THE FRICTION AND WEAR BEHAVIOUR OF MODIFIED RICE HUSK FILLED EPOXY COMPOSITE

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ABSTRACT: Rice Husk (RH) is an agricultural waste material abundantly available in rice producing countries. They are removed during the refining process of rice and has no commercial interest. It is generally used as a fuel for heating because of its easy availability and low cost. rice - husk has proved to be efficient filler for developing polymer based composites, provided there is a good compatibility between rice husk and base polymer matrix. In the present work two series of composites were prepared using randomly oriented unmodified and modified rice husk as reinforcement in epoxy matrix. The wear behavior of RH composites reinforced with 5, 10, 15 and 20 wt% were studied using a pin-on-disc apparatus. The wear rate and co-efficient of friction were found to be the functions of normal load, sliding velocities and filler volume fraction. The morphology of worn surfaces of composites was studied using a scanning electron microscope (SEM). The positive effect of rice husk reinforcement of both untreated and treated has reflected improved tribological properties of the epoxy composite.

1 INTRODUCTION.

In recent years, natural fiber reinforced with polymer matrix have attracted the attention of researchers worldwide because of their low cost, lightweight, renewability, low density, high specific strength, non-abrasivity, combustibility, non-toxicity, low cost and biodegradability. Interestingly, several types of natural fibers that are abundantly available, such as jute [(Roe ,1985) (Sridhar , 1984) (Kumar , 1986) (Shah , 1981)], sisal [Bisanda, 1991], coir [(Prasad , 1983) (Pothan , 1997)], and banana [Pothan , 1997] have proved to be good and effective reinforcement in thermoset and thermoplastic matrices. The easy availability of natural fibers and manufacturing have tempted researchers to try locally available inexpensive fibers and to study their feasibility of reinforcement purposes and to what extent they satisfy the required specifications of good reinforced polymer composite for tribological applications [Eleiche, 1986]. If we look in to agricultural waste materials, with regards to their usage in tribological environment rice husk, is one such fiber which is produced during rice milling. It is the outer covering which surrounds the paddy grain and accounts for 20-25 of its weight [Eleiche, 1986]. It is interesting to note that rice husk contains 20% ash, 22% lignin, 38% cellulose, 18% pentosans and 2% moisture. Like other natural fibers the rice husk is also not free from shortcomings like higher moisture absorption, poor wetability and poor fiber matrix adhesion.

If the rice husk did not move through any chemical surface treatment, it certainly contributes to a weak interface between the husk and the resin matrix. This is because the lignin content of rice husk is high (22% on average). A high lignin content is considered to prevent a good surface wetability between polymer matrix material and natural fiber (Navarro et al. 1991), although it increases the resistance to chemical and microbial attack (Godfried et al. 1975).

In the present study an attempt has therefore been made to develop rice husk composites using modified (by treating the fillers with benzoyl chloride and acetone) and unmodified rice husk as reinforcement. The composites are prepared with different concentration of rice husk and the abrasive wear behavior of the composites has been studied with different fiber loading.

2 EXPERIMENTAL DETAILS.

2.1 *Materials*

The type of epoxy resin used in the present investigation is Araldite LY556 and hardener HY 951, supplied by Ciba-Geigy of India Ltd. The Rice husks were collected locally. They were washed several times with plane water to remove the dust and other foreign particles adherence to the fibers and were dried in sun light. After drying a batch of RH surface were modified through Benzoylation and acetone treatment. The process of treatment is carried out as per the procedure explained by Deo [ ] A mixture of epoxy resin and hardener was prepared in the ratio of 10:1 at room temperature. Different amounts of plain RH (5, 10,15, 20 wt%) were added separately in the above epoxy mix and stirred for 10 min using a glass rod to obtain uniform dispersion. Because of stirring the fibres were randomly distributed in the matrix. The resultant mix of RH and resin was poured into cylindrical moulds [Fig. 1(a)] and fixed properly. During fixing some of the polymer mix was squeezed out. Care was taken for this in the experiment to make composite pins of length 35mm and diameter 10mm Fig. 1(b).The samples were kept in the moulds for curing at room temperature (29 ^{0}C) for 24 h. Cured samples were then removed from the moulds and used for experimentation. The processes of making treated RH composites are also same as untreated RH.

