

FRICITION AND DRY SLIDING WEAR BEHAVIOR OF RED MUD FILLED BANANA FIBRE REINFORCED UNSATURATED POLYESTER COMPOSITES USING TAGUCHI APPROACH

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Abstract. This present article describes the effect of red mud filler on wear responses of banana fiber reinforced unsaturated polyester composites. Banana fiber treated NaOH and untreated were taken for the wear studies as reinforcement along with unsaturated polyester and red mud. Red mud, polyester and banana fiber of different weight proportions were taken by keeping the fiber length as fixed (30 mm) which is optimal ones. Compression molding technique is used for preparing the specimens. Wear studies were carried out by using a pin-on-disc wear tester for the specimens prepared as per ASTM standard. Taguchi design of experiments with L9 orthogonal array is used to optimize the parameter with respect to sliding velocity, load and sliding distance.

1. Introduction

Wear is related to interactions between surfaces and more specifically the removal and deformation of material on a surface as a result of mechanical action of the opposite surface. The addition of ceramic fillers along with polyester matrix composites posses better results, the drawback involved in that is the costs involved, to avoid this issue composites are developed by using waste materials as reinforcement and reported that the compatibility of red mud with polyester is fairly good the usage of red mud along with polyester is justified [1].

Suresha et.al. reported that increase in sliding velocity/load increased the sliding wear loss. In particular, from the tests conducted the sliding wear behavior of 10 wt.% graphite filled glass epoxy composites are better compared to unfilled and lower graphite filled carbon fiber reinforced epoxy composites [2].

Unal et. al. reported for pure polytetrafluoroethylene (PTFE) and its composites where with load increases the friction coefficient decrease. In case of wear rate maximum reductions happened for the case of glass fibre with weight percentage 17 % reinforced PTFE. Also it is reported that adding fillers such as carbon and bronze along with PTFE found to be better in reducing wear rate [3].

Wear studies on polyester resin filled with ZnO nano particles were carried out by Nagaraju et.al. It is strongly proved that the addition of filler graphite improves the wear resistance to a much greater extent along with glass fibre reinforced epoxy composites when compared with other sample combinations [4, 5].

Vishwanath et al reported about wear studies on both polyester and phenolic reinforced glass fibre composites. It is observed that in both case of composites 30 wt.% of resin gives low wear and coefficient of friction, also with resin beyond 30 wt.% results in high wear rate [6].



Fig. 2. Wear specimens.

A pin-on-disc test setup was used for slide wear experiments. The surface of the sample comes in contact with a hardened disc of hardness 62 HRC. The counter surface disc was made of EN 32 steel having dimensions of 165 mm diameter, 8 mm thick and surface roughness (Ra) of 0.84 μm . The test was conducted on a track of 100 mm diameter for a specified test duration, load and velocity. The specimen was initially weighed using a digital electronic balance (0.1 mg accuracy). The test was carried out by applying normal load (10, 20, 30 N) and run for a constant sliding distance (3000 m) at constant sliding velocity (3 m/s). At the end of the test, the sample was again weighed. The difference between the initial and final weights was a measure of weight loss.

2.3. Experimental design using Taguchi's technique.

2.3.1 Eight steps in Taguchi methodology.

Step-1: Identify the main function, side effects, and failure mode.

Step-2: Identify the noise factors, testing conditions, and quality characteristics.

Step-3: Identify the objective function to be optimized.

Step-4: Identify the control factors and their levels.

Step-5: Select the orthogonal array matrix experiment.

Step-6: Conduct the matrix experiment.

Step-7: Analyze the data, predict the optimum levels and performance.

Step-8: Perform the verification experiment and plan the future action.

There are three Signal-to-Noise ratios of common interest for optimization of Static Problems. Taguchi's Signal-to-Noise ratios (S/N), which are log functions of desired output, serve as objective functions for optimization, help in data analysis and prediction of optimum results.

(1) Smaller-the-better:

$$n = -10 \text{Log}_{10} [\text{mean of sum of squares of measured data}].$$

This is usually the chosen S/N ratio for all undesirable characteristics like “defects“ etc. for which the ideal value is zero. Also, when an ideal value is finite and its maximum or minimum value is defined then the difference between measured data and ideal value is expected to be as small as possible.

