
Flexural strength (MPa)	140
Modulus of elasticity E (GPa)	3.3
Density ρ (g.cm^{-3})	1.1
Heat distortion temperature HDT (ºC)	71
Maximum elongation (٪)	2.2

B. Composite Manufacturing Method.

There are various techniques available for manufacturing of hybrid composites namely resin transfer molding, compression molding, vacuum molding and pultruding. The hand lay-up technique [10] is one of the simple and easy methods for fabrication of hybrid composite. A principal advantage of the hand lay-up method is to reduced manufacturing times, simple equipment and tooling, moderately less costly than other manufacturing processes [11]. This is a commonly used method of composite fabrication. Few important stages of fabrication of these hybrid composites are shown in figure 2. Composite sheet specimens consisting of polyester resin with jute fiber and glass fiber reinforcement was fabricated with the dimensions of 300mmx300mmx4mm. Three hybrid composites were made up of 30% fiber and 70% resin by weight with different combinations of jute fiber content (10, 15 and 20 wt%) and Glass fiber content (10, 15 and 20 wt%) as shown in table II.

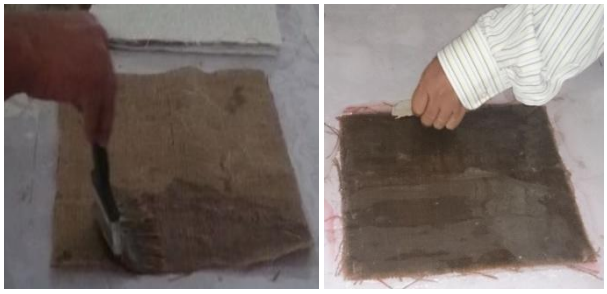

Fig. 2. Different stages of composite fabrication

TABLE II. SAMPLES WAIGHT CALCULATION FOR HYBRID COMPOSITE

% of polyester	% of Jute fiber	%of Glass fiber	Mass of resin	Mass of Jute fiber	Mass of Glass fiber	Total mass
70	10	20	350g	50g	100g	500g
70	15	15	350g	75g	75g	500g
70	20	10	350g	100g	50g	500g

C. Mechanical Testing.

All experimental tests were carried out at Charusat (CSPIT), changa, India. Cutting operations have been carried out with the aim to produce specimens suitable for mechanical characterization, in accordance to the related standards.

Tensile tests were performed on rectangular flat specimens of dimensions 165 × 13 × 4mm according to ASTM D638 on 50 KN universal testing machine at room temperature. Specimens were positioned in the grips and pulled at a speed of 2 mm/min until failure occurred.

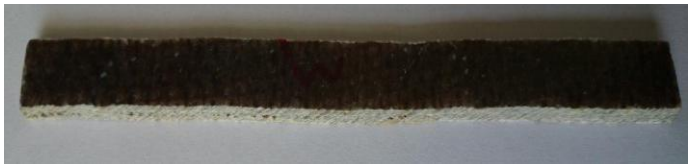

Fig. 3. Tensile speciman

Flexural testing generally known as three-point bending testing was again done by universal testing machine as per ASTM D790M. Composite specimens of dimensions 10 × 98 × 4mm were placed on two supports and load was exerted at the centre with speed of 2 mm/min.

Fig. 4. Flexural speciman

Compression testing was also carried out on universal testing machine as per ASTM D3410 with dimensions 140 x 12 x 4 mm. Composite specimens were placed in vertical position and 50KN force were applied at a speed of 2 mm/min.

Fig. 5. Compressive speciman

3. RESULTS AND DISCUSSONS

Tensile properties.

The tensile properties of various hybrid composites at different fiber loading of reinforcement are shown in table-III. The results show that addition of natural fiber content in glass fibers imparts more tensile strength of composites. Conversely, natural fiber content should be lesser than synthetic fiber content. The maximum tensile strength is observed for composite with 20% of glass and 10% of jute fiber loading.

TABLE III. ULTIMATE TENSILE STRENGTH

% wt of Jute	% wt of Glass	Flexural strength in MPa					Avg. Flex. strength in MPa
10	20	149	147	159	159	220	167
15	15	271	209	224	263	261	246
20	10	302	256	282	290	288	284

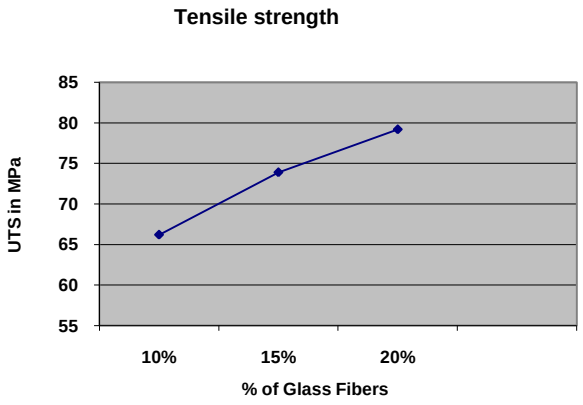

Fig. 6. Variation of UTS values with glass fiber loading

Flexural properties.

