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Experimental Investigations on Tribological Properties of Glass-Jute Fibre Reinforced Hybrid Composites

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ABSTRACT: This paper presents the tribological properties of Glass-Jute Fibre reinforced with epoxy hybrid composites. The fabrication of these composites were carried out using hand layup process. Using Taguchi technique and Taguchi orthogonal array, the main effect plots for composite with 5% filler material and 10% filler material were plotted. The Analysis of Variance (ANOVA) values were also studied for composites with 5% and 10% filler material.

KEYWORDS: Glass Jute Fibre reinforced composites, Taguchi technique.

I. INTRODUCTION

Nowadays, composite materials are used in large number of engineering applications such as aviation, automobile and robotics due to versatility in their properties which enables them to be applied in large number of fields. Other reasons are their light weight, corrosion resistance and durability. Composite materials are commonly classified at following two distinct levels: The first level of classification is usually made with respect to the matrix constituent. The major composite classes include Organic Matrix Composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs). Polymer Matrix Composites (PMCs) and carbon matrix composites commonly referred to as carbon-carbon composites. The second level of classification refers to the reinforcement form - fibre reinforced composites, laminar composites and particulate composites. Fibers are the important class of reinforcements, as they satisfy the desired conditions and transfer strength to the matrix constituent influencing and enhancing their properties as desired. Glass fibers are the earliest known fibers used to reinforce materials. Hybrid polymeric composites are new and more developed composites as compared to the traditional fiber reinforced polymer composites. FRP composite contains on one reinforcing phase in the single matrix but hybrids can have more than one reinforcing phase and a single matrix phase or single reinforcing phase with multiple matrix phases or multiple reinforcing. [1]

II. OBJECTIVE OF THE PRESENT WORK

On the basis of the available literature following objectives were selected for this work

1. Fabrication of hybrid composites using hand lay-up process (glass fiber-jute fiber with filler material).
2. To study the influence of varying speed and load on wear rate of the hybrid composite using Taguchi method.

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III. MATERIALS AND METHODS

The materials [matrix and reinforcements] used in this present work are:

1. Glass Fibre
2. Jute Fibre
3. Epoxy
4. Coconut shell powder

The fabrications of composite slab are carried out by conventional hand layup technique. The bi-directional jute fibre and the E-glass fibres are used as reinforcement and epoxy is taken as matrix material. The low temperature curing epoxy resin and hardener are mixed in a ratio of 10:1 by weight percentage. Composites of different compositions like (without filler, 5 % filler and 10 % filler) are made. The cast of each composite is cured under a load of about 50 kg for 24 hours. Finally the specimens of suitable dimension are cut with the help of diamond indenter cutter in for characterization and testing.

IV. RESULTS AND DISCUSSIONS

A. Evaluation of Tribological Properties

The experiments conducted using a pin-on-disc machine against polished ES23 rotating steel disc. The tribological test was performed according to the ASTM G99 standard with constant applied load and sliding speed as shown in table 3.1.

Table 3.1 Process parameters with their values at 3 levels

Levels	Sliding speed, S in m/s	Load , L In N	Sliding distance, D in m
1	3	20	1000
2	4	40	2000
3	5	60	3000

Glass-Jute Fibre hybrid composites (Without filler material)

Table 3.2 Process parameters with their values at 3 levels

Experiment	Load in N	Speed in m/s	Sliding distance in m	S/N ratio COF	S/N weight loss
1	20	3	1000	11.21	60
2	20	4	2000	5.03	60
3	20	5	3000	7.43	55.9
4	40	3	2000	5.64	57.07
5	40	4	3000	5.40	51.05
6	40	5	1000	6.02	58.41
7	60	3	3000	6.92	52.04
8	60	4	1000	6.35	61.93
9	60	5	2000	6.09	64.43

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For S/N ratio COF

Table 3.3 Response table for S/N ratio smaller is better

Level	Load	Speed	Sliding distance
1	17.48	17.61	17.55
2	15.09	14.91	14.92
3	16.19	16.23	16.29
Delta	2.39	2.70	2.63
Rank	3	1	2

Table 3.4 Response table for means

Level	Load	Speed	Sliding distance
1	7.89	7.92	7.86
2	5.68	5.59	5.58
3	6.56	6.51	6.58
Delta	2.20	2.33	2.27
Rank	3	1	2

