

Dry Sliding Wear of Teak Wood -Epoxy Composites

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Abstract

Composites of 10, 15 and 20% weight fractions of teak wood saw dust in epoxy matrix have been developed with 150,212 and 300 μm particle sizes. Attempt has been made in the present investigation to find out the wear characteristics of such composites while sliding against steel counterpart for a longer period. Pins of 8 mm diameter and length of 25 mm have been cast in house with the help of a die. In the long run tests after sliding for 15 km the lowest wear was observed with composite of 300 μm size and 10% wood dust filled composite though lower wear rates were also observed with 150 and 212 μm size wood dust composites with 15% filler. After comparison it has been concluded that 300 μm size dust filled composite is a better choice for frictional applications.

Keywords: Teak wood dust, Epoxy, Composite, Wear Tests

1. Introduction

Materials of light weight, high strength, easy to manufacture and environment friendly are gaining importance for wide use in various engineering applications. To cite a few are materials for infrastructure development. automotive applications, household gadgets, space and rocketry engineering, furniture and fittings etc . Other than such usage environmental impact like pollution and human safety has urged the researchers to find out alternate materials. Development of composite material specifically reinforced plastic composites has made a significant contribution in this regard since last few decades. However natural fibre reinforced composite has carved an important place made out of waste of organic materials. In this context composites prepared out of wood waste such as saw dust has been considered to replace artificial fibre reinforced composites owing to its eco friendly nature and reasonably sound mechanical properties. Therefore an attempt has been made in this investigation to fabricate composites using teak wood saw dust as a filler

material with varying weight percentages and grain sizes in epoxy matrix. The wear characteristics of these materials must be investigated for use in brake linings in automotives, traction, domestic appliances or such other use for frictional applications. In the present work long run wear tests have been carried out after developing teak wood dust filled epoxy composites sliding against steel counterpart. The best out of these materials is to be found out for frictional use.

2. Review of literature

In the literatures, many works devoted to the properties of natural fibres from micro to nano scales are available. A number of investigations have been conducted on several types of natural fibres such as kenaf, hemp, flax, bamboo, and jute to study the effect of these fibres on the mechanical properties of composite materials. Abrasive and sliding wear tests were carried out by (Dwivedi and Chand, 2008) for wood flour epoxy composites with varying weight fractions of wood flour. Composites containing 40 Wt % of wood flour exhibited lowest specific wear rate in abrasive wear mode where as composite with 20 Wt % of wood showed lowest wear in sliding mode. It was observed that specific wear rate of all the composites decreased with increasing load in sliding wear mode. (Kranthi et al., 2010) studied the wear performance of a new class of epoxy based composites filled with pine wood dust. According to the study pine wood dust possesses good filler characteristics as it improves the sliding wear resistance of polymeric resin. The filler content, sliding velocity and normal loads are important factors which affect the specific wear rate. A study on the dry sliding wear of oil palm empty fruit bunch (OPEFB) epoxy composite was done by (Kasolang et al., 2011). The result showed that the mass loss was significantly higher for smallest fibre size (100 μ m) examined at 30N load and at other fibre sizes, the mass loss values were relatively close depending on the distribution and orientation of fibres. Artificial neural network and design of experiment method were used by (Vafaenezhad et al. , 2012) to analyze the wear performance of carbonized oak tree wood with epoxy as reinforcement. Wood pyrolysis was carried out at different temperatures ranging from 400⁰C to 550⁰C to produce carbonized matrix. After infiltration of epoxy into the porous areas, the samples were made for sliding wear tests. Significant improvement was observed in the sliding wear resistance of carbon matrix. (Chandra Rao et al., 2012) studied the wear of coir fibre (10, 20 and 30 %) reinforced epoxy composites at varying velocities and load. It was found that the abrasive wear rate decreases with increase in coir concentration where as increases with increase in load and velocities. Taguchi method was also employed to minimize the time of experiment and validate the results. (Majhi et al. , 2012) conducted experiments with rice husk filled epoxy composites in pin-on-disc machine to determine the abrasive wear rates. It was observed that with addition of 10 % filler the abrasive wear rate was the lowest. However the wear rate decreases with increase in sliding distance and attains steady state in multipass

