Investigation in to Wear behavior of coir Fiber Reinforced Epoxy Composites with the Taguchi Method

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ABSTRACT

In present investigation the wear behavior of treated and untreated coir dust filled epoxy resin matrix composites were studied. The effect of treated and un treated coir dust concentration (10%, 20% and 30%), varying loads (10, 20 and 30N) and varying velocities (300, 400 and 500) on the abrasive wear rate of composite has been analyzed. The abrasive wear property of the composite is examined on a pin-on-disc machine against 400µm grit size abrasive paper with test. To minimize the experimental time and cost of investment taguchi method model L9 is selected. However, it is found that the treated fiber composite shows better wear resistance than the untreated fiber composites. Abrasive wear rate is decreased with increasing the coir dust amount. As the load increase the wear rate increases also observed similar trend also observed in velocities also.

Keywords - **coir fiber, taguchi method, abrasive wear, SN ratio**

I. INTRODUCTION

Composite materials are emerging chiefly because of unprecedental demand from technology due to rapidly advancing activities in aircraft, aerospace and automotive industry. These materials due to their low density, excellent stiffness and good thermal and mechanical properties are particularly superior to many traditional materials such as metals. Natural material which having great amount of carbon and cellulose which gives strength and good bonding which can easily replace the traditional filler in composite fields. Cellulosic fibers, like sisal, henequen, jute, oil palm, bamboo, wood paper in their natural condition, as well as, several waste cellulosic products such as shell flour, wood flour and pulp have been used as reinforcement agents of different thermosetting and thermo plastic resins[1],[2],[3] [4], [5], [6], [7], [8]. Natural fibers having the unique properties such as bio degradability, environmental friendliness, low cost, low density, high specific strength and so forth have shifted the focus of researchers from synthetic to natural fiber-reinforced polymer matrix composites.

Wear of composites is strongly influenced by the filler loading and operating parameters. Hashmit et al, [9] investigated the sliding wear behavior of cotton-polyester composites and obtained better wear properties on addition of cotton reinforcement. Tung et al, [10] studied the abrasive wear behavior of bamboo and reported that the abrasive resistance of a bamboo stem is affected by the vascular bundle fiber orientation with respect to the abrading surface and the abrasive particle size.

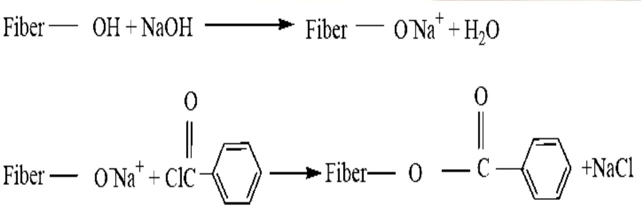
In order to achieve the accurately and repeatedly of the certain values of the erosion rate, the parameters which influence of the process have to be controlled accordingly. Generally such parameters are too large and the parameter-property correlations are not always known, statistical methods can be employed for precise identification of significant control parameters for optimization. In recent years the Taguchi method has become a widely accepted methodology for improving productivity. This methodology consists of a plan of a minimum number of experiments with the objective of acquiring data in a controlled way, executing these experiments, and analysing data, in order to obtain information about the behavior of a given process. One of the advantages is that optimum working conditions determined from the laboratory work can also be reproduced in the real production environment [11]. Precisely, Taguchi's design is a simple, efficient, and Systematic approach to optimize designs for performance, quality, and cost [12][13][14][15][16][17].

In the present work a new natural fiber composites were developed with treated and untreated coir natural bio waste material as reinforcement in to epoxy resin with different volume fraction and also the Taguchi experimental design method was adopted to investigate the specific wear rate. The wear rate was studied with the SN ratio graphs.

II. EXPERIMENT

2.1 **Fiber preparation:** In the present investigation treated and un treated coir fiber are used first the coir fibers were cleaned and dried in atmosphere for one day and then kept in oven at 50^0 c to remove the moisture.