The generic form of S/N ratio then becomes

$$n = -10 \text{Log}_{10} [\text{mean of sum of squares of \{measured - ideal\}}].$$

(2) Larger-the-better:

$$n = -10 \text{Log}_{10} [\text{mean of sum squares of reciprocal of measured data}].$$

orthogonal array L9 layout is chosen. The corresponding process parameters and the cycle of experiment is presented in Table 2.

3. Results and discussions

3.1. Wear results of untreated banana fibre composites. Specific wear rate for red mud filled untreated banana fiber composite is shown in Fig. 3. Specific wear rate result shows that 30 % weight fraction of fiber with 10 % of red mud having lower wear rate and higher wear resistance at 10N, 20 N load compare to 40% weight fraction of fiber without red mud. Condition of without and 10 % of red mud at 10 N loading shows decrease in specific wear rate decrease from 3.1×10^{-5} to 2.5×10^{-5} and applying the load of 20 N wear rate decrease from 2.4×10^{-5} to 2.0×10^{-5} , same combination at load of 30 N wear rate increase from 2.5×10^{-5} to 3.6×10^{-5} . Addition of 20 % and 30 % red mud composites wear rate increase compare to the 10 % and without red mud composites.

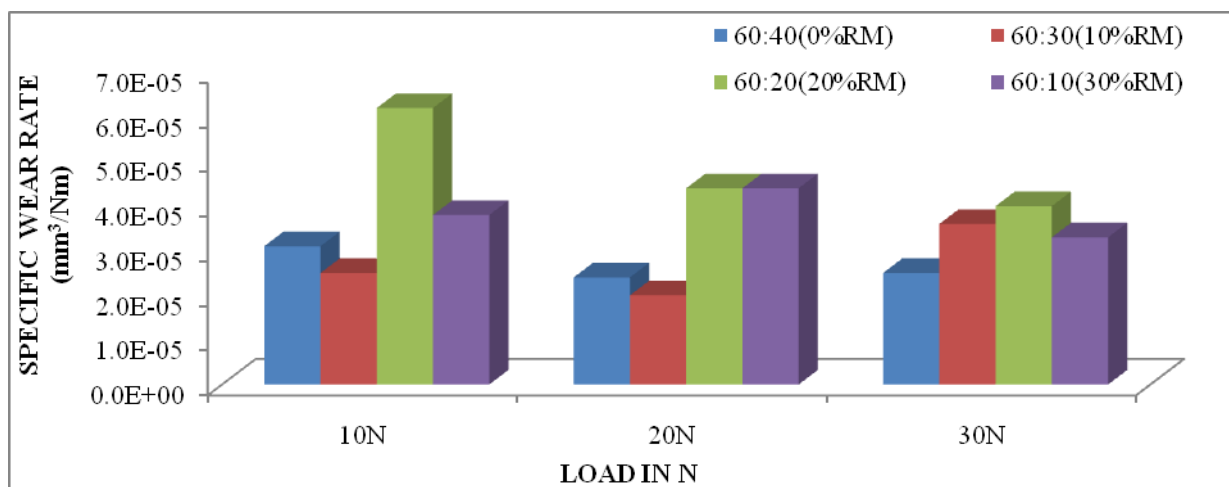


Fig 3. Specific wear rate for untreated banana fiber composites.

