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Optimization of Tensile Strength of Hybrid Composites by Using Taguchi (ANOVA)

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Abstract
The polymer Matrix composite (PMCs) gaining more importance compared Monolithic materials with the urge to develop new PMCs their properties have been increased by the addition of one or more fibers. the present work describes the characterization of fiber based Natural composite consisting of chicken Feather, carbon fiber and reinforcement and epoxy resin as the matrix the Manufacturing process by using hand layup technique is used to develop the new composite. In this experimental study essentially focused to the tensile strength of composite of different weight percentage of carbon fiber and chicken feather the major variation created by the chicken feather fibre the basics of weight. The optimum percentage by weight fraction of carbon fiber Chicken fiber and resin is determined using Experiments (DOE) Taguchi: "(ANONA) L9" orthogonal Array the experimental result were obtained by using Taguchi (ANOVA) with 5% confidence level of Significant optimization method or orthogonal array of Taguchi the (S/N) ratio the analysis of variance (ANOVA) are employed.

Keywords: *Epoxy Resin, chicken feather, carbon fiber, Taguchi technique analysis of DOE*

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I. INTRODUCTION

Composite material growth has been of enormous concentration to researchers and material engineers ever since man revealed that conventional materials could be combined to obtain specific desirable properties hitherto unobtainable. The speed of technological development in the 21st century has led to a constant demand for innovative composite materials which can meet the unique material property requirements of this new age. The common wastes such as chicken feather can be added to improve the mechanical properties of the composites. When the chicken feather are added to the Carbon fiber, the tensile strength of the developed composite was improved by 18 % and the compressive strength has also increased by 30 %. The powder mixed to form the fiber reinforced composite is 100 um at 10 % of weight of composite.

Carbon reinforced composites recorded a increase in tensile strength along with appropriate fiber orientation. Hybrid epoxy composites mixed with chicken fiber and carbon fibre in appropriate composition has improved the tensile strength.

Material when compared to the base materials. The composites reinforced with chicken fiber barbs had improved tensile strength than the composite made with chicken fiber rachis. The flexural strength was also high for chicken fiber reinforced composites. Taguchi's technique can be used for identifying the best combination of the reinforcement material and its orientation angle for better mechanical properties

II. MATERIALS AND METHODS

The materials which are used for our project are

S.NO	COMPOSITE \MATERIAL	MATERIAL SELECTION
I	Matrix material	Epoxy(LY556)+Hardener (HY951)
2	Fibre material	Carbon fibre and Chicken feather

Table 1.2 material and method

2.1 Material used

The reinforcement materials including chicken feather, carbon fibre and matrix material including epoxy resin and hardener are shown in Table 2. The reinforcement used are processed before being used in the development of hybrid composite.

2.1.1 Chicken feather fibre

Chicken feathers are waste products from rooster and poultry farm. Around world 24 Billion chickens are killed yearly and round 10billion tones of hens feathers are generated each 12 months by rooster processing plants, growing a solid waste problem.. However CFF are restricted in landfill disposal on grounds due to the pose of greenhouse gas generation that it is danger for the environment. Chicken feathers are enormously ordered, hierarchical branched structures, ranking many of the most complicated of keratin structures determined in vertebrates. Since the main parts of the Chicken feather includes barbs and rachis which leads good characteristic strength. There are five commonly recognized categories of feathers: a) Semiplume, b) Contour Feather & After feather, c) Filoplume, d) Bristle, and e) Down Feather.

2.1.2 Carbon fibre

Carbon fibers or carbon fibers are fibers about 5–10 micrometers in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber very popular in aerospace, civil engineering, military, and motorsports, along with other competition sports. However, they are relatively expensive when compared with similar fibers, such as glass fibers or plastic fibers.

2.2 Hand layup method

The method implemented in the fabrication of chicken feather and carbon fibre hybrid composite is hand layup procedure and is a closed molding technique. The process flow chart of hand layup is shown in Figure.2.1. In this method, chicken feather and carbon fibre are mixed with epoxy resin for uniform dispersion. Chicken feather of varying sizes are randomly oriented in the mould cavity. Epoxy resin mixed with carbon and chicken feather for proper wetting. A roller is used to compact the layer.

