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Investigation of Wear Behavior of Rice Husk Filled Cotton Fiber Reinforced Polyester Composites

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ABSTRACT

Usage of natural fiber-reinforced polymeric composites has drastically increased in recent years for industrial applications. In this investigation, Composite specimens were prepared with polyester resin, cotton-polyester resin, and cotton-polyester resin with rice husk filler. The hand layup method was used to prepare composite sheets with specially prepared steel die. The specimens were prepared as per ASTMG99 standards and Friction coefficient and wear rate were measured for the proposed materials under dry sliding contact with steel counter face. Pin on disc wear testing machine used to perform the proposed tribological measurement and 20,40, and 60N applied normal loads.

KEYWORDS: *Wear behavior, polyester composites, Cotton fiber, Rice husk filler*

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I. INTRODUCTION

Researchers in tribology emphasize concern over environmental issues such as biodegradability, less weight to strength, and asbestos-free [1]. Polyester composites have good tribological properties. In the industrial applications such as brake pad and floorings etc. require more friction and wear resistance [2]. The environment-friendly, natural fiber reinforced polymer composites are being preferred over the synthetic fiber reinforced composites due to their inherent biodegradability, low density, a range of mechanical properties, less abrasiveness, etc. [3]. Tensile, flexural, impact, friction, wear, and other mechanical and tribological properties can be enhanced by employing fillers or fibers to reinforce and improve the performance of polymers [4].

Among the various natural fibers, cotton is one of the most popular and used in several applications [5]. The cotton fiber is easily available since the plant is locally grown and a lot of weaving industries available nearby. The cotton fabric has been used as reinforcing fibers for the preparation of the cost-effective, biodegradable composites [6]. Similarly, rice husk cotton fiber composite was proposed due to its low density, good thermal and acoustic insulation, and high strength to weight ratio [7].

Analysis of Dry Sliding Wear Behaviour of Rice Husk Filled Epoxy Composites Using Design of Experiment and ANN was done with four different compositions (5, 10, 15, and 20) wt.% of rice husk reinforced in epoxy resin. That investigation concluded rice husk possesses good filler characteristics and improves wear behavior [8]. Various fillers suitable for polymer composites and their details were given by authors in [9]. The basics of Tribology, Friction, and Wear of Engineering Materials were explained [10]. Investigation on the friction and wear behavior of PTFE filled with alumina tri particles was done. They used 40nm alumina particles in their composite and found wear resistances with increasing filler concentration [11]. The insertion of mineral fillers in thermoplastics improves mechanical properties and at the same time, it also reduces other properties, such as impact strength was explained [12]. Mechanical properties of walnut shell powder filled polypropylene composite by varying filler contents from 0 to 20 wt % and particles sizes from 0.1 to 0.3 mm and found that mechanical properties such as tensile strength and flexural strength decrease with increasing walnut shell powder filler content in the composite were studied [13].

Zinc powder-filled HDPE composite and their result showed the addition of filler leads to poor mechanical properties than unfilled composite, however, density and hardness are higher in zinc powder filled composite were evaluated [14]. An improvement in wear resistance of the composite containing less percentage of graphite and more percentage of sic in the epoxy composite in the range of 5-40% SIC and 5-40% Graphite was observed [15]. By the addition of CuO nanoparticles and PTFE micro particles in the epoxy resin matrix, the tribological behavior has been studied by [16]. The sic filler composite which was made using epoxy resin and fabrication was done with the hand layup method. They have investigated mechanical properties as well as wear behavior. SiC- Glass fiber fabric and epoxy resin composite exhibited less wear when comparing Glass fiber fabric Epoxy composite were reported [17].

A 7.5 wt% graphite powder filled in the Glass-Epoxy resin composite system showed the least coefficient of friction and highest wear resistance compared to the plain Glass-Epoxy composite system reported [18]. Sliding wear performance was studied by [19] by moving against a mild steel disc and silicon carbide abrasive paper under different loads. Wear properties of unidirectional E-glass fiber-reinforced composite by the incorporation of mica particles in epoxy resin. The result showed that mica particles enhance the hardness as well as the compressive strength of the composites [20]. The abrasive wear performance of hybrid glass–polyamide fibers in epoxy resin composites were planned. The composite specimens were tested using a pin-on-disc wear tester at different applied normal loads for dry and wet specimens. Specimens were made-up in planned configurations using the hand layup technique [21]. The wear behavior of glass fiber fabric reinforced polyetherimide composite has been analyzed. The test was carried out according to the Standard ASTM G99 using a device pin-on-disk. The effect of temperature in wear at 50, 100, 150, and 200°C was studied and a relationship was found [22].

Polyetherimide (PEI) matrix with short carbon fiber (SCF) and graphite as reinforcements fabricated a composite and evaluated in dry sliding conditions and reported SCF could effectively enhance both the wear resistance and the load-carrying capacity of the polymers [16]. Wear Behaviour in polyester matrix composite with coconut coir fiber reinforcement with two types of fillers, graphite, and coconut shell powder used as particulate. Upon the investigation revealed that the wear resistance of carbon or coir fiber reinforced polyester is higher than the wear resistance of carbon or coir powder reinforced polyester composite were investigated [23]. The effect of filler concentration, siding distance on the weight loss of bamboo powder-filled polyester resin composites was studied. It was found that weight loss decreases with an increase in sliding distance. Specimens with 20wt.% showed maximum weight loss during abrasion[24]. Effect of fiber orientation and applied load on tribological behavior of Jute fiber reinforced polyester composites and found the coefficient of friction decreased with an increase of applied load was studied [25]. The fabrication method for the natural fiber reinforced polymer composite and percentage of catalyst, accelerator, and promotor to be used were found in [26].