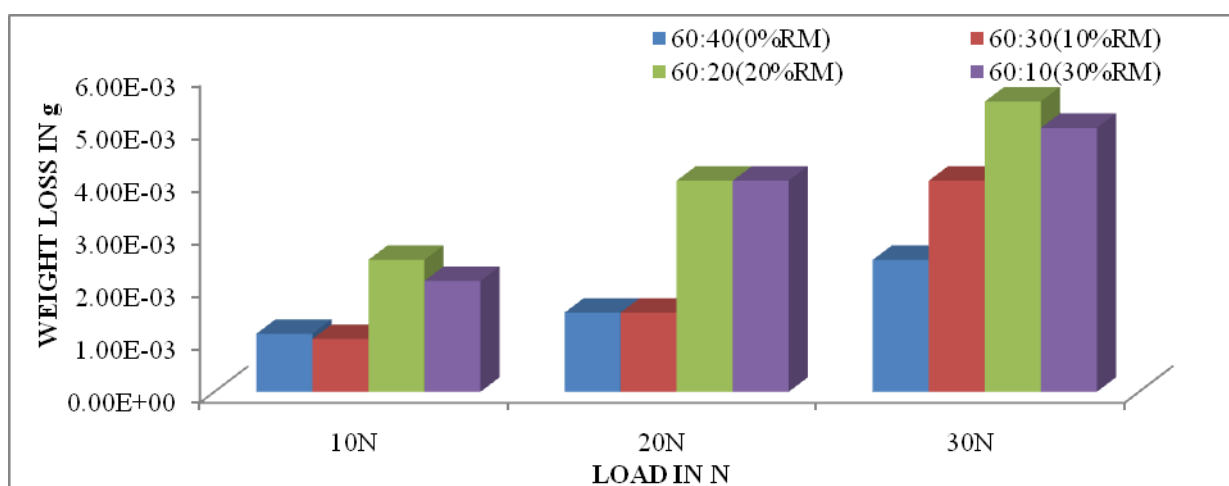


Fig. 4. Weight loss for untreated banana fiber composites.

Weight loss for untreated banana fiber composite is shown in Fig. 4.

The weight loss result shows that increasing weight loss depends on the increasing load and addition of red mud content.

Coefficient of friction for untreated banana fiber composites is shown in Fig. 5.

The weight loss result shows that increasing weight loss depends on the increasing load and addition of red mud content 10 % weight fraction of fiber with 30 % red mud composite having more material loss due to more amount of red mud.

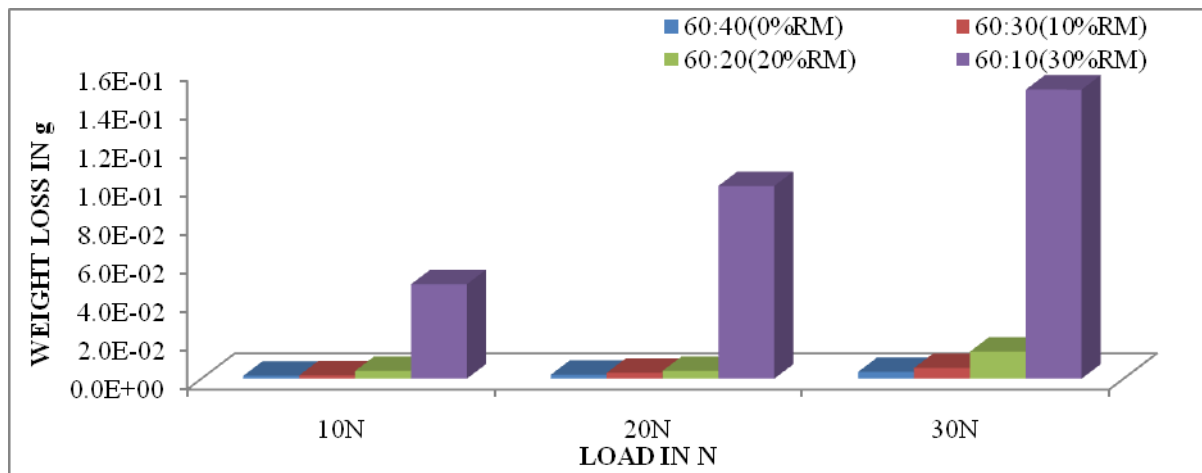


Fig. 7. Weight loss for NAOH treated banana fiber composites.

Coefficient of friction for NAOH treated banana fiber composites is shown in Fig. 8. Result shows that applying load of 10 N and 30 N the coefficient of friction increasing from 0.1 to 0.6 conditions of 40 % of fiber without red mud filler. Addition of more and more red mud filler at different load increases the coefficient of friction gradually.