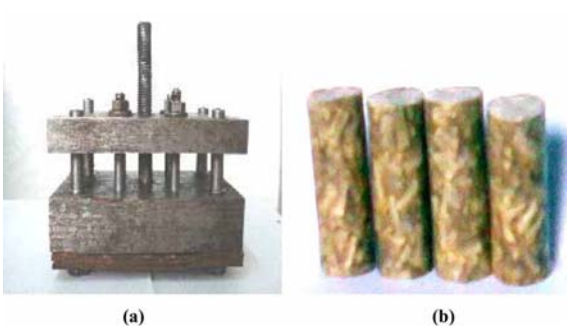

Figure 1. (a)Mould used for preparing samples and (b) fabricated composite pins

2.2 *Experimental design*

The composite systems outlined in Table 1 were manufactured to investigate varying properties such as fiber volume fraction and chemical treatment of fibers. The first group of samples (Group 1) contains 5, 10, 15 and 20, weight fraction of untreated RH fillers. The initial results of abrasive wear behavior indicates, 10 wt% of fiber as the optimum one as it possessed the maximum wear-resistance. Based on this result the second group of samples of 10% weight fraction was selected for further

Group	Sample	% wt fraction	Type	Remarks
Group1 Volume Fraction Analysis	1	05	Washed RH fiber	10% Optimum
	2	10	Washed RH fiber	
	3	15	Washed RH fiber	
	4	20	Washed RH fiber	
Group2 Fiber surface Treatment		1	Acetone treatment	10Wt Percent only
		2	Benzoyl chloride	

Table 1. Types of RH samples used in the research

experimentation (Group 2). These fibers were then treated with acetone and benzolisation as per the procedure explained by Deo[ ] and subsequently used in the matrix for manufacturing composites for studying the abrasive wear behavior.

Pin-on-disc Wear Test

Wear tests were carried out by using a pin-on disc wear tester (Fig.2) supplied by Magnum engineers, Bangalore. Abrasive paper of 400 grade (grit-23 µm) was pasted on a rotating disc (EN 31 Steel disc) of 120mm diameter using double-sided adhesive tape. The sample pin was fixed in a holder and was abraded under different applied loads (5N, 7.5N,10 and 15N). Each set of test was carried out 6 times for a period of 5 minutes run. After each run the samples were removed from the machine and weighted accurately to determine the loss in weight. The experimental details are presented in table-2.The experimental procedure remains same for treated and untreated fiber composites.

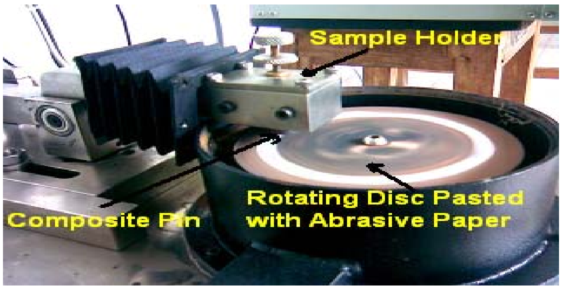

Figure 2.Pin-on-disc abrasives wear Tester

Table 2. Experimental Details

Test Parameters	Units	Values
Wt fraction of fiber	%	0,5, 10, 15 and 20
Load (L)	N	5, 7.5, 10 and 15
Sliding Velocity (v)	m/s	0.837, 1.256 and 1.675
Track radius (r)	mm	50
Temperature	^0C	25

2.3 *Wear Rate Measurement*

Wear rate was estimated by measuring the mass loss in the specimen after each test and mass loss, Δm in the specimen was obtained. Care has been taken after each test to avoid entrapment of wear debris in the specimen. Wear rate which relates to the mass loss to sliding distance (L) was calculated using the expression,

$$W_r = \Delta m/L \quad (1)$$

For characterization of the abrasive wear behavior of the composite, the specific wear rate is employed. This is defined as the volume loss of the composite per unit sliding distance and per unit applied normal load. Often the inverse of specific wear rate expresses in terms of the volumetric wear rate as,

$$W_s = W_v / V_s F_n \quad (2)$$

where V_s is the sliding velocity.

3 RESULTS AND DISCUSSIONS.

The variation of wear rate with sliding distance for a specified normal load is shown in Figure 3.It is clear from the figure that the abrasive wear rate decreases with addition of rice husk fibers under all testing condition. It can be conclude here that addition of the rice husk fibers in epoxy is very effective in improving its wear resistance. The wear rate for 10wt% fibers found to be minimum. Further increase in fiber content (15%, 20 wt %) increases the wear rate again. This increase in wear rate for higher volume fraction of fiber might have happened due to agglomeration of fibers in the composite, which leads to poor interfacial adhesion between the fiber and the matrix. Similar type of behavior was reported by Wu and Cheng [20], while they studied the tribological properties of Kevlar pulp reinforced epoxy composites.