The flexural properties of various hybrid composites at different fiber loading of reinforcement are shown in table IV. The results show that adding up natural fiber content in glass fibers increases the overall flexural strength of composites. However, natural fiber content should be lesser than synthetic fiber content. The maximum flexural strength is observed for composite with 20% of glass and 10% of jute fiber loading.

TABLE IV. FLEXURAL STRENGTH

% wt of Jute	% wt of Glass	Ultimate tensile strength in MPa					Avg. UTS in MPa
10	20	80.2	66.3	78.7	83.7	87.1	79.2
15	15	51	76.7	84	77.9	79.8	73.9
20	10	53.9	70.9	63.6	76.8	65.9	66.2

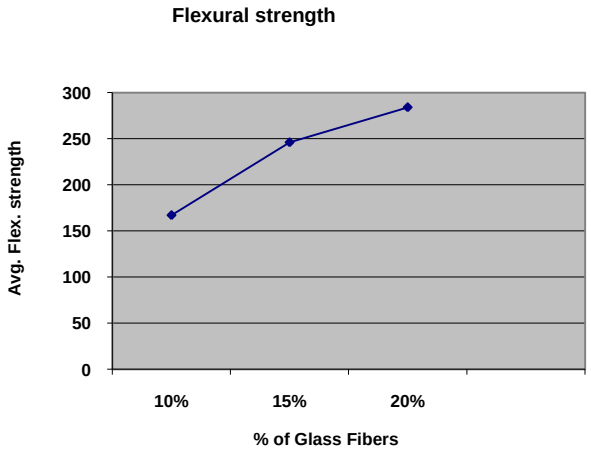

Fig. 7. Variation in Flexural strength with glass fiber loading

Compressive properties.

The compressive properties of various hybrid composites at different fiber loading of reinforcement are given in table V. The results show that adding of natural fiber content in glass fibers increases the overall compression strength of composites. However, natural fiber content should be lesser than synthetic fiber content. The maximum compression strength is observed for composite with 20% of glass and 10% of jute fiber loading.

TABLE V. ULTIMATE COMPRESSIVE STRENGTH

% wt of Jute	% wt of Glass	Ultimate Compressive strength in MPa					Avg. comp. strength in MPa
10	20	39.0	42.4	34.3	34.5	37.6	37.55
15	15	45.2	50.1	45.7	35.3	47.7	44.67
20	10	53.0	56.3	51.7	46.8	50.9	51.97

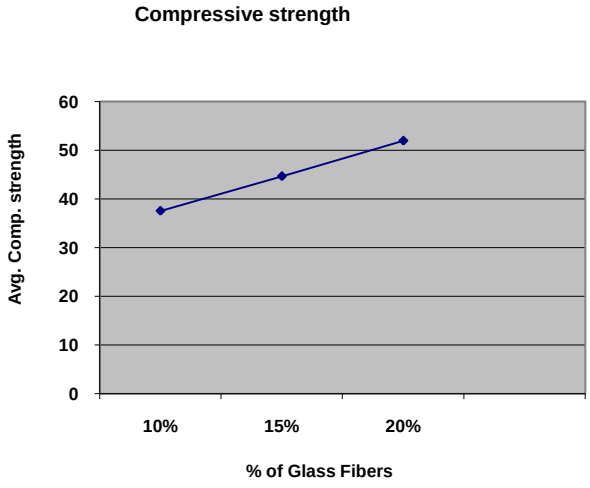

Fig. 8. Variation in Compressive strength with glass fiber loading

4. ANALYSIS OF VARIANCE

The ANOVA technique can be used to examine any number of factors which are hypothesized or influence the dependent variable. This design makes use of two factors, each at three levels.

ANOVA for Tensile Strength Testing

Statistical analysis has been carried out using analysis of variance-one way un-stacked (ANOVA) and the results are shown in table VI comprises the variation of tensile strength into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 9.77, is a ratio of the between group estimate to the within group estimate. Since the P-value of the F-test is near by 0.05, there is a statistically significant difference between the mean tensile strength of hybrid composite.

ANOVA for Flexural Strength Test

Statistical analysis has been carried out using analysis of variance-one way un-stacked (ANOVA) and the results are shown in table VII comprises the variation of flexural strength into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 47.8, is a ratio of the between group estimate to the within group estimate. Since the P-value of the F-test is near by 0.05, there is a statistically significant difference between the mean flexural strength of hybrid composite.

ANOVA for compressive strength Test

Statistical analysis has been carried out using analysis of variance-one way un-stacked (ANOVA) and the results are shown in table VIII comprises the variation of flexural strength into two components: a between-group component and a within-group component. The F-ratio, which in this case equals 18.24, is a ratio of the between group estimate to the within group estimate. Since the P-value of the F-test is near by 0.05, there is a statistically significant difference between the mean flexural strength of hybrid composite.

5. COST ANALYSIS

The prices of natural fiber compared to synthetic fiber are much less. Table VI shows the cost of each fiber. Cost analysis for making of hybrid composite plate with 10% jute & 20% glass is shown in table VII.