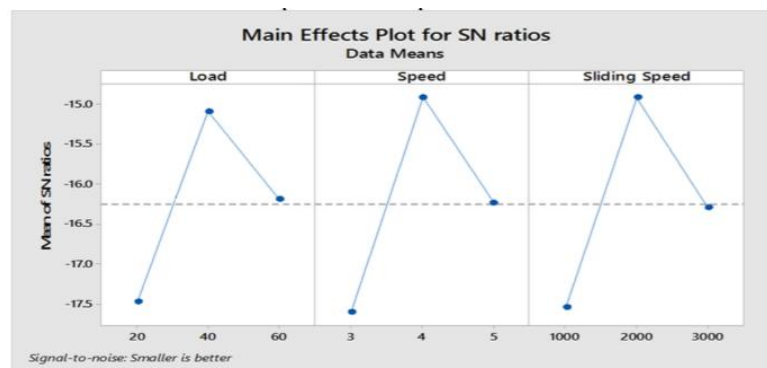


Fig 3.1 Main effect plot for SN ratios

Table 3.5 Analysis of Variance

Source	DOF	Adj SS	Adj MS	F-Value	P-Value
Load	2	7.50	3.75	1.92	0.342
Speed	2	8.28	4.14	2.12	0.320
Sliding distance	2	7.78	3.89	2.0	0.334
Error	2	3.90	1.95		
Total	8	27.48			

The experiments were conducted with an aim of relating the influence of sliding speed (S), applied load (L) and sliding distance (D) with dry sliding wear for the developed composites specimens. After performing the experiments as per Taguchi's experimental design, main effect plots for SN ratios for COF are plotted for without filler composite. Typical main effect plots of parameters with respect to COF are shown in Fig 3.1. It can be observed that for without filler material composite, load had maximum effect on COF, followed by sliding distance and speed respectively. From analysis of variance it can be seen that Load contributes 34.2%, followed by sliding distance 33.4% and speed 32%. for COF.

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For S/N Ratio Weight loss

Table 3.6 Response table for S/N ratio smaller is better

Level	Load	Speed	Sliding distance
1	35.36	35.01	35.58
2	34.87	35.19	35.62
3	35.45	35.49	34.48
Delta	0.58	0.48	1.15
Rank	2	3	1

Table 3.7 Response table for means

Level	Load	Speed	Sliding distance
1	58.64	56.37	60.11
2	55.51	57.66	60.50
3	59.47	69.58	53.00
Delta	3.96	3.21	7.50
Rank	2	3	1



Fig 3.2 Main effect plot for S/N ratios

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Table 3.8 Analysis of Variance

Source	DOF	Adj SS	Adj MS	F-Value	P-Value
Load	2	26.12	13.06	5.16	0.162
Speed	2	15.68	7.84	3.10	0.24
Sliding distance	2	106.99	53.50	21.16	0.045
Error	2	5.05	2.52		
Total	8	153.86			

Typical main effect plots of parameters with respect to weight loss are shown in graph 4.9 .It can be concluded that for without filler material speed had maximum effect on weight loss, followed by load and sliding distance. From ANOVA Load contributes 16.2%, followed by speed 24% and sliding distance 4.5%. At the medium values of the wear parameters matrix gets powdered and retains at the site of the fibers, consequently the breakage of the fibers also takes place at certain areas of the sample. Simultaneous accumulation of all the wear parameters at medium level contributes the overall weight loss.

Composite with 5% filler material

Table 3.9 Process parameters with their values at 3 levels

Experiment	Load	Speed	Sliding distance	S/N COF	S/N Weight loss
1	20	3	1000	11.21	60.91
2	20	4	2000	6.54	61.93
3	20	5	3000	8.17	60
4	40	3	2000	6.93	52.04
5	40	4	3000	7.95	53.15
6	40	5	1000	11.70	60
7	60	3	3000	7.95	60
8	60	4	1000	9.62	60.91
9	60	5	2000	6.19	64.43

For S/N ratio COF

Table 3.10 Response table for S/N ratio smaller is better

Level	Load	Speed	Sliding distance
1	18.52	18.60	20.69
2	18.73	18.00	16.32
3	17.83	18.48	18.09
Delta	0.89	0.613	4.35
Rank	2	3	1

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Table 3.11 Response table for means

Level	Load	Speed	Sliding distance
1	8.64	8.69	10.84
2	8.86	8.04	6.55
3	7.92	8.68	8.02
Delta	0.94	0.65	4.28
Rank	2	3	1