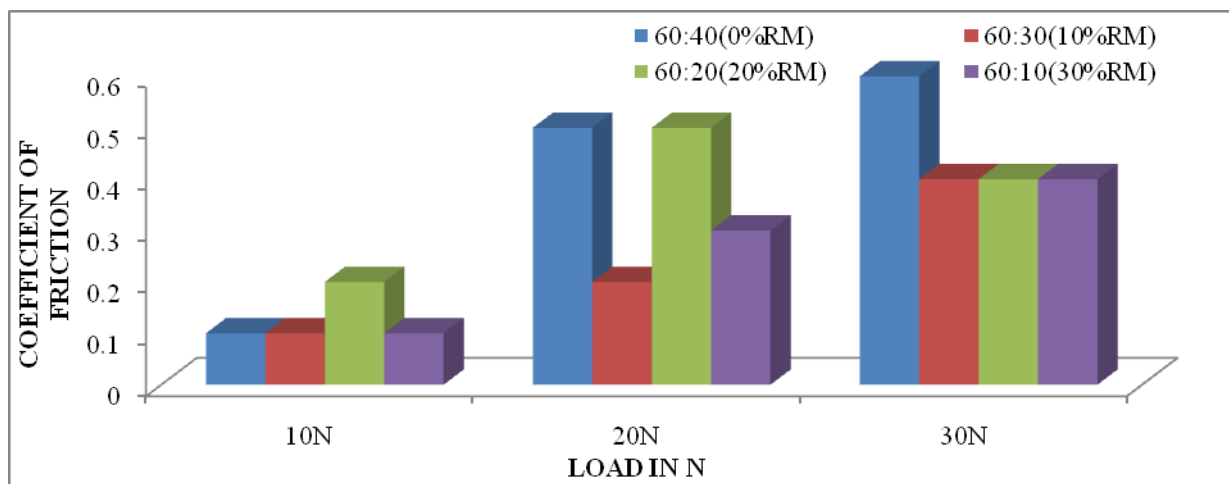


Fig. 8. Coefficient of friction for NAOH treated banana fiber composites.

Comparison of specific wear rate for untreated and NAOH treated banana fiber composites is shown in Fig. 9. Comparative study of wear rate indicates the 40 % weight fraction of NAOH treated fiber without red mud different loading condition increasing wear rate compare to 40 % weight fraction of untreated fiber. Untreated treated fiber weight of 30 % reinforcing with 10 % of red mud having low wear rate and achieving higher wear resistance property compare to 30 % of NAOH treated fiber with 10 % of red mud composites and other composite combinations.

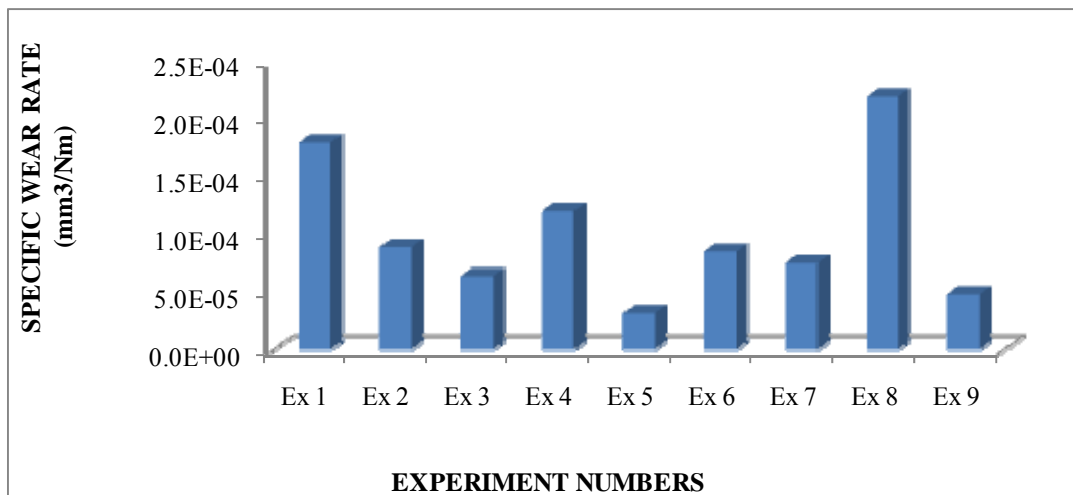


Fig. 10. Specific wear rate for L9 experiment.

