ABRASIVE WEAR BEHAVIOUR OF BAMBOO-GLASS FIBER REINFORCED EPOXY COMPOSITES USING TAGUCHI APPROACH

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ABSTRACT

Recently hybrid composite are new emerging material. Hybrid composite materials are the material which contains two or more different types of fiber in which one type of fiber could balance with what are lacking in the other. Hybridization of natural fiber with stronger and high corrosion resistance synthetic fibers like glass can improve the various properties such as strength, stiffness etc. As an attempted, a set of epoxy based composites reinforced with both glass and bamboo fiber are fabricated. The goal of the present work is to study the physical and abrasive wear behaviour of the composites. To minimize the time, cost and mainly parametric analysis for abrasion wear characteristics Taguchi's experimental design is selected.

KEYWORDS: *glass fiber, bamboo, abrasive, taguchi*

I. INTRODUCTION

Replacing the heavy metal material with the polymer material reinforced with synthetic fibers such as glass, carbon, and aramid is a great achievement in the field of materials. Present generation researchers are focussing to reduce the utilization of traditional fillers and increase the utilization of bio waste natural fiber material. All shows interest in developing the new natural fiber instead of traditional fibers because of their low cost, combustibility, lightweight, low density, high specific strength, renewability, non-abrasivity, non-toxicity, low cost and biodegradability. Despite these advantages, the widespread use of natural fiber-reinforced polymer composite has a tendency to decline because of their high initial costs, their use in non-efficient structural forms and most importantly their adverse environmental impact. Still yet many challenges to overcome in order to become largely used as reliable engineering materials for structural elements. However, their use is steadily also increasing and many large industrial corporations are planning to use, or have yet commencing to use, these materials in their products [1].
Recently, a series of works have been done to replace the traditional synthetic fiber with natural fiber composites [2-6]. For a moment, hemp, sisal, jute, cotton, flax and broom are the most commonly fibers used to reinforce polymers like polyolefins [7, 8], polystyrene [9], and epoxy resins. To be more, fibers like sisal, jute, coir, oil palm, bamboo, wheat and flax straw, waste silk and banana [4, 5, 10-12] have proved to be good and effective reinforcement in the thermoset and thermoplastic matrices. Combination of traditional and natural fiber leads to hybrid composites.

Many researchers studied the tribological and mechanical properties of hybrid composites; they had also studied the erosion rate for different parameters in erosion test [13, 14].
Nayak et.al [15] studied on influence of short bamboo/glass fiber on the thermal, dynamic mechanical and rheological properties of polypropylene hybrid composites. Prasad et.al [16] studied on the tensile properties of bamboo and glass fibers reinforced epoxy hybrid composites. It was found that the hybrid composites exhibit good tensile properties.
To accomplish the accurately and constantly of the certain values of the abrasive rate, the parameters which influence of the process have to be controlled accordingly. As the number of input parameters is too large, statistical methods can be employed for precise identification of significant control parameters for optimization. Taguchi method has become a widely accepted methodology for reducing the time, cost number of experiments and improving efficiency. [17-19].
In the present investigation a new hybrid composite were prepared with a different volume fraction of glass and bamboo reinforced with a polymer epoxy were prepared. The characterization and the abrasive wear behaviour of the composite by using the taguchi approach.

II. MATERIALS AND METHODS

2.1. Specimen preparation

A New cylindrical discontinues Hybrid Composite pins are prepared with diameter of 10 mm by using high strength E-glass fiber and natural bamboo fiber with Epoxy as a matrix by using metal mold. Different set of composites are prepared those are given in table 1.the E-glass fiber, bamboo fiber and Epoxy possesses a density of 2.56 gm/cm3, 0.72 gm/cm3 and 1.1 gm/cm3 respectively. Composites were prepared by using resin to hardener ratio as 10:1. The different composites tested are given in table 1.

Table 1. Composite sequence and names.

Sl .no	Composite	Name eroded surface
1	C1	Epoxy
2	C2	Epoxy+bamboo10%+glass 10%
3	C3	Epoxy+bamboo20%+glass 20%

2.2. Abrasive wear test

Two-body abrasive wear tests were performed using a single pin-on-disc wear testing. Cylindrical samples which are fabricated by hand layup technique were tested under different testing conditions. Test samples were polishing to dimensions 10 mm diameter and 32mm length. The composite sample was abraded against the water proof silicon carbide (SiC) abrasive papers of 320 grit sizes at a different running speed of 0.837, 1.256 and 1.6752 m/s in multipass condition. Different types of loads applied in this test are 5, 10 and 15N. The abrasive wear rate was calculated by equation 1.

$$\boldsymbol{W} = \frac{\boldsymbol{w_a} - \boldsymbol{w}_b}{(\boldsymbol{\rho} \times \boldsymbol{S_d})} \tag{1}$$

'W' is the wear rate in cm3/m, 'w_a 'and 'w_b' are the weight of the sample after and before the abrasion test in gm 'ρ' is the density of the composite and 'S_d' is the sliding distance in m.