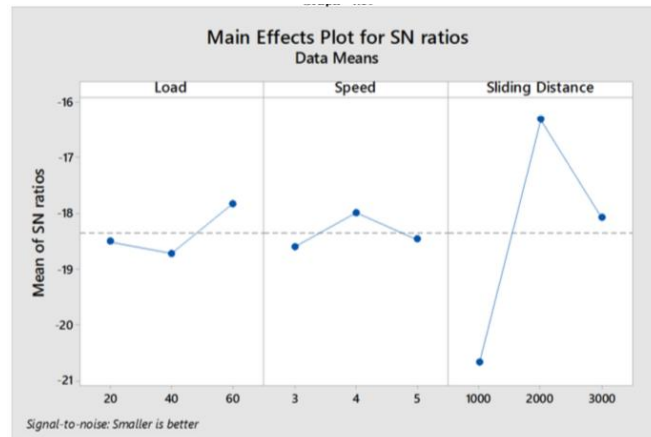


Fig 3.3 Main effect plot for S/N ratio

Table 3.12 Analysis of Variance

Source	DOF	Adj SS	Adj MS	F-Value	P-Value
Load	2	1.45	0.72	3.93	0.20
Speed	2	0.84	0.42	2.31	0.30
Sliding distance	2	28.647	14.23	77.44	0.013
Error	2	0.36	0.18		
Total	8	31.15			

Main effect plots of parameters with respect to COF are shown in tables for 5% filler material speed had maximum effect on COF, followed by load and sliding distance respectively. By ANOVA contribution of Load was 20%, sliding distance 30% and speed 1.3%.

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For S/N ratio weight loss

Table 3.13 Response table for S/N ratio smaller is better

Level	Load	Speed	Sliding distance
1	35.70	35.19	35.65
2	34.08	35.35	35.45
3	35.81	35.77	35.21
Delta	1.01	0.57	0.44
Rank	1	2	3

Table 3.14 Response table for means

Level	Load	Speed	Sliding distance
1	60.95	57.65	60.61
2	55.06	58.66	59.47
3	61.78	61.48	57.72
Delta	6.72	3.83	2.89
Rank	1	2	3

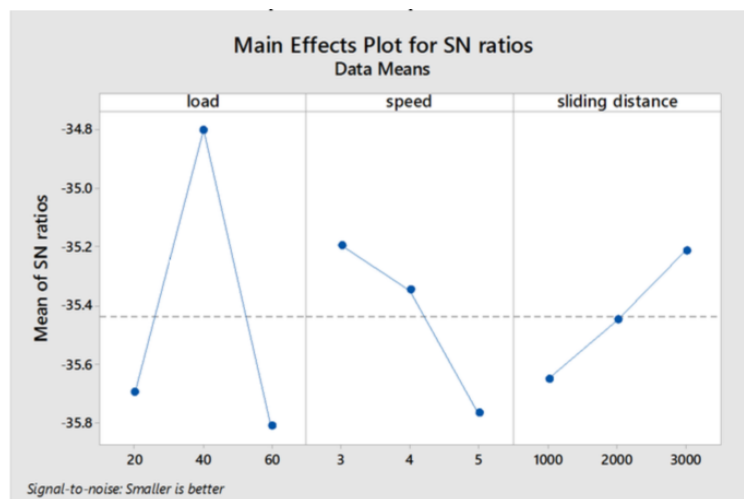


Fig 3.4 Main effect plot for S/N ratios

Table 3.15 Analysis of Variance

Source	DOF	Adj SS	Adj MS	F- Value	P- Value
Load	2	80.42	40.21	5.88	0.145
Speed	2	23.59	11.79	1.72	0.36
Sliding distance	2	12.71	6.35	0.93	0.51
Error	2	13.69	6.84		
Total	8	130.41			

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Typical main effect plots of parameters with respect to COF and weight loss are shown in figures. For 5% filler material sliding distance had maximum effect on weight loss, followed by speed and load respectively. By ANOVA Load contributes 14.5%, followed by sliding distance 51% and speed 36% respectively.