condition. The effects of the tribological operating parameters (applied load, sliding velocity and sliding distance) on the frictional and wear performance of natural fibre polymer composites were demonstrated by (Shalwan and Yousif , 2012). The collected data and analyses revealed that volume fraction, orientations, type of treatment and physical characteristics of the natural fibres significantly influence the mechanical and tribological behaviour of composites. Frictional characteristics of the natural fibre composites are poor and solid lubricants are recommended to reduce the friction coefficient of the materials. (Mishra, 2014) investigated the friction and wear characteristics of teak wood dust filled epoxy composites of three different types of specimens. It was observed that wood dust filled with 10 % of 300 μm size composite has exhibited better wear performance. The tensile, flexural and erosive wear resistance tests were conducted by (Ojha et al. , 2014) for epoxy matrix composites incorporated with 5, 10, 15, and 20 wt% of wood apple shell particles. It was clearly observed that the incorporation of wood apple shell particles tends to increase the tensile strength, flexural strength, erosive wear resistance, and viscoelastic stiffness of the polymer composite. Further (Mishra 2014) concluded that composite filled with 10 % wood dust of 150 μm size showed better wear resistance for a sliding distance of 5km. Under above circumstances it is felt that long run tests are required for precisely evaluating the wear characteristics of such composites.

3. Theoretical investigations

The properties of teak wood dust and epoxy were taken from the earlier work [11] as indicated in Table 1 and 2. The density, strength and elastic modulus for different grain sizes of wood dust were calculated by rule of mixture shown in Table 3, 4 and 5.

Table .1 Properties of Teak wood dust

Properties	Value
Density (g/cc)	0.8
Young's modulus of elasticity (GPa)	10.5
Tensile Strength (MPa)	95

Table.2 Properties of Epoxy

Properties	Value
Density (kg/m^3)	1200
Youngs modulus of elasticity (GPa)	20

Tensile Strength (MPa)	75
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Table 3 Composite properties- 150 micron size wood dust

Specimens	Density(kg/m ³)	Elastic Modulus(GPa)	Tensile strength (MPa)
Sp-1(10%)	1185	19.6	75.6
Sp-2(15%)	1177	19.4	76.0
Sp-3(20%)	1169	19.2	76.5

Table 4. Composite properties – 212 micron size wood dust

Specimens	Density(kg/m ³)	Elastic Modulus(GPa)	Tensile strength (MPa)
Sp-1(10%)	1186	19.7	75.6
Sp-2(15%)	1178	19.5	76.0
Sp-3(20%)	1172	19.3	76.6

Table 5. Composite properties – 300 micron size wood dust

Specimens	Density(kg/m ³)	Elastic Modulus (GPa)	Tensile strength (MPa)
Sp-1(10%)	1185	19.7	75.7
Sp-2(15%)	1184	19.6	75.6
Sp-3(20%)	1171	19.3	76.4

Sp-1, Sp-2 and Sp-3 refers to specimens of three different compositions.

It is observed that the density, elastic modulus and strengths are decreasing with increase in filler content for all types of specimens. Hardly there is much difference in these properties with variation in sizes of wood dust.

4. Experimental Procedure

The teak wood dust has been collected from M/s Sharma Furnitures at Bhubaneswar, Odisha, India. The three different sizes of the dust i.e. 150, 212 and 300 μm were found out by sieve shaker. A metallic die has been developed in house by machining aluminium block for casting pins of 8 mm diameter and 50 mm length. After proper mixing in 10, 15 and 20% by weight for all the three grades of wood dust with epoxy, the mixture has been poured to the mould cavity and allowed to cure at room temperature for 24 hours. The pins so produced were taken out from the mould and cut to 25 mm length for clamping in the pin on disc friction monitor to conduct sliding tests against steel disc. These test pieces have been shown in Fig.1.



Figure 1: Samples of composite pins [12]

The tests were carried out in Pin on disc wear and friction testing machine (Fig.2 and 3) supplied by M/s Magnum Engineers, Bangalore, India, having the following specifications:

Load range- Up to 100 N, friction force measurement- up to 100 N, wear measurement- 2000 μm or +/- 2mm, sliding speed – 0.26 to 10 m/s, disc speed – 100-2000 rpm, diameter of track – 40-90 mm, disc size- 100 dia and 8 mm thk, disc material – EN-31(58-60 RC), pin – 3-10 mm dia and length – 25 mm, Software- MAGVIEW-2011 data acquisition software. For evaluation of friction coefficient under dry sliding condition the speed and time were kept constant i.e 1000 rpm and 3 minutes with varying the load up to 50 N. Similarly for estimating the wear , the pins were slid against mild steel disc for 15 km of sliding distance keeping the speed at 1000 rpm and load of 50 N.



