Investigation on abrasive wear behavior of coir dust reinforced polymer Matrix composites

Harinth Aireddy* and S.C.Mishra

Metallurgical and Materials Engineering Dept.

National Institute of Technology, Rourkela

INDIA

Corresponding author:harinathaireddy364@gmail.com

Abstract

In the present work coir dust reinforced epoxy matrix composites of different compositions (varying the amount of reinforcement) are prepared by hand lay-up method, at the room temperature. The abrasive wear property of the composites are examined in dry conditions on a pin-on-disc machine against 400µm grit size abrasive paper, with test speed of 0.540 m/sec and normal loads of 5,10,15,20, and 25N.The experimental results shown that, the abrasive wear resistance of the composite depends on the coir dust concentration, sliding distance and applied normal load. The abrasive wear resistance decreases with increase in normal load and increases with increasing coir dust content, because at higher coir dust loading,wear mechanism was dominated by reinforcement , which is less brittle than the epoxy matrix.The worn surface morphologies were examined by SEM and possible wear mechanisms has been discussed.

Key Words: abrasive wear, coir dust, epoxy resin, SEM

1. Introduction

The growing global environmental concern ,high rate of depletion of petroleum resources, as well as new environmental regulations have forced the search for new fiber reinforced composite materials that are compatible with the environment[1].Natural biomaterials have some unique properties and function and have attracted many researchers interest including their structures, mechanical properties, physical and chemical behavior and their biomimetics[2-5].Natural fibers represents an environmentally friendly alternatives to conventional reinforcing fibers, due to the following advantages :they are abundantly available renewable resources, nontoxic, inherent biodegrability, low density, less cost, a range of mechanical properties, and less abrasiveness[6-10].

Interestingly, several types of natural fibers which are abundantly available like oil palm, banana, sisal , jute, wheat, flax straw and bamboo have proved to be good and effective reinforcement in the thermo-set and thermoplastic matrices[11-15]. Visualizing the importance of polymeric composite in tribological application, lots of work already have been published. Abrasive wear of composites is strongly influenced by the filler loading and operating parameters(Harmi et ai .2006; chand and Dwivedi 2006).The interaction of both parameters influence the abrasive wear behavior (Chand et al.1995; venkateswarlu 2006). Hashmit et al.[16] investigated the sliding wear behavior of cotton-polyster composites and obtained better wear properties on addition of cotton reinforcement .

The aim of the present work is to analyze the effect of the fiber content of coir dust on its abrasive wear against free abrasive material .Hardness and flexural strength of the composite material was also discussed.

2. Experimental Details

Here the matrix material is Epoxy LY556,chemically belonging to the 'epoxide' family is used as the Matrix Material. The hardener with IUPAC name NN0 (2-amineethylethane-1, 2- diamin) used with the epoxy has the designation HY-951.The epoxy resin and the hardener were supplied by Ciba Geigy India Ltd.Resin and hardener are mixed in a ratio of 8:1 by weight as recommended. Density of the epoxy resin system is 1.28 g/cc .

Different amount of coir dust (10, 20, 40,and 60 wt%) is added to the mixture of epoxy resin and hardener and stirred for 15 min by a glass rod to obtain uniform dispersion of coir dust particles in the matrix material then poured into cylindrical mould. Composite samples having cylindrical shapes with 20mm length and 10 mm dia. were prepared. These samples were kept in the mould for curing at room temperature (30°C) for 48 h. Cured samples were removed from the moulds and used for abrasive test.

To evaluate the value of flexural strength (FS), the short beam shear (SBS) tests(generally it is a3-point bend test) are performed on the samples at room temperature. The SBS test is conducted as per ASTM D2344-84 using the Instron 1195 UTM. Leitz Micro –hardness tester was used for Hardness measurement.

Abrasive wear tests are carried out in pin-on-disc type friction and wear monitoring test rig (supplied by DUCOM) as per ASTM G99.The coir dust composite specimen(of size 10mm dia. And 15 mm length) were abraded against the waterproof SiC paper (having 400 μm grit size), fixed on the rotating disc .The specimen is held stationary and the disc is rotated while a normal force is applied through a lever mechanism. A series of tests are conducted for sliding distances 20,40,60,80,and 100 m under different normal loadings of 5,10,15,20,and 25N .The material loss from the composite surface is measured by using a precision electronic balance and then the specific wear rate(mm^3/N-m) is then expressed on volume loss basis as;

$$W=\Delta m/\rho tVF$$

Where Δm is the mass loss(in gm) , ρ is the density of the composite(gm/mm^3), t is the test duration (sec),V is the sliding velocity (m/sec) , and F is the avg normal load(N).