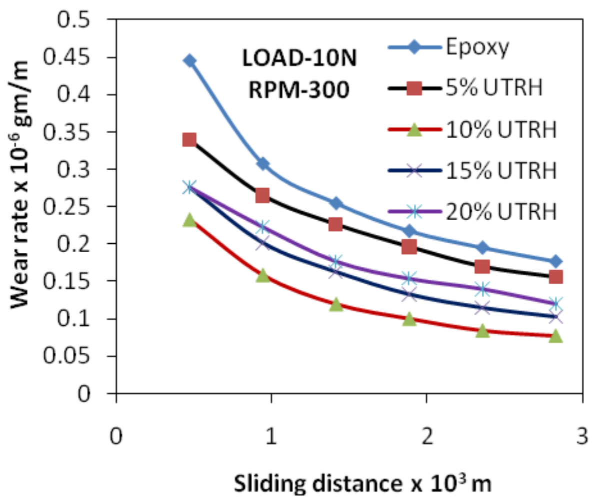

Figure 3. Variation of Wear Rate with Sliding Distance at a Load of 10N and Sliding Velocity of 1.5708 m/s.

It is also observed from Fig.4. that the specific wear rate decreases with increasing sliding distance. Further it is observed from the result that, the range of specific wear rate is high at initial stage of sliding distance and achieved a steady state at a distance of about 282.75 m. In other words, there is less removal of material at longer sliding distances and this could be due to the less penetration of abrasive particle in to the composite sample. Because at initial stage the abrasive paper is fresh and then become smooth due to filling of the space between abrasives by wear debris, which consequently reduce the depth of penetration. It is also observed that the 10wt% rice husk reinforced composite shows a minimum specific wear rate under all testing conditions. On further increase in weight fraction of rice husk leads to increase in the specific wear rate. This again reveals that the addition of rice husk fiber can improve the wear resistance of neat epoxy.

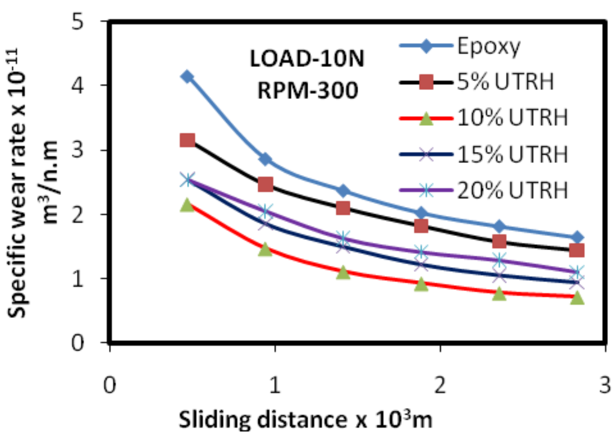

Figure 4. Variation of Specific Wear Rate with Sliding Distance at a Load of 10N and Sliding Velocity of 1.5708 m/s.

Fig-5 and Fig-6 show the comparison of wear rate and specific wear rate between untreated and treated rice husk epoxy composites. It is clear from the figures that in case of treated rice husk epoxy composite both the abrasive wear rate and specific wear rate is minimum as compared to untreated rice husk epoxy composite. This happened because the compatibility between rice husk particles and polymer increases due to fiber treatment. This is possible because the treatment completely wets the surface of RH and more and more OH groups are used for chemical bonding. On comparing the results of rice husk treated with benzoyl chloride and acetone, it is found that benzoyl chloride treatment of fibers gives better wear property than acetone treated rice husk reinforced epoxy composites.