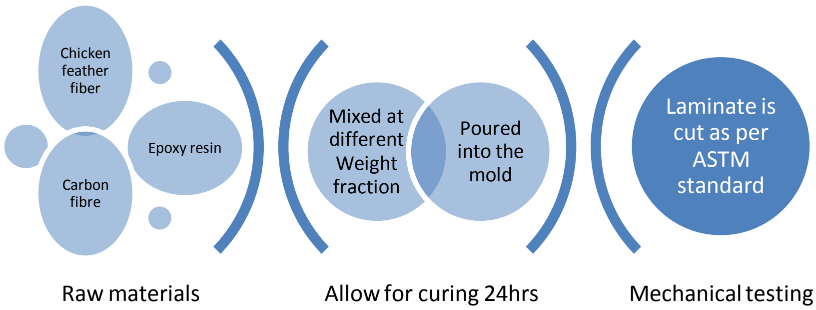

Figure 2:Hand layup process flow chart

2.3 Overview of Taguchi technique

Design of experiment (DOE) as a statistical technique has been applied to determine simultaneously individual and interactive effects of manufacturing parameters on the composites performance. The conventional DOE, a full factorial method, can study all the possible cases of various factors but requires a large number of experiments and high cost. The Taguchi method is a powerful DOE technique to overcome this problem as it can decrease the number of experiments significantly by a specially designed orthogonal array (OA), which can accommodate the selected manufacturing parameters for the analysis. Furthermore, signal to noise ratio (SIN) reflecting both the amount of variation present and the mean response of several repetitions can be used in Taguchi method to measure the amount of variability in the response data. The S/N can minimize the effects of noise (uncontrollable) factors and identify control factors settings, thus reducing the sensitivity of the system performance to a source of variation.

The objective of this study is to determine the optimal values of Input parameters namely, volume fraction composition of chicken fiber and carbon fibre using Taguchi experimental design method. Orthogonal arrays of Taguchi, the signal-to-noise (S/N) ratio are employed to determine the optimal combination of weight fractions of above mentioned reinforcements and to analyze their effects on the tensile strength of resulting composite.

III. EXPERIMENTARTION PLAN

The design of experiments carried out with the help of Taguchi's L9 orthogonal array to reduce the number of experiments. TheL9 orthogonal array contains nine rows and three columns, with 9 degrees of freedom (df) to treat one for Mean value and twoeach for the other factors. Each parameter level is set according to the L9 orthogonal array, based on Taguchi method of design.The experimental results further transferred into

S/N ratio using MINITAB 17 software. The different levels of variables used in experiment listed in table1. When response maximized (Larger-the-better), Taguchi uses the following formula for S/N ratio(η).

$$\eta = -10\, log_{10}\left(\frac{1}{n}\sum_{i=1}^{n} y^2{}_i\right)$$

Table 3.1 Selected Factors and their Levels

S.NO	PARAMETER	CODE	LEVELS			UNITS
			1	2	3	
1	Weight Fraction of the Resin	X	89.5	83.5	80.5	Grams
2	Weight Fraction of the Chicken feather	Y	1.7	4	4.5	Grams
3	Weight Fraction of the Carbon fibre	Z	8.8	12	15	Grams

The most suitable orthogonal array for experimental is L9 array as shown in Table 2. Therefore nine experiment are carried out

Table3.2 Orthogonal Array(OA) L9

Experiment No.	Control Factors		
	X	Y	Z
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

3.1 Conducting the matrix experiment

In accordance with the above OA, experiments were conducted with their factors and their levels as mentioned in table. The experimental layout with the selected values of the factors is shown in Table 3. Each of the above 9 experiments wereconducted 4 times(36 experimentsinall)to accountforthevariationsthatmayoccurdueto thenoisefactors.