Worn surfaces of samples were observed by using a scanning electron microscope (JEOL JSM-6480LV).

3. Results and Discussion

Fig.1 gives the effect of fiber content on the specific wear rate(SWR),from the figure it is clear that with increasing fiber content specific wear rate is decreases.It means that coir dust fiber is very effective in improving the tribological performance of epoxy,especially for its wear resistance.The main reason for decrease the wear rate ,at higher coir dust loading,wear mechanism was dominated by coir dust,which is less brittle than the epoxy resin matrix.

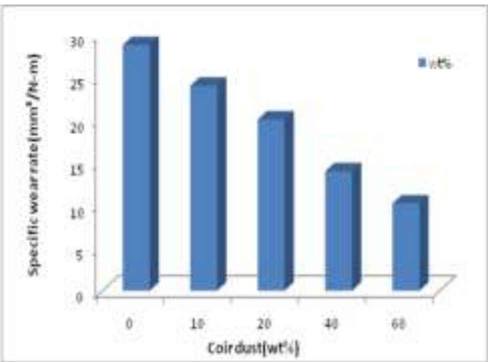
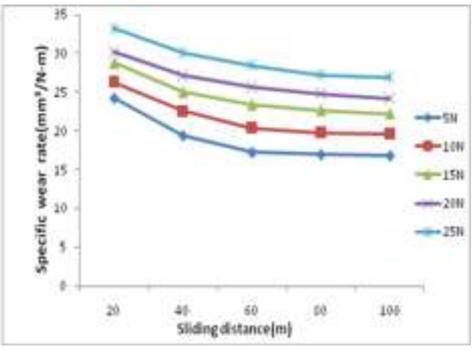


Fig .1 Variation of Specific wear rate with fiber content

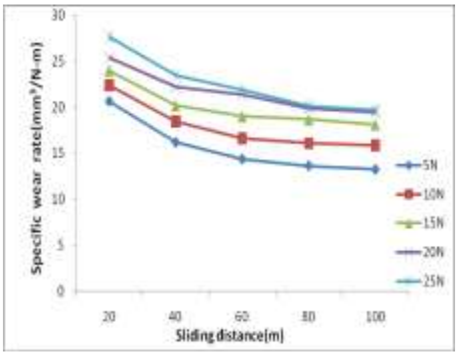
Fig.2 shows the plot for for specific wear rate as a function of sliding distance for different composites at different normal loads.The SWR decreased with increase of sliding distance for all the samples.Also initially high wear SWR observed because the abrasive paper was fresh.With consecutive runs,wear loss decreased gradually,becuasethe abrasive grits became less effective.The wear debris filled the space between the abrasives(SiC grits),which reduced the depth of penetration in the sample.In other words,contact stress was reduced when debris came between the surfaces.

Fig.3 shows the plot for SWR as a function of normal loads for unreinforced and reinforced composites at different sliding distances(and the sliding velocity is 0.540 m/sec).The SWR increases with increasing of normal load.The SWR was relatively low at lower load because of less penetration and less number of abrasive particles were in action with sliding surface.The SWR was increased with increasing load because most of the abrasive particles were in action with the sliding surface and created more grooves ,resulting high material was removed from the surface.

(a)



(b)



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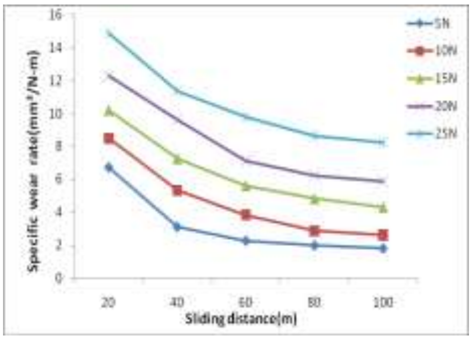
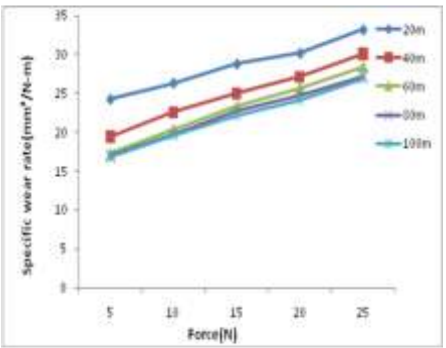
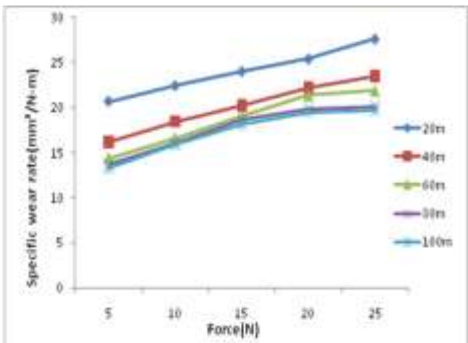


Fig.2. Sliding distance dependence of Specific wear rate at different normal loads for (a) sample A,(b)sample B and (c)sample E.