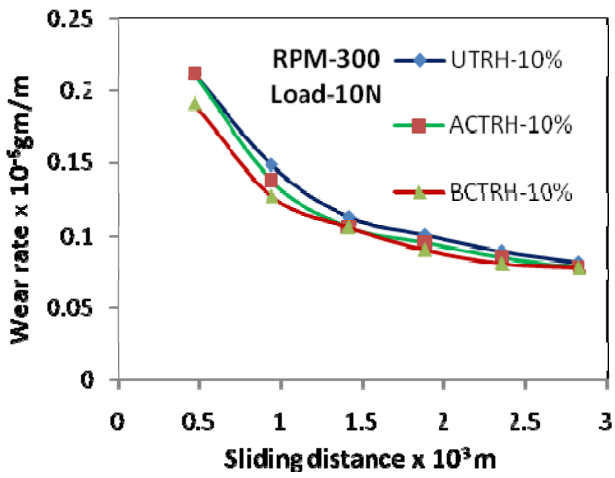

Figure 5 Variation of Wear rate with sliding Distance for rpm-300 and load-10N

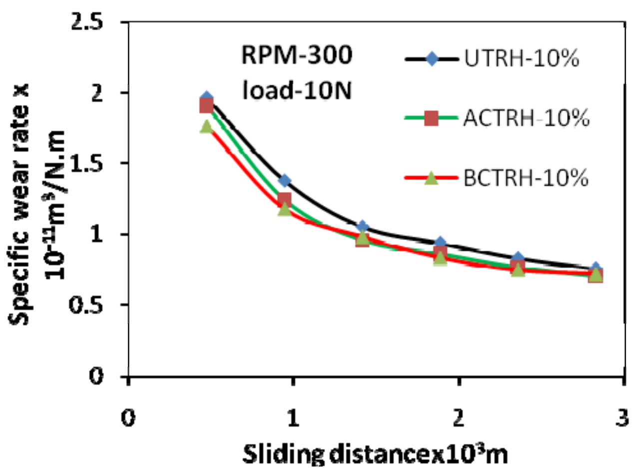

Figure 6. Variation of specific wear rate with sliding distance for RPM-300 & Load-10N

3.1 *SEM Observation*

Scanning electron microscopy (SEM) JeolJSM- 6480LV was used to examine the microstructure of the samples and the morphologies of worn surfaces.From the surface topography of the unmodified rice husk (Fig-7(a)) and modified rice husk [Fig-7(b)]. It appears that matrix cracking and surface damage are more pronounced for unmodified filled Rice husk composite. Both longitudinal and transverse cracks are seen on the fiber surface. For modified rice husk filled composite(benzoyl chloride), it is seen that though the surface topography is not smooth, surface damage appears to be minimal and only longitudinal cracks are visible on the fiber surface in the direction of rolling. The treatment of fiber surface probably restricted the cracks to propagate in the transverse direction which in turn improves the wear resistance of the composite.

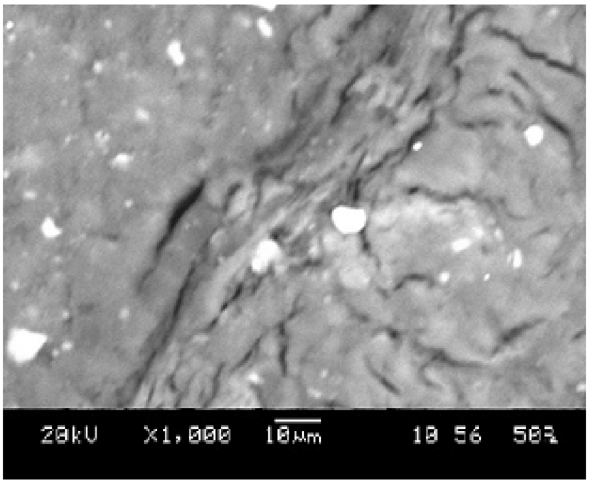

Figure 7-(a)

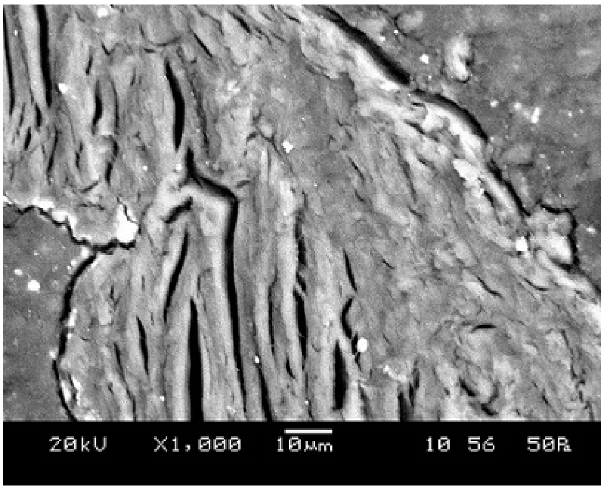

Figure 7-(b)

Figure 7. Scanning Electron Micrograph of Worn Surface of (a)10wt% by Untreated Rice Husk Composite and (b) Benzoyl Chloride Treated Rice Husk Reinforced Epoxy Composite

4 CONCLUSIONS

The following conclusions are drawn from this study.

1. The incorporation of rice husk in to epoxy can significantly reduces the abrasive wear loss. The optimal wear resistance property was obtained at a fiber content of 10 weight percent .

2. Wear resistance of the rice husk reinforced epoxy composite can be increased if the surface of the rice husk is treated suitable. For the present case the Benzoyl Chloride treated rice husk composite shows maximum wear resistance.

3. With increasing sliding distance, wear rate gradually decreases and attains an almost steady state in multi pass condition.

4. The specific wear rate of composite decreases with addition of fiber. In this present study, the optimum fiber fraction which gives maximum wear resistance to the composite is found to be 10 weight percent

4.1 *References*

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