Figure 2: Pin on disc friction monitor

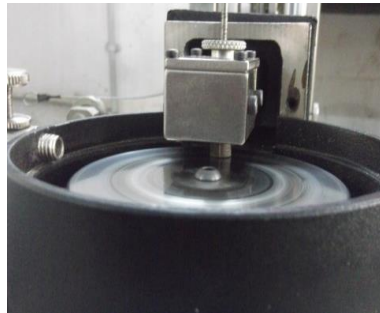


Figure 3: Close up view of the tests

5. Results and discussion

The variations of coefficient of friction against load at constant speed and time have been plotted in Fig.4 to 6 for 150, 212 and 300 μm sizes of wood dust composites. Further long run test results in terms of wear of composite pins have also been shown in Fig. 7 to 9. The friction force, speed at each set of experiment have been recorded from the control panel of the monitor. The timer has been set accordingly. The sliding distances were calculated by knowing the track diameter and speed of rotation of the disc.

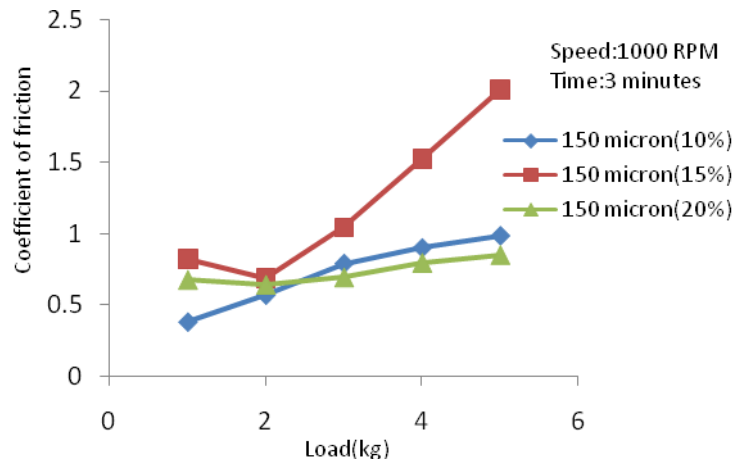


Figure 4: Variation of coefficient of friction with load (150 μm wood dust)

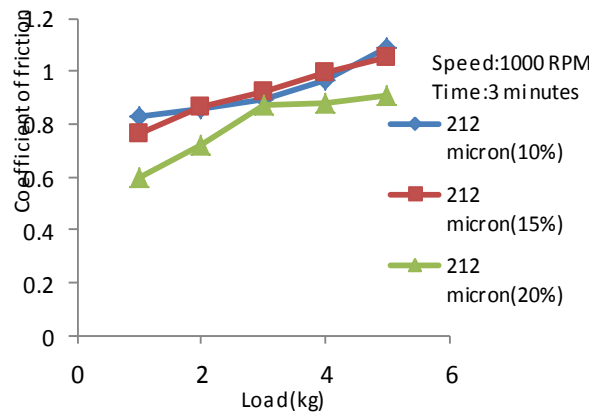


Figure 5: Variation of coefficient of friction with load (212 μm wood dust)

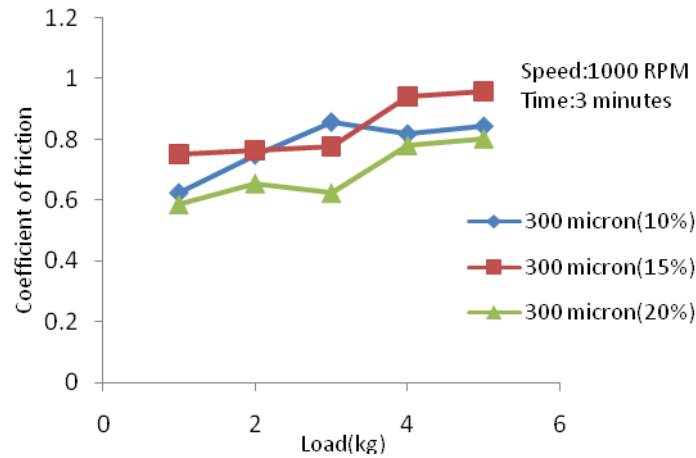


Figure 6: Variation of coefficient of friction with load (300 μm wood dust) [11]