Table3.3 Orthogonal Array(OA)with control factors

Serial no	Weight fraction of resin%	Weight fraction of chicken feather %	Weight fraction of carbon %
1	89.5	1.7	8.8
2	89.5	4	12.5
3	89.5	4.5	15
4	83.5	1.7	12.5
5	83.5	4	15
6	83.5	4.5	8.8
7	80.5	1.7	15
8	80.5	4	8.8
9	80.5	4.5	12.5

3.1 Processing:

Many techniques are available in industries for manufacturing of composites such as compression mouldings, pultruding, and resin transfer moulding are few examples. The hand layup process of manufacturing is one of the simplest andeasiest methods for manufacturing composites. A primary advantage of the hand layup technique is to fabricate very large,complex parts with reduced manufacturing times. Additional benefits are simple equipment and tooling that are relatively lessexpensivethanothermanufacturingprocesses.Thefiberswereaddedtotheresinmixedhardenerwithrequiredweight percentages. The fiber resin hardener mixture was poured in to the moulds for different testing prepared as per ASTM standards.Thesetting timetaken by thecompositeswasapproximately

24hours.Thepreparedcompositesweresubjectedtotensile,flexuralandimpacttests.

3.2 Tensile tests:

An electronic tensometer used to find the tensile and flexural properties of the composite specimens. The tensile test specimenswere made in accordance with ASTM-A 370M to measure the tensile properties.

IV. Results and Discussion

4.1.Taguchi analysis for tensile strength

Experiment results for tensile strength, S/N ratio for each combination parameters is calculatedand shown in table 4, for epoxy resin respectively. Analysis of the influence ofcontrol factors (weight fraction of resin(X), weight fraction of chicken feather(Y) and weight fraction of carbon fibre (Z)) on the responses areobtained from the response tables of mean S/N ratio and the results are listed in table 4.1. The main effect plots for S/N ratio are presented in Fig. 4, respectively.

Table4 Experimental results of tensile strength

Expt no	Weight fraction of resin(A) %	Weight fraction of chicken feather(B) %	Weight fraction of carbon fiber(C) %	Tensile strength (MPa)
1	89.5	1.7	8.8	15.8
2	89.5	4	12.5	11.0
3	89.5	4.5	15	13.5
4	83.5	1.7	12.5	19.4
5	83.5	4	15	15.5
6	83.5	4.5	8.8	17.4
7	80.5	1.7	15	334.2
8	80.5	4	8.8	259.2
9	80.5	4.5	12.5	296.8

Table4.1 Experimental results of tensile strength along with S/N ratio

Expt no	Weight fraction of resin(A) %	Weight fraction of chicken feather(B) %	Weight fraction of carbon fiber(C) %	Tensile strength (MPa)	Signal to Noise	Mean
1	89.5	1.7	8.8	15.8	23.97	15.50
2	89.5	4	12.5	11.0	20.82	11.00
3	89.5	4.5	15	13.5	22.60	13.50
4	83.5	1.7	12.5	19.4	25.75	19.40
5	83.5	4	15	15.5	23.80	15.50
6	83.5	4.5	8.8	17.4	24.81	17.50
7	80.5	1.7	15	334.2	50.48	334.30
8	80.5	4	8.8	259.2	48.27	259.50
9	80.5	4.5	12.5	296.8	49.45	295.80

Table4.1 Response table for S/N ratio for Tensile Strength

Level	Resin	Chicken Feather	Carbon fiber
1	49.40	33.40	32.36
2	24.79	30.97	32.01
3	22.47	32.29	32.30
Delta	26.94	2.43	0.34
Rank	1	2	3

4.2 Main efforts plot for S/N ratio

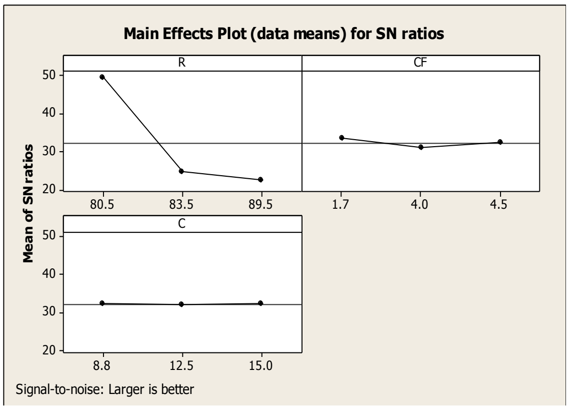

Fig 4 Main effect plot for S/N ratios

Main effects plot is used to examine differences between level mean for one or more factors. There is a main effect when different levels of factor affect the response differently. A main effect plot graphs the response mean for each factor level connected by a line.