TABLE VI. COST OF FIBER/KILOGRAM

Type of fiber	Price(INR)\Kg
Glass fiber	1500/Kg
Jute fiber	250/Kg

TABLE VII. COST ANALYSIS OF HYBRID COMPOSITE

Weight of fibers	Price(INR)
50 gm of jute fiber	12.5
100 gm of glass fiber	150
Total cost	162.5
Total saving (with respect to glass fiber)	62.5
Percentage saving	38.46%

6. CONCLUSION

The mechanical properties of hybrid composite based of jute/glass reinforced polyester have been investigated. The experimental study on the effect of fiber loading on mechanical behavior of jute/glass fiber reinforced polyester based hybrid composites leads to the following conclusions

1. The successful fabrications of a new class of polyester based hybrid composites reinforced with jute and glass fiber have been done using hand lay-up technique.
2. The present investigation revealed that fiber loading significantly influences the different properties of composites.
3. The maximum tensile, flexural and compression strength is obtained for composites reinforced with 20 wt% glass fiber loading and10 wt% of jute fiber with 70 wt% of polyester resin i.e.,79.2 MPa, 284MPa, 51.97MPa.
4. Also the change in flexural strength is quite marginal from 10-30% of glass fiber content.
5. Cost analysis for manufacturing of hybrid composites shows 38.46% cost reduction.
6. Statistical analysis by ANOVA-one way predicts that the dissimilarity of results obtained from samples is significant, which confirm a very stable tensile, flexural and compressive strength of hybrid composite under different fiber loading.
7. This research work is adding indication that mixing up more than one fiber in the composites provides maximum strength of any composite.

ACKNOWLEDGMENT

First, we are indebted to our parents and family members for their blessings and moral support. We are grateful to all the faculties and friends for their supports and sharing of knowledge. We are also thankful to all who helped directly or indirectly for the doing well for this research work.

REFERENCES

[1] L. Humberstone and S.M.Bleay, "Mechanical and electricalassessment of hybrid composites with hollow glass reinforcement,"Composites Science and Technology, 1999.

[2] J. K. Michael and C. K. Subhash, "Thick-section AS4-graphite/PPS/E-glass hybrid composites: Flexural response," Composites Science and Technology, 1996.

[3] G. K. Sathiya, A. Elayaperumal, and N. Venkateshwaran, "Prediction of tensile properties of natural-hybrid fiber composites," Composites B, 2012.

[4] D. R.Mulinari, T. F.Maia, and E. F. Rodrigues, "Tensile strengthof polyester resin reinforced bagasse fibers modifiedby estherification," Procedia Engineering,2011.

[5] N. Benseddiq,A.Imad, H. Osmania, and M. Rokbi, "Effect of chemical treatment on flexural properties of natural fiber reinforced polyester composite," Procedia Engineering,2011.

[6] G Rajeshkumar and P Sivaraj, "Prediction of Mechanical Properties of Hybrid Fiber Reinforced Polymer Composites", International Journal of Engineering Research,2014.

[7] K. Gupta, S. P. Singh, and R. Chandra, "Damping studies in fiber-reinforced composites," Composite Structures,1999.

[8] P. Prince, S. Singh, and A. K. Haldar, "Vibration characteristics of thermoplastic composite," in Proceedings of AIP conference,Jaipur, India, November 2011.

[9] S. K. Jain, P. Kumar, and S. Singh, "An numerical and experimental investigation of mechanical properties of glass fiber reinforced polyester composites," Advanced Materials Letters, 2012.

[10] C. C. Ant´onio, P. Reis, and J. P. Davim, "Experimental study of drilling glass fiber reinforced plastics (GFRP) manufactured by hand lay-up," Composites Science and Technology, 2004.

[11] Rajesh Khanna1,N. K. Batra, Satnam Singh and Amit Bindal, "Development of Glass/Jute Fibers Reinforced Polyester Composite," indian journal of materials science, 2013

TABLE VIII. ANOVA TEST FOR TENSILE STRENGTH AT VARIOUS FIBER WEIGHT FRACTIONS

DF	SS	MS	F-Ratio	P-value
2	381.8	190.9	9.77	0.006
9	175.9	19.5		
11	557.6			
.421	R-Sq = 68.46%		R-Sq(adj) = 61.45%	

DF - degrees of freedom, SS - sum of squares, MS - mean squares, p-p value, S-sample standard deviation

TABLE IX. ANOVA TEST FOR FLEXURAL STRENGTH AT VARIOUS FIBER CONTENT

DF	SS	MS	F-Ratio	P-value
2	38730	19365	47.8	0.000
12	4861	405		
14	43591			
0.13	R-Sq = 88.85%		R-Sq(adj) = 86.99%	

DF - degrees of freedom, SS - sum of squares, MS - mean squares, p-p value, S-sample standard deviation

TABLE X. ANOVA TEST FOR COMPRESSION STRENGTH AT VARIOUS FIBER WEIGHT FRACTIONS

DF	SS	MS	F-Ratio	P-value
2	38730	19365	47.8	0.000
12	4861	405		
14	43591			
0.13	R-Sq = 88.85%		R-Sq(adj) = 86.99%	

DF - degrees of freedom, SS - sum of squares, MS - mean squares, p-p value, S-sample standard deviation