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Research paper

A reinforced coconut char, jute and glass fibers composite material mechanical effects compared by using taguchi method and analysis (Anova) technique

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Abstract

This research work explains the different mechanical effects of natural fiber composites to increase its strength and they were reinforced with different reinforcements. The matrix is considered as natural fiber matrix composites with coconut char; Jute and glass fiber composite materials were taken and give special properties for different applications in automobiles. Natural fiber composites have different advanced applications in current engineering materials. Hence the special properties like high strength, greater flexibility and abundantly available properties. With the help of different combination and proportions these materials were reinforced with different combinational materials were obtained for testing and selection of best combination material. The general properties for any material like mechanical properties of different reinforcements with different samples were tested and results were analyzed with the help of ANOVA and signal to noise ratio were found out by using MINITAB 18 Statistical software and results were compared.

Keywords: *Composite Material; Natural Fibers; Natural Fiber Matrix; Coconut Char; Jute and Glass Fiber.*

1. Introduction

The composite material is prepared with the help of coconut char, Jute and glass fiber material and they are reinforced to give better properties over the normal material without any combination. The metal and their alloys have different properties like friction, mechanical and tribological. Therefore the composite material gives the high toughness, high strength and non corrosive. The basic advantage of any composite material is their high quality, consolidated with less density, when contrasted with mass materials, which gives further weight reduction in the completed part [1]. Since the properties of composite material have excellent consideration from past ten years, because of the special properties, they are used in various applications in current innovation. The composite material properties depend on the particle size and according to the dispersion level of composite particles, which influences the factor properties. A factor which gives the properties of the composite materials is the basic communication surface between the host matrix and particles. The different composite materials are made of a base material which is well known as matrix. The composite material is made of a base material called matrix which has low properties, yet ease cost price, reinforced with different materials in the form of continuous fibres, short fibres or particles with mechanical physical or chemical properties [2]. Due to very high demand in environmental awareness, the natural fibers have become very popular in scientists as reinforcement for polymer matrix are replaced against synthetic fibers. The natural fibers have many advantages like cheap cost, density, availability in abundance, and also they are environment friendly non-toxicity, high flexibility, renewability, biodegradability, high specific strength and modulus, and also they easy processing. The natural fibers have very high moisture absorption and low thermal stability because of their drawbacks [7-8]. The hybridization was used to overcome the above said drawbacks of the natural fibers.

2. Materials selection

The following are the different materials made in the form of fiber were used to make material and testing and further analysis purpose. Since the natural material in the form of fiber has good strength and biodegradable, the composite material has high strength and can be used for automobile and light weight applications. The following figure 1, figure 2 and figure 3 shows the Glass fiber, Jute and coconut char trees with and fiber for each material. The materials were purchased from go green products, Vadapalani Chennai. And the epoxy LY 556 and corresponding hardener HY 951 Javanthi enterprises Guindy, Chennai, India

Fig. 1: Glass Fiber Tree and Glass Fiber.

Fig. 2: Jute Tree and Jute Fiber.

Fig. 3: Coconut Shell and Coconut Fiber

3. Mechanical properties

3.1. The hardness test

Hardness of the different composite mainly depends on the particulate reinforcements with very low aspect ratio. The hardness of the material was carried out by Rockwell hardness test machine.. The tests were carried out by applying different indentation loads. The different papers contributed a lot of research regarding the effect of particulate reinforcement on the hardness of the material have been summarized. Rajmohan et al., [3] found the hardness value of the natural composites reinforced with some constant percentage value of 20% of Silicon carbide particles and different mass fraction of mica particles. The different results gave the maximum hardness value is achieved with 5% mica particles after that the values of hardness continuously decreased. Suresha and sridhara [4] in their research paper shown and they were observed that the hardness value of the hybrid natural composite material reinforced with the help of silicon carbide and graphite particles were increase value of about 2.5 to 3% in weight reinforcement content. The hard ceramic particles increase the hardness and soft graphite reinforcement decreases hardness. Once the graphite percentage had been increased further, the porosity of the composite material increased. Boopathi et al., [5] had worked on the natural, silicon carbide and fly ash hybrid composites and they were found the value of the hardness increased. Hence they had investigated that adding of fly ash as reinforcement significantly improved the hardness value of the natural matrix. Also the additional increase in weight to 8 % increases the hardness value. The diameter of 30 mm steel ball as indenter ball was used for duration about 30 seconds. The hardness value was increased once the age hardening treatment. Therefore if the ceramic materials were used the hardness value was increased and have better properties.