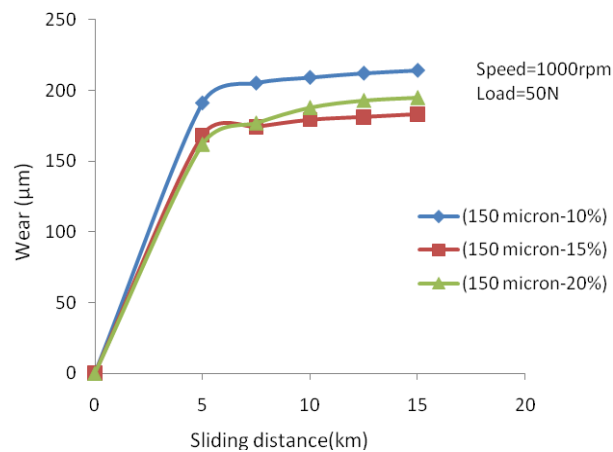


Figure 7: Variation of wear with sliding distance (150 μm wood dust)

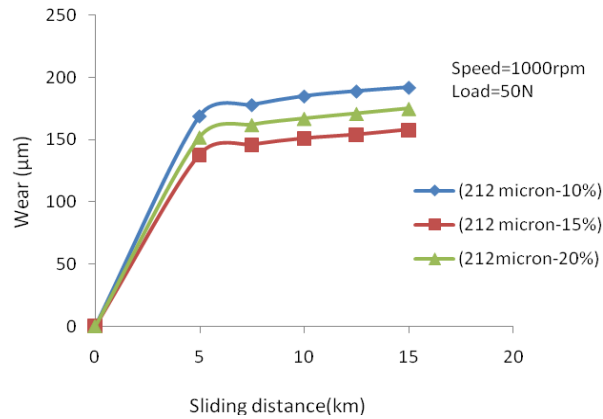


Figure 8: Variation of wear with sliding distance (212 µm wood dust)

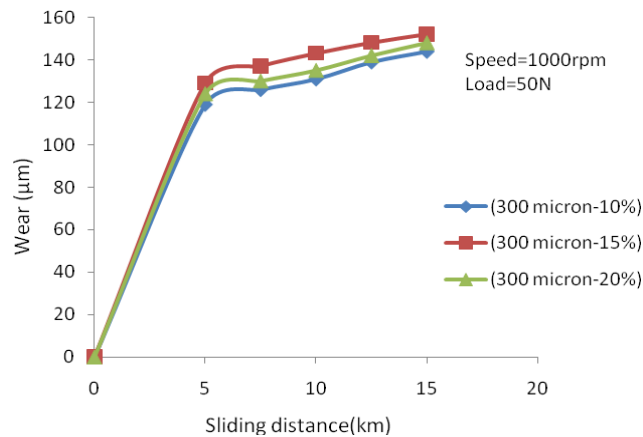


Figure 9: Variation of wear with sliding distance (300 µm wood dust)

Out of the above results it is observed that the composite with mesh size 300 µm of teak wood dust exhibited least wear rate with 10, 15 and 20 percent weight fraction of wood dust. The composite with 150 µm size of wood dust exhibited highest wear in all the experiments. Lowest coefficient of friction was obtained for the composite with 150 µm size wood dust filler. The composites with 150 and 300 µm size dust particles are in close range of coefficient of friction i.e for 150 µm size 0.38 to 0.85 and for 300 µm size filler 0.62 and 0.85 respectively. It is further observed that 150 µm grain size (Fig.7) with 15% wood dust exhibited least wear. Similarly for 212 µm size it was 15% and for 300 micron sizes of wood dust, it was 10% wood dust filled composite exhibited lowest wear (Fig.8 and 9).

6. Conclusions

The coefficients of frictions obtained from the tests indicates that for both 150 and 300 μm size dust filled composites they are more or less equal. The wear tests shows that the wood dust of 300 μm composite with 10% filler is a better choice for frictional applications as it has exhibited lowest wear (144 μm) sliding for 15 km under dry condition in comparison to wood dust sizes of 150 and 212 μm (15 %) filled composites (158 and 183 μm) under same conditions of tests. From the nature of the graphs it is expected that the wear will attain steady state after being slid for more than 15 km.

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