2.2 **Benzoylation Treatment:** Benzoylation is an important transformation in organic synthesis (paul et al, 2003). Benzoyl chloride is most often used in fiber treatment. Benzoyl chloride includes benzoyl (C6H5C=O) which is attributed to the decreased hydrophilic nature of the treated fiber and improved interaction with the hydrophobic polymer matrix. The reaction between the cellulosic hydroxyl group of the fiber and benzoyl chloride is given as follows:



The pre-treated coir fibers were suspended in 10% NaOH solution and agitated with benzoyl chloride. The mixture was kept for 15 min, filtered, washed thoroughly with water and dried between filter papers. The isolated fibers were then soaked in ethanol for 1 h to remove the benzoyl chloride and finally was washed with water and dried in the oven at 80^0 C for 24 h.

2.3 **Preparation of composites:** Different amount treated and untreated fibers (10, 20, and 30 wt %) were added to the mixture of epoxy resin (Araldite LY556) and hardener (HY 951) of 10:1 ratio at room temperature. The above mixture was stirred for 10 min by a glass rod to obtain uniform dispersion of fiber and then poured into cylindrical mould. The upper and lower portions of the mold were fixed properly. Composite pins of length 35 mm and diameter of 10 mm were prepared by this process. The samples were kept in the moulds for curing at room temperature (29^0C) for 24 hr. Cured samples were then removed from the moulds and used for abrasive wear test.

2.4 **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 200, 300 and 400 rpm in multipass condition (Fig. 1). Different types of loads applied in this test are 10, 20 and 30N. The abrasive wear rate was calculated by equation 1.

$$W = \frac{w_a - w_b}{(\rho \times S_d)}$$

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

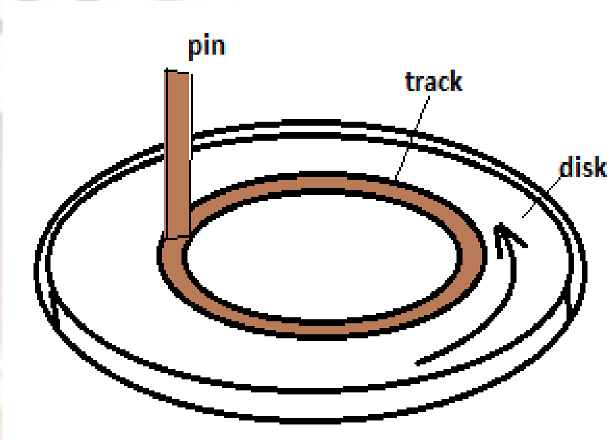


Fig 1. Multipass condition disc

The numbers of experiments are very high with all these parameters in order to reduce the time and cost a taguchi method L9 method is used for the abrasive wear which shown in table 1

Table 1. Experimental lay out and Abrasive test results

Sl. no	Fiber content	load	Rpm	Wear rate Un treated coir	Wear rate treated coir
1	10	10	200	0.0005940	0.0003150
2	10	15	300	0.0011560	0.0009270
3	10	20	400	0.0016000	0.0014910
4	20	10	300	0.0005100	0.0001500
5	20	15	400	0.0010210	0.0008610
6	20	20	200	0.0008520	0.0004920
7	30	10	400	0.0005912	0.0003822
8	30	15	200	0.0005392	0.0003402
9	30	20	300	0.0007123	0.0006033

The S/N ratio response analysis, presented in Table 2 shows that among treated and un treated coir composites the treated coir fiber gives maximum value of response when compared to un treated.

Table 2. S/N ratio of different test conditions

Sl. no	Fiber content	load	Rpm	SNRA Un treated	SNRA treated
1	10	10	200	64.5243	70.0338
2	10	15	300	58.7408	60.6584
3	10	20	400	55.9176	56.5304
4	20	10	300	65.8486	76.4782
5	20	15	400	59.8195	61.2999
6	20	20	200	61.3912	66.1607
7	30	10	400	64.5653	68.3542
8	30	15	200	65.3650	69.3653
9	30	20	300	62.9467	64.3893

III. Results and Discussion

Figure 2 illustrates the trend of erosion wear rate with different test conditions, as obtained in Table 1. By analyzing the figure it is clearly visible that the abrasive wear is less for the treated fiber material when compared to the UN treated fiber.