3.2. The tensile test

There are [2] types of strengthen mechanism in case of natural. The primary one is direct strengthening and the later one is indirect strengthening. Chawla and Shen [12] given that the primary one gives the result of high hardness by adding hard and stiff reinforcement in soft matrix. Because of this the matrix reinforcement in the matrix is directly transformed from matrix to reinforcement, therefore this increases the composite resistance to behaviour plasticity in case of external loads. In case if the temperature changes, the thermal stress were developed which leads to the formation of dislocation at the reinforcement interface. Thus the strength of the composite material was increased due to this dislocation, also if the size of the reinforcement increases the size of the particle size decreases. Boopathi et al., [5] in their research work said that the reinforced increased with the increase in silicon carbide and fly ash. The composite material strength will be increased when the reinforcement is added. The final results shown that the tensile strength of 282N/mm^2 and this value further increased when natural 10% with fly ash. And this was further increased when natural 10%, fly ash 10% with silicon carbide. Therefore the strengthening can be increased with the help of reinforcement different percentages. Therefore it increases dislocation, and hence further strength is increased.

4. Experimental materials

4.1. Jute fibre

The Jute fibers were obtained from the linum usitatissimum stems and they are used mainly to make linen, the particular plant used for fiber production. But the structure is more crystalline in nature and make stronger and stiffer to handle at any conditions. The Jute fibers are in the range in length up to 90cm and the average diameter is about 13 to 15 microns. Since they absorb and release water instantly they are very useful and have no corrosion. The prepared woven Jute is shown in the following figure 4.

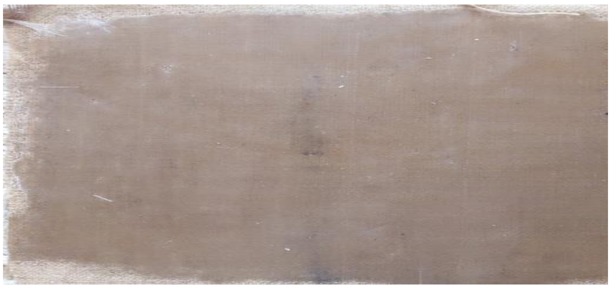

Fig. 4: Woven Jute.

4.2. Coconut char fibre

The hem fibers are derived from the plant called cannabis sativa and it grows easily to 4 meters height. The long, durable and strong coconut char fibers are about 75% cellulose and also they contain lignum level is very low around=d 8 to 11%. The diameter of the fibers ranges from 15 to 50 microns. They conduct heat and blocks the ultraviolet light and anti bacterial property. Therefore the application of coconut char with Jute gives better properties. The prepared woven coconut char is shown in the following figure 5.

Fig. 5: Woven Coconut Char.

4.3. Glass fibre

Glass fiber is the natural fiber and is extracted from native plant. They are very strong fibers and also extracted from date palm. For getting the fiber, the raw fibers were taken and soaked in normal salt water for duration of 30 days and then rinsed to remove the binding material further they were dried in sunlight. The prepared woven glass fiber is shown in the following figure 6.

Fig. 6: Woven Glass Fiber

4.4. Epoxy resin

The epoxy resins are widely used for different applications like adhesives, coatings and different electronic materials. The hardener (hy951) is mixed with epoxy resin (LY556) to have better bonding.