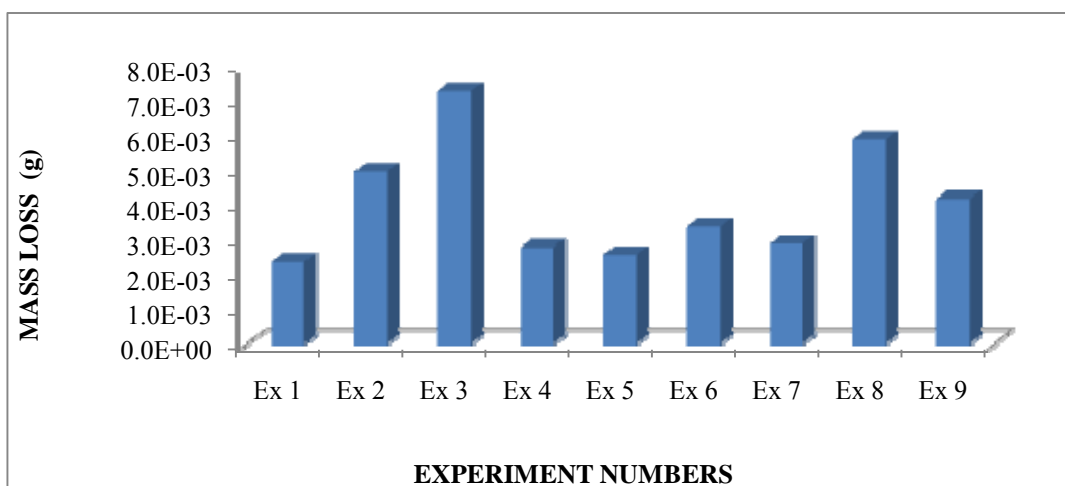


Fig. 11. Mass loss for L9 experiment.

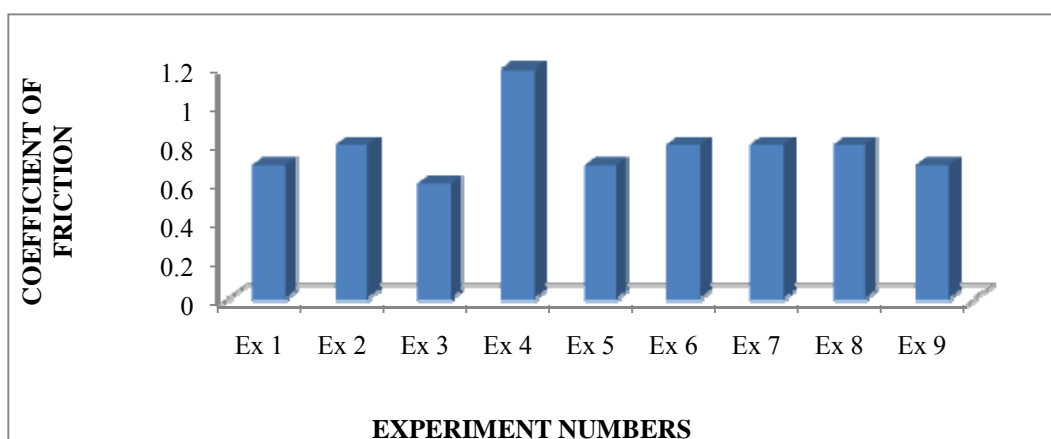
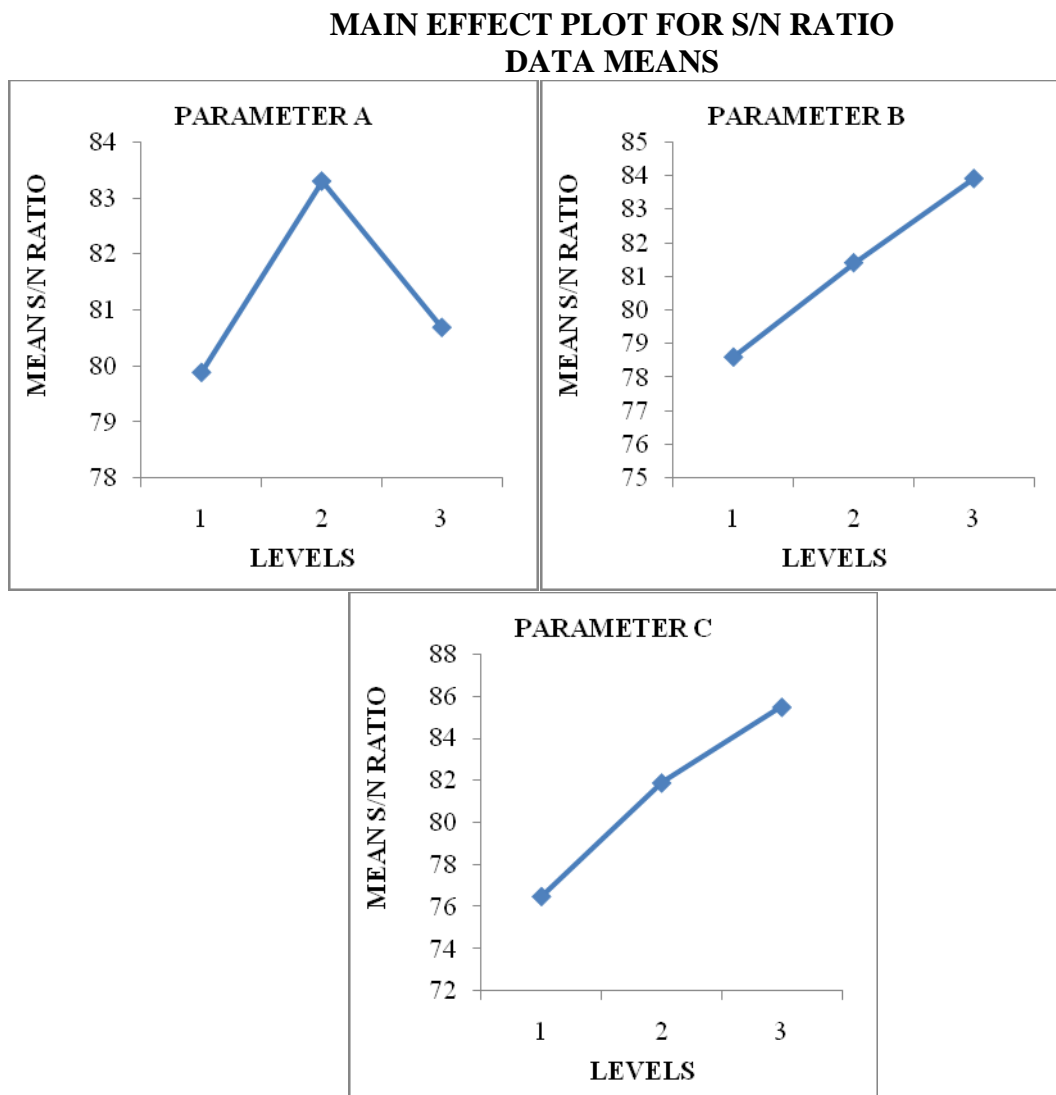