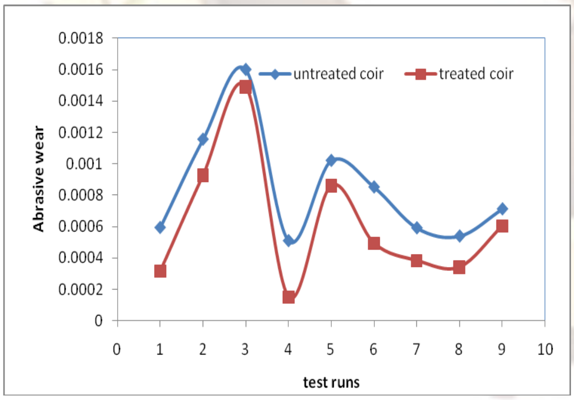


Fig.2 Abrasive wear VS Test runs

Figure 3 illustrates the trend of SN ratio with different test conditions in table 3. It is observed that the SN ratio of the treated coir reinforced composite is more when compared to untreated reinforced coir it shows that the best erosion resistance is shown by treated coir reinforced composite..

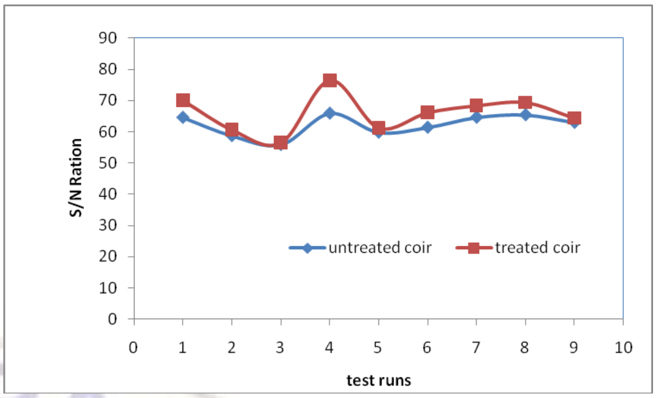


Fig 3 SN Ratio VS Test runs

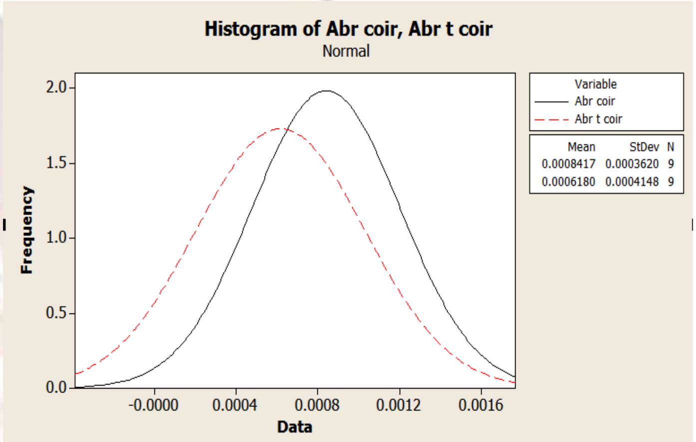


Fig 4 Histogram of both treated and untreated composites

From the fig 4 interpreting the results that the abrasive wear rate is very less compared to untreated coir fiber. This is indicated by the tabled means that the value for treated coir is very less compared to others (0.0006180),The standard deviation for other three (GS1, JS1 and JS2) are much greater than that of GS2 (0.00007560). This translates into a shorter and wider-looking fitted distribution for GS2.

IV. Conclusion

Wear performance treated and untreated coir fiber reinforced composites were determined experimentally by using the Taguchi experimental design method and the following conclusions were drawn:

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The treated and untreated coir successfully be utilized to produce composite by suitably bonding with resin for value added product.

In the initial investigation it is observed that the treated fiber gives the best wear resistance.

As the percentage of treated and untreated coir fiber increases the wear resistance also increases.

From the results of S/N ratio also it is observed that load is the domination factor for wear rate in both treated and untreated coir composites.

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