5. Taguchi method for coconut char, jute and Glass fiber

The taguchi method was carried out with L9 orthogonal array in order to reduce the number of repetition experiments. The array consists of [3] columns and 9 rows with degree of freedom as 9 for treatment for mean values. Therefore each parameter were set according the L9 array, as per Taguchi method of design of experiments, the experimental results were obtained. The different values and results obtained were tabulated in the following table 1

Table 1: Description of Material with Different Levels

Sl No	Different levels			
	Description	1	2	3
1	Coconut char weight fraction in grams	0	0.3	0.5
2	Jute weight fraction in grams	0	0.3	0.5
3	Glass fiber in grams	0	0.3	0.5

The most applicable orthogonal array is L9 array for the experimentation and as shown in the following table 2

Table 2: No of Experiments

No of experiments	x	y	z
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	1
5	2	2	2
6	2	3	3
7	3	2	1
8	3	2	1
9	3	3	2

From the above table results and order the different experiments were conducted with the above factors and their levels as shown in table 1. The each of the above [9] experiments were conducted for 3 times to get variations. The following table 3 shows the arrays with control factors.

Table 3: Arrays with Control Factors

Sl No	Coconut char + Jute weight fraction	Jute weight fraction	Glass fiber weight fraction
1	0	0	0
2	0	0.3	0.3
3	0	0.5	0.5
4	0.3	0.3	0.3
5	0.3	0.5	0.5
6	0,3	0	0
7	0.5	0.3	0
8	0.5	0.5	0.5
9	0.5	0.3	0.5

5.1. Hand layout preparation

Even though there are many techniques are available, we followed a hand layup process to prepare composite material since it is one of the cheap processes and also it is very easy process for manufacturing composite materials. With the help of hand layup the complex parts can be prepared with less time. This process involves simple equipment and tools which are very less expensive. The fibers coconut char, Jute and glass fiber are added to the resin and hardener is mixed with required weight percentages. The fiber with hardener was poured in the moulds for different samples and was tested as per ASTM Stands. The curing time for composite material is for 1 day. The prepared composite material and matrix material were tested by tensile, flexural, impact and water absorption test.

6. Tensile, flexural and impact tests

The equipment electronic tensometer was used to find the properties of composite materials samples. The first test was tensile sample was made according to ASTM-D 638M to scale tensile properties for flexural properties, the 3-point bend test was performed in according to ASTM D790M. The different samples were tested with crosshead speed of 1.5mm/min and also the Izod impact test equipment was used to find out the impact properties of the composite material. And these specimens were prepared with ASTM D256-97 standard. Further the results were analysed with the help of MINITAB 18 version statistical software. For better clarity of figures, the values of MINITAB 18 statistical software values were exported to excel file and figures were generated.

Fig. 7: Tensile Specimen Before and after Test.

Fig. 8: Flexural Specimen before and after Test.

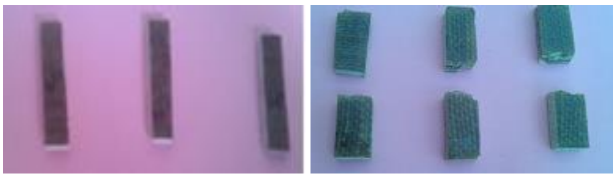

Fig. 9: Impact Specimen before and after Test.

The figure 7, figure 8 and figure 9 were the tensile, flexural and impact specimens prepared and tested.

7. Water absorption test

The water absorption test was used to find the how much water was absorbed during 24 hours of composite material in curing tank. For this water absorption test the composite prepared material were kept in oven for 15 minutes at temperature of 40 degrees and then make it cool under room temperature. As soon as the specimen cooled, the weight of the material was taken. Then the material is immersed in curing tank for 24 hours duration. Then it is cleaned with dry cloth and weight was noted.

Weight of the specimen before curing = 100 grams

Weight of the specimen after curing = 110 grams

Percentage of water absorbed = (wet weight –dry weight) / Dry weight x 100

Therefore the percentage of water absorbed = 10%
From the above test it was clear that the absorption of water for our specimen for 24 hours is very less. Therefore percentage of absorption is very less. Hence the specimen is fit to use for application purpose.

8. Results and discussions

Tensile strength, flexural strength and impact strength for experimental results were calculated and shown in the following table 4, table 5 and table 6 for epoxy resin. The control factors which were in weight fractions for coconut char x, weight fraction for Jute y and weight fraction of Glass fiber (z) were analysed and the responses were tabulated in the tables 7, table 8 and table 9 for epoxy.