Fig. 12. Coefficient of friction for L9 experiment.

Experiment no five enhance the lower wear rate than other combination of experiment. The computation of variation using L9 orthogonal array for wear rate is shown in Table 4.

Average S/N ratio for control factors is shown in Fig. 14. The maximum values of average S/N ratio are the optimum values for the parameters. Identify the optimum parameters to get enhanced smaller wear rate.



SIGNAL TO NOISE: SMALLER IS BETTER

Fig. 14. Average S/N ratio for control factors.

4. Conclusions

This experimental and investigation on the reinforcement of red mud filled Banana polyester treated / untreated composites lead to the following conclusions:

Banana fiber reinforced polyester composites filled with red mud was made successfully by simple compression moulding technique.

An industrial waste like red mud can also be gainfully utilized for the composite making purpose. Incorporation of these fillers modifies the wear strength of the composites.

In dry sliding wear test shows that the 10 % red mud filler on 30 % weight fraction of untreated / NAOH treated fiber having low wear rate at load of 10 N only and condition of 3 m/s sliding velocity, 3000 m sliding distance.

Design of experiments approach by Taguchi method enabled to analyze successfully the wear behaviour of composites with load, sliding distance, sliding velocity as test variables.

Found that optimum parameters for wear test are 4 m/s sliding velocity, load of 30 N and 3000 m sliding distance.

Environmental pollution related issues are minimized drastically by consuming the red mud for the useful composite fabrication

Acknowledgements

The authors submit their thanks to the Centre for Composite Materials, Kalasalingam University for providing facilities to carry out this work.

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