4.3 Response Table for Means tensile strength

Level	Resin	Chicken feather	Carbon fiber
1	296.85	123.13	97.57
2	17.43	95.33	109.08
3	13.43	109.25	121.07
Delta	283.42	27.80	23.50
Rank	1	2	3

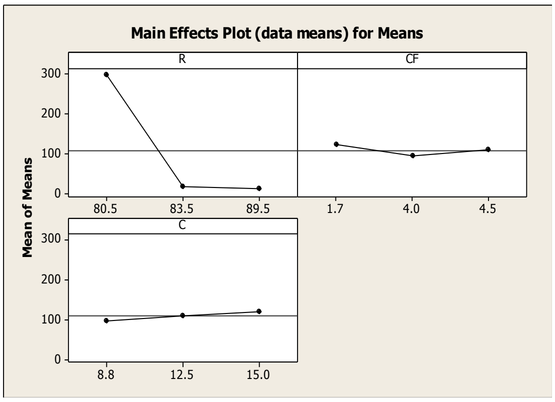

Fig 4.1 Main effects plot for mean

The normal probability plot is a graphical technique for assessing whether or not a data set is approximately normally distributed. The data are plotted against a theoretical normal distribution in such a way that the points should form an approximate straight line.

4.4 Analysis of variance (ANOVA) for tensile strength

Analysis of variance (ANOVA) is a collection of statistical models used to analyze the difference between group means and their associated procedures, in which the observed variance in a particular variable is partitioned into components attributable to different sources of variation. In order to find out statistical significance of vaious factors like fibre arrangement on tensile strength, analysis of variance (ANOVA) is performed on experimental data. Table shows the results of the ANOVA with the tensile test. The analysis is undertaken for 5% confidence level of significance.

Source	DF	Seg SS	Adj SS	Adj MS	F	S
Weight% of Resin	2	158415	158415	79207.3	192.85	0.005
Weight% of Chicken feather	2	1159	1159	579.6	1.41	0.415
Weight% of Carbon	2	828	828	414.2	1.01	0.498
Error	2	821	821	410.7		
Total	8	161224				

Table 4.4 Analysis of variance (ANOVA) for TS

4.5 Analysis of variance for tensile value of tensile test

Source	DF	Sum of Square	Mean sum of square	F cal	F table	% Contribution
Weight % Of resin	2	0.987612	1.01254	329.01	5.14	98.76
Weight % Of chicken Feather	2	0.007225	138.40816	2.406	5.14	0.722
Weight % Of carbon Fibre	2	0.005162	193.7231	1.719	5.14	0.518
Total	8	0.999999	333.1438	–	–	99.998

Error= 0.002%

Table 4.5 Analysis variance for tensile value

V. CONCLUSION

The experimental investigation on the effect of hybridization on tensile strength of chicken finer, carbon fiber, and epoxy resin composite leads to the following conclusions. The successful development and fabrication of a new class of epoxy based composite has been done by Taguchi’s design of experiments the optimum weight fraction for the hybrid composite is determined as 1.7.% chicken feather, 15 % carbon fiber and 83.5 % resin

The influence of carbon fiber is significant compared to chicken feather. The chicken feather is insignificant the carbon percentage is increase the tensile strength and (S/N) ratio also increases in which contain are 95% carbon and 5% chicken feathers fiber accomplished the further most yield strength

The increase in the tensile property is due to the increase the chicken fiber (1.7%) and carbon fiber (15%) the maximum tensile strength (334.2 MPa) The maximum (S/N) ratio is [50.48.]

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