Table 4: Tensile Strength for S/N Ratio for Epoxy Resin

Coconut char Weight fraction	Jute Weight fraction	Glass fiber Weight fraction	T1	T2	T3	S/N Ratio	Mean
1	1	1	21	23	23.6	26.9	22.5
1	2	2	32	32.3	34.6	30.2	32.9
1	3	3	38	36.5	37.5	31.6	37.3
2	1	1	24.5	25.6	34	27.9	28
2	2	2	26.3	26.7	25	28.2	26
2	3	3	25	29.3	25.9	28.2	26.73
3	2	1	24.6	35.7	26.2	27.9	28.8
3	2	1	37.5	35.6	36	31.1	36.3
3	3	2	45.9	45	49.2	33.8	46.7

Table 5: Flexural Strength for S/N Ratio for Epoxy Resin

Coconut char Weight fraction	Jute Weight fraction	Glass fiber Weight fraction	F1	F2	F3	S/N Ratio	Mean
1	1	1	92	95	92	40	93
1	2	2	95	100	109	40	101
1	3	3	137	153	156	44	149
2	1	1	150	156	158	45	155
2	2	2	258	256	299	43	271
2	3	3	134	153	156	46	148
3	2	1	245	254	253	47	251
3	2	1	143	145	149	41	146
3	3	2	285	252	284	49	274

Table 6: Impact Strength for S/N Ratio for Epoxy Resin

Coconut char Weight fraction	Jute Weight fraction	Glass fiber Weight fraction	I1 (j/m)	I2 (j/m)	I3 (j/m)	S/N Ratio	Mean
1	1	1	93	95	95	40	94
1	2	2	125	195	127	45	149
1	3	3	186	190	191	46	189
2	1	1	189	189	189	46	189
2	2	2	116	116	116	44	116
2	3	3	145	145	145	41	145
3	2	1	64	64	64	43	64
3	2	1	76	76	76	45	76
3	3	2	159	159	159	45	159

Table 7: Response Table for S/N Ratio for Tensile Epoxy Resin

Levels	Coconut char Weight fraction	Jute Weight fraction	Glass fiber Weight fraction
1	41	43	42
2	46	44	45
3	44	45	47
Delta	4	1	5
Rank	1	3	2

Table 8: Response Table for S/N Ratio for Flexural Epoxy Resin

Levels	Coconut char Weight fraction	Jute Weight fraction	Glass fiber Weight fraction
1	30	28	29
2	39	30	34
3	35	32	30
Delta	3	4	2
Rank	2	1	3

Table 9: Response Table for S/N Ratio for Impact Epoxy Resin

Levels	Coconut char Weight fraction	Jute Weight fraction	Glass fiber Weight fraction
1	45	42	41
2	43	42	42
3	15	44	42
Delta	2	3	4
Rank	2	2	2

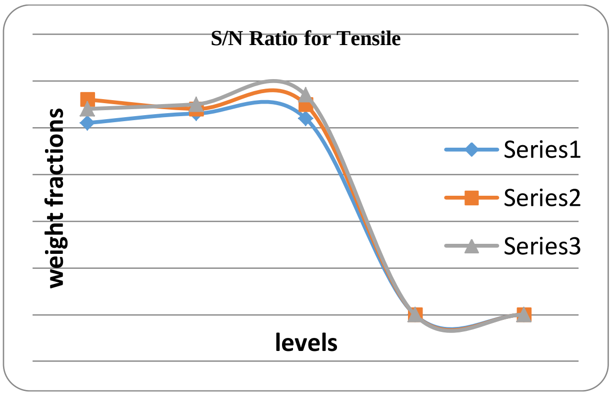

Fig. 10: Signal to Noise Ratio Values for Tensile Strength.