2.3. Taguchi method

Taguchi experimental design is an important tool for robust design. It offers a simple and systematic approach to optimize the design parameters because it can significantly minimize the overall testing time and the experimental costs. In this robust design, two major tools are used: signal to noise ratio (S/N), which measures quality with emphasis on variation and orthogonal array. The numbers of experiments are very high with all these parameters in order to reduce the time and cost a taguchi method L27 method is used. The abrasive wear and SN ratio results are shown in table 2.

Table 2. Experimental lay out and Abrasive test results.

Sl. no	Fiber content	load	Sliding velocity	Wear rate	SN ratio
1	0	5	0.837	0.0000149	96.536
2	0	5	1.256	0.0000160	95.918
3	0	5	1.675	0.0000238	92.468
4	10	10	0.837	0.0000132	97.589
5	10	10	1.256	0.0000164	95.703
6	10	10	1.675	0.0000217	93.271
7	20	15	0.837	0.0000085	101.412
8	20	15	1.256	0.0000107	99.412
9	20	15	1.675	0.0000136	97.329
10	10	15	0.837	0.0000160	95.918
11	10	15	1.256	0.0000184	94.704
12	10	15	1.675	0.0000218	93.231
13	20	5	0.837	0.0000072	102.853
14	20	5	1.256	0.0000082	101.724
15	20	5	1.675	0.0000143	96.893
16	0	10	0.837	0.0000199	94.023
17	0	10	1.256	0.0000216	93.311
18	0	10	1.675	0.0000258	91.768
19	20	10	0.837	0.0000096	100.355
20	20	10	1.256	0.0000110	99.172
21	20	10	1.675	0.0000127	97.924
22	0	15	0.837	0.0000570	84.883
23	0	15	1.256	0.0000645	83.809
24	0	15	1.675	0.0000713	82.938
25	10	5	0.837	0.0000136	97.329
26	10	5	1.256	0.0000121	98.344
27	10	5	1.675	0.0000222	93.073

2.4. Density

The density of composite materials in terms of volume fraction is found out from the following equations

$$s_{ct} = \frac{w_0}{(w_o) + (w_a - w_b)} \qquad (2)$$

Where 's_{ct}' represents specific gravity of the composite, W_0 represents the weight of the sample, W_a represents the weight of the bottle + kerosene; W_b represents the weight of the bottle + kerosene + sample.

$$\text{Density of composite} = S_{ct} * \text{density of kerosene} \qquad (3)$$

The density values are plotted in table 3.

Table 3. Density of different composites samples.

Sl .no	Composite	Density
1	C1	1.1
2	C2	1.336
3	C3	1.294

2.5. Micro-hardness

Micro-hardness of composite specimens is made using Leitz micro-hardness tester. A diamond indenter in the form of a right pyramid of a square base of an angle 136° between opposite faces under a load F is forced into the specimen. After removal of the load, the two diagonals of the indentation (X and Y) left on the surface of the specimen are measured and their arithmetic mean L is calculated.

The load considered in the present study is 24.54N and Vickers hardness is calculated using the following equation:

$$H_v = \frac{0.1889F}{L^2} \qquad \text{and} \qquad L = \frac{X+Y}{2} \qquad (4)$$

Where F is the applied load (N), L is the diagonal of square impression (mm), X is the horizontal length (mm) and Y is the vertical length (mm). The hardness values are plotted in table 4.

Table 4. Hardness of different composites samples.

Sl .no	Composite	hardness
1	C1	18.094
2	C2	20.85
3	C3	22.67

III. Results and Discussions

The density of the composites increases when the reinforcement is increases due to the glass density is more when compared to epoxy density still it is not increases to greater extent because the density of bamboo is less than the remaining two. The density of the 20% reinforced is less when compared to 10 % this may causes due to void content. The hardness values also increase with increasing in fiber content.

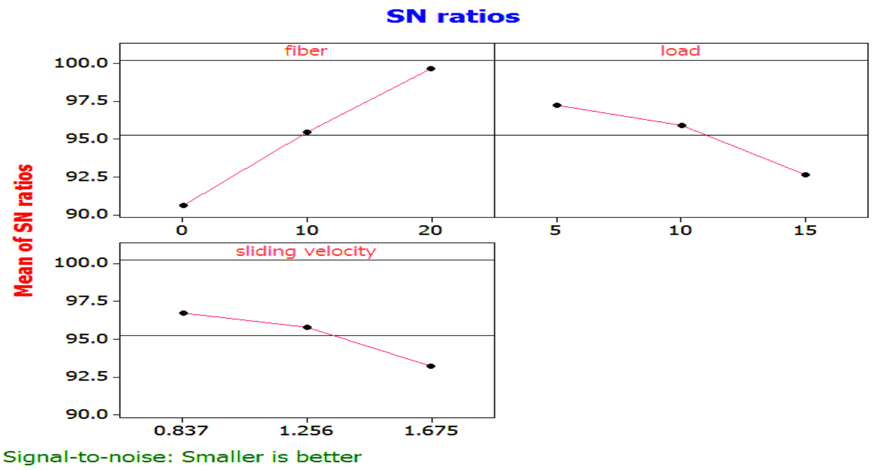

Figure 1. Main effects plot of S/N ratio for untreated coir fiber.