(a)



(b)



(c)

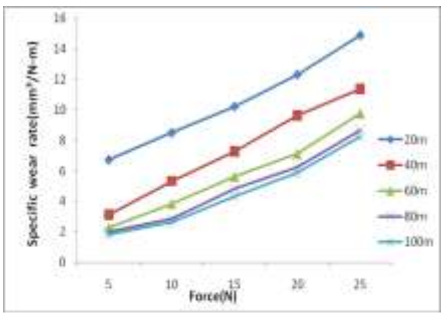
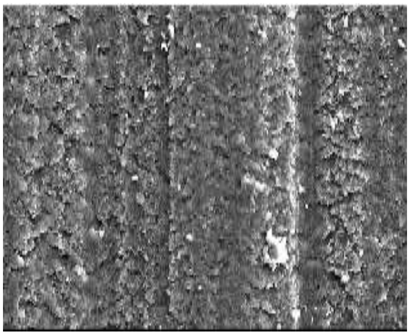


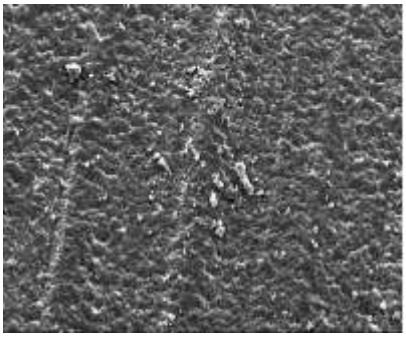
Fig.3 Normal load dependence of Specific wear rate at different Sliding distances for (a)sample A,(b)sample B and (c) sample E.

Figure 4(a),4(b),and4(c) shows the worn surface morphologies of pure epoxy ,10wt%,and 60wt% of coir dust composites after 100m sliding distance(sliding velosity 0.540 m/sec, 400 µm grit size ,and load at 20N).Wear tracks are formed during multi pass wear. It is clear from the microstructures ,initially micro- cracs are formed around the coir dust paricles, and particles were removed under compression and shear.Increase of the coir dust content increased the resistance to shear force ,this is due to its honeycomb like structureof the mesocarp.

(a)



(b)



(c)

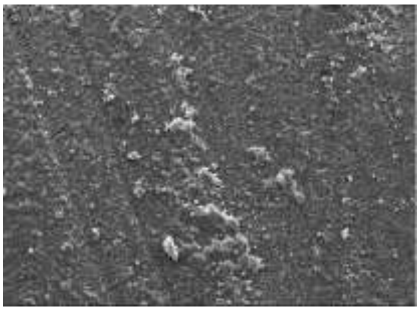
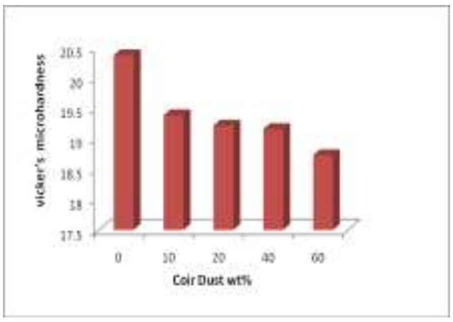


Fig.4 Scanning electron micrograph of (a) worn surface of pure epoxy , (b) worn surface of 10 wt% coir dust reinforced composite,and (c) worn surface of 60 wt% coir dust reinforced composite under 20 N normal load against 400µm grit size abrasive paper.

Fig.5 (a) shows that the variation of the hardness of the coir dust reinforced polymer matrix composites with the fiber content. From the figure it was clear that with increasing the fiber content hardness of the material is decreases, due to the softness of the coir dust compare with the matrix material. Fig.1(b) shows the effect of the fiber content on the flexural strength of the composite material, from the figure it was clear that with increasing fiber loading flexural strength of the material decreases because the increased coir dust acted as filler, not as reinforcement[17].

(a)



(b)

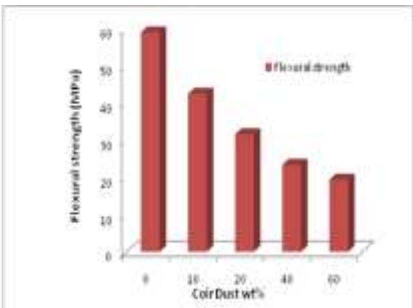


Fig.5 Variation of (a) hardness (b) Flexural strength with fiber content

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