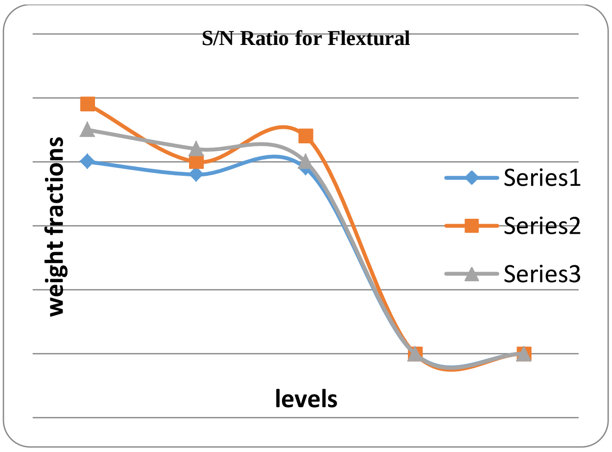

Fig. 11: Signal to Noise Ratio Values for Flexural Strength.

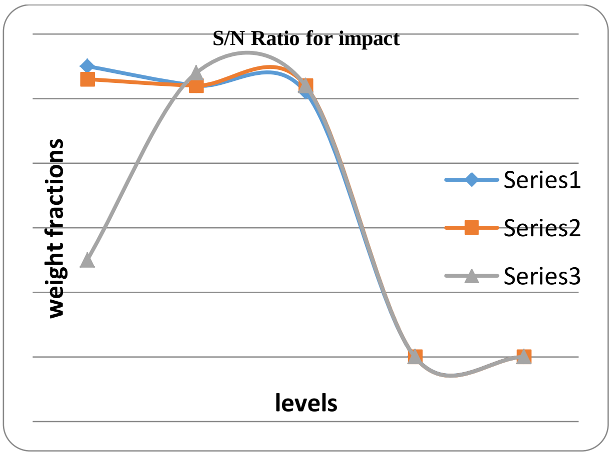

Fig. 12: Signal to Noise Ratio Values for Impact Strength.

From the above figures 10, figure 11 and figure 12, it was concluded that the maximum values of signal to noise ratio gives the better combination. for tensile strength X3Y3Z2 , for flexural strength X2Y2Z3 and for impact strength X1Y3Z3 were the optimal results.

9. ANOVA classification test

The main reason of the statistical test 3 way Analysis of variance is to find the parameters which were designed significantly correct or not for checking the composite material strength. The level of significance is 5% level at confidence limit of 95%. The three way analysis of variance was carried out to test the 3 weight factors Coconut char(X), Jute(Y) and Glass fiber (Z) with comparing the population means. The following tables 10, table 11 and table 12 shows the ANOVA 3-way classification test results. The different parameters are Degree of freedom (DOF), Sum of squares (SS), Variance (V). From the below tables the lowest values in P-value were 0.13 for tensile strength, 0.17 for flexural strength and 0.3 for impact strength

Table 10: Tensile Strength Results from ANOVA Table

Source of variation	DOF	SS	V	F	P	% values
X	2	185	95	3.51	0.19	29
Y	2	296	145	5.37	0.13	45
Z	2	95	49	1.81	0.32	14
Error	2	49	27			12
Total	8	625				100

Table 11: Flexural Strength Results from ANOVA Table

Source of variation	DOF	SS	V	F	P	% values
X	2	270	135	4.37	0.17	50
Y	2	14567	6830	11.5	0.99	0.01
Z	2	11450	5321	3.41	0.25	39
Error	2	3000	1560			11
Total	8	29287				100

Table 12: Impact Strength Results from ANOVA Table

Source of variation	DOF	SS	V	F	P	% values
X	2	620	311	0.3	0.8	52
Y	2	6304	3152	3	0.5	24
Z	2	2903	1453	1.5	0.3	11
Error	2	2294	1143			13
Total	8	12121				100

From the above table it was concluded that the weight fraction for Jute (y) from tensile strength, weight fraction for Coconut char (x) for flexural and finally weight fraction for Glass fiber fiber (z) was significant.

10. Conclusion

From the above results it is clear that the Jute (y) shows the greater values and hence Jute have greater strength. Also it was concluded that the maximum values of signal to noise ratio gives the better combination. for tensile strength X3Y3Z2 , for flexural strength X2Y2Z3 and for impact strength X1Y3Z3 were the optimal results and also weight fraction for Jute (y) from tensile strength, weight fraction for Coconut char (x) for flexural and finally weight fraction for Glass fiber fiber(z) was significant.

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