Table 5. Response table for S/N ration- smaller is better.

level	fiber	load	velocity
1	90.63	97.24	96.77
2	95.46	95.90	95.79
3	99.67	92.63	93.21
Delta	9.05	4.61	3.56
Rank	1	2	3

The calculated S/N ratio for three factors on the abrasive wear rate for hybrid composite for each level is shown in Figure 1. As shown in Table 5 and in figure 1 fiber is a dominant parameter on the abrasive wear rate. Based on the above discussion and also evident that the optimum conditions for the abrasive wear resistance are (a): 20 % fiber (b):5 load (c): 0.837 m/s velocity.

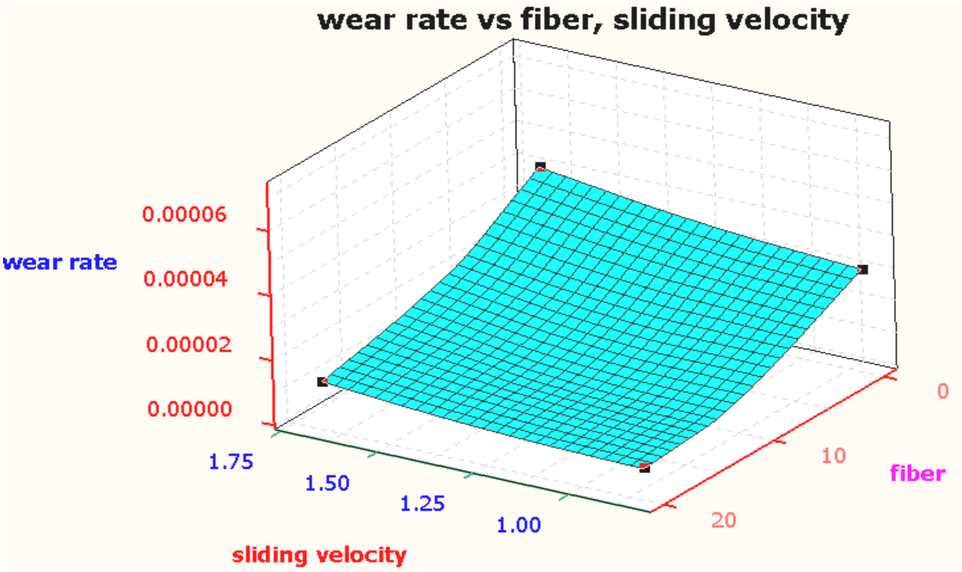

Figure 2. 3D surface graph of treated fiber abrasive wear rate Vs fiber and velocity.

Figure 2 shows the 3D graphs drawn for wear rate vs. fiber and sliding velocity. From the figure it is clear that the wear rate is more polymer composites without any reinforcement and also observed that as the reinforcing of glass and bamboo is increased the wear rate is decreased to a greater extent. It is also noticed that as the velocity increases the wear rate increases but more is observed only in the neat epoxy composites.

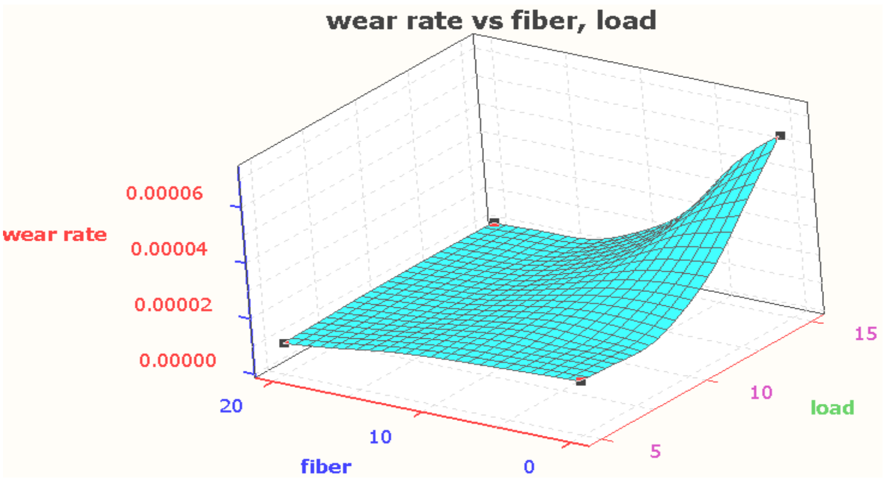

Figure 3. 3D surface graph of treated fiber abrasive wear rate Vs fiber and load

IV. CONCLUSIONS

Experiments were carried out to study the Abrasive wear behaviour of different composites of bamboo and glass fiber reinforced hybrid composite with silica sand abrasive paper. Based on the studies the following conclusions are made.

1. New hybrid cylindrical composites were successfully prepared.
2. The composite with 20% reinforced gives the best wear resistance when compared to
3. The density is more for the composite prepared with the 10%. The hardness is more for the composites prepared with the 20 % reinforced composites.
4. The wear increases with increasing in load and the maximum wear occurs at 15 N.
5. From the SN ratio taguchi analysis the fiber is the dominating factor for wear resistance.

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