Composite with 10% filler material

Table 3.16 Process parameters with their values at 3 levels

Experiment	Load	Speed	Sliding distance	S/N ratio COF	S/N ratio Weight loss
1	20	3	1000	11.21	64.43
2	20	4	2000	5.27	64.43
3	20	5	3000	5.43	52.04
4	40	3	2000	10.75	60
5	40	4	3000	6.69	52.76
6	40	5	1000	6.69	60.91
7	60	3	3000	8.17	61.93
8	60	4	1000	7.11	66.02
9	60	5	2000	8.92	67.95

For S/N ratio COF

Table 3.17 Response table for S/N ratio smaller is better

Level	Load	Speed	Sliding distance
1	16.71	19.95	18.88
2	17.88	15.99	18.02
3	18.10	16.74	16.48
Delta	1.39	3.96	1.70
Rank	3	1	2

Table 3.18 Response table for means

Level	Load	Speed	Sliding distance
1	7.30	10.04	8.33
2	8.04	6.35	8.31
3	8.06	7.01	6.76
Delta	0.76	3.68	1.57
Rank	3	1	2

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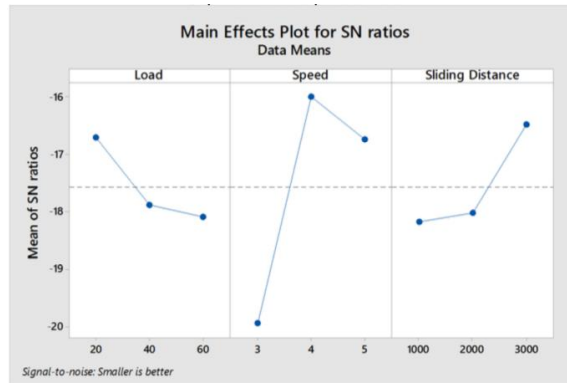


Fig 3.5 Main effect plot for S/N ratio

Table 3.19 Analysis of Variance

Source	DOF	Adj SS	Adj MS	F- Value	P- Value
Load	2	1.131	0.57	0.15	0.66
Speed	2	23.20	11.60	3.11	0.24
Sliding distance	2	4.87	2.43	0.65	0.05
Error	2	7.46	3.73		
Total	8	36.68			

Main effect plots of parameters with respect to COF is shown in tables, for 10% filler material load had maximum effect on COF, followed by sliding distance and speed respectively. By ANOVA Load contributes 66%, followed by sliding distance 5% and speed 24% as per previous cases.

For S/N ratio weight loss

Table 3.20 Response table for S/N ratio smaller is better

Level	Load	Speed	Sliding distance
1	35.56	35.86	36.09
2	35.23	35.67	36.13
3	36.29	35.55	34.87
Delta	1.06	0.31	1.26
Rank	2	3	1

Table 3.21 Response table for means

Level	Load	Speed	Sliding distance
1	60.30	62.12	63.79
2	57.89	61.07	64.13
3	65.30	60.30	55.58
Delta	7.41	1.82	8.55
Rank	2	3	1

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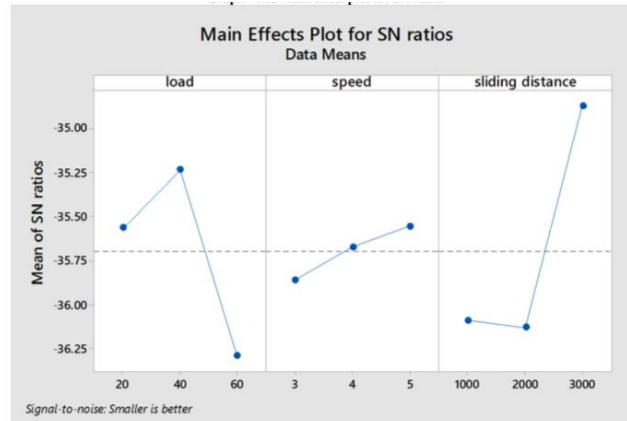


Fig 3.6 Main effect plot for S/N ratio

Table 3.22 Analysis of Variance

Source	DOF	Adj SS	Adj MS	F- Value	P- Value
Load	2	85.71	42.85	5.53	0.153
Speed	2	5.00	2.50	0.32	0.756
Sliding distance	2	140.62	70.31	9.07	0.099
Error	2	15.49	7.74		
Total	8	246.85			

Typical main effect plots of parameters with respect to weight loss is shown in tables. It can be concluded that for 10% filler material speed had maximum effect on weight loss, followed by load and sliding distance respectively. By ANOVA Load contributes 15.3% , followed by speed 75.6% and sliding distance 9.9% respectively.

V. CONCLUSIONS

The present study has been carried out using simple hand lay-up technique. However, the research work can be extended further by considering other methods of composite fabrication and the effect of manufacturing techniques on the performance of composites can similarly be analyzed. Besides many advantages of natural fibers, the main disadvantages of natural fibers in composites are the poor compatibility between fiber and matrix and the relative high moisture absorption due to their hydrophilic nature. Therefore, this study can be extended further by considering the chemical treatments in modifying the fiber surface properties to improve the adhesion between fiber and matrix materials.

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