II. Experimental

2.1. Material

In the composite sheets production, polyester resin mixture and cotton fiber were used. It was a cold-setting resin system consisting of polyvinyl ester resin, MEKP catalyst, cobalt naphthenate promoter (6%), and dimethylaniline accelerator. All these items were purchased from M/s Covai Seenu and company, Coimbatore. Cotton fibers used in this study were received from APK Industries, Erode as a woven mat. Among various fillers, rice husk is available as plenty in India. Rice husk (RH) is a natural sheath that forms around rice grains during their growth. As a type of natural fiber obtained from agro-industrial waste, RH can be used as filler in composites materials in various polymer matrices. It is found that Rice husk has the characteristics of enhancing heat resistance. Rice husk has been used in polymer composites as filler with a variety of blending [21].

2.2. Die- to prepare the composites.

Die is the main component for preparing mold and die is made to ASTM standards for the study of wear behavior. Mild steel material is used for the preparation of die and it can be made to high accuracy by machining on CNC Vertical Milling Machine. Size of composite sheet = 90 x 90 x 6mm

Fig.1. Conceptions and definitions of time frames and frequencies

2.3. Fabrication of composite

After the mixture of matrix material solution with filler, we can take the woven mat into two pieces from the dimensions of die volume. The die is ready to take the mold from composite structures. Some matrix material solution with filler is poured into the die and put the layer of the woven mat on the surface of the matrix material solution with filler. Again the solution is poured into two layers in between the woven mat involvement. After the composites are reinforced, the next step of resting hours to hold the mixtures and fibers to merge as the mold of composites to give the structures with size and shape to deliver the material as external results.

Table 1 Content percentages

Sample designation	Polyester Resin (g)	Cotton fibre (g)	Rice husk (g)
Virgin polyester resin	100	0	0
Cotton fibre reinforced polyester	75	25	0
Rice husk filled Cotton fibre reinforced polyester	75	20	5

III. Testing

3.1. Wear behavior test

In order to find alternate material to asbestos, these polyester resin matrix and cotton fiber reinforcements and rice husk fillers are proposed and its composites are to be studied for wear so that it can be used in automobile brake linings.

PIN-ON-DISC METHOD

Wear tests can be taken in different types of machines, one can select based on the accuracy of readings required and materials to be tested. In this investigation, the "PIN-ON-DISC" machine is used.

The pin was pressed against the rotating disc which is made up of EN 31 steel with wear track dimensions of 60 mm. Another end of the pin was loaded with a deadweight loading system. The wear rate for all specimens was determined under the normal loads of 20N, 40N, 60N and a sliding velocity of 2 and 4 m/s.

In this pin on the disc machine, the shape and size of the testing specimen vary from machine to machine and maybe square or cylindrical cross-section. Similarly, the length of the piece to be cut for 25-30mm dimensions.

In the Wear measurement, If the specimen is not flat, it is rubbed against an emery sheet to make it flat, then it will be fitted in the machine. The readings were taken out for a total sliding distance of approximately 3000m under similar conditions. The samples and wear track were cleaned with acetone and weighed before and after each test. The wear rate was calculated from the weight loss technique and expressed in terms of wear volume loss per unit sliding distance.

Table 2 Details

Description	Specification
Disc material	EN31 steel
Pin dimension	Cylinder with diameter 12mm height 30mm
Siding speed (m/s)	2,4
Normal load	20,40,60
Sliding Distance (m)	3000

Fig.2. PIN ON DISC WEAR TESTING MACHINE

IV. Results and discussion

Fig. 3 shows different plots of the coefficient of friction vs time drawn corresponding to specimens of Virgin polyester, cotton-polyester, and cotton-polyester with rice husk filler. Specimens containing cotton-polyester show deviation with time at different applied pressures. The coefficient of friction increases to a peak value suddenly then decreases with time and then stabilizes. It was due to the loosening of cotton fibers from the resin matrix[27]. The performance of virgin polyester is found to be poorer than the other two specimens. Rice husk filled cotton-polyester specimen maintains initial peak and after elapses, its reinforcement loosens from the polyester matrix. But comparing the other two specimens, it showed high performance from the initial state concerning time.

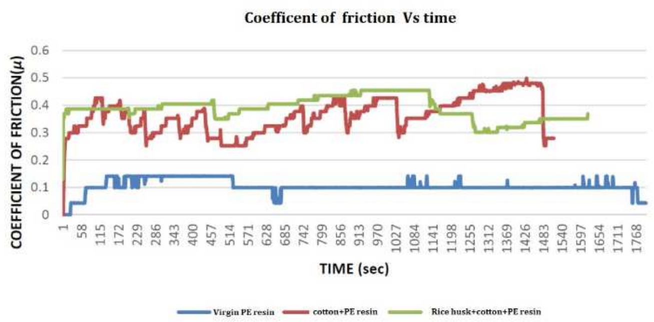

Fig.3.COEFFICIENT OF FRICTION VS TIME GRAPH FOR V.PE,COT+PE, COT+PE+RH

Fig. 4 shows graph plots between the specific wear rate and the applied load on the specimens made up of polyester resin, cotton-polyester composite, and cotton-polyester -rice husk composites. The specific wear rate shows composites are sensitive to changes in normal loads. The virgin polyester resin specimen showed the poorest wear performance when compared with cotton reinforced sample or cotton + polyester + rice husk sample. Fig.5 shows the wear rate of cotton polyester showed a slight increase in wear rate in the 20N applied load and between 40 to 60 N categories, its performance started poorly. It was due to more friction and more heat generation due to load. Rice husk withstands heat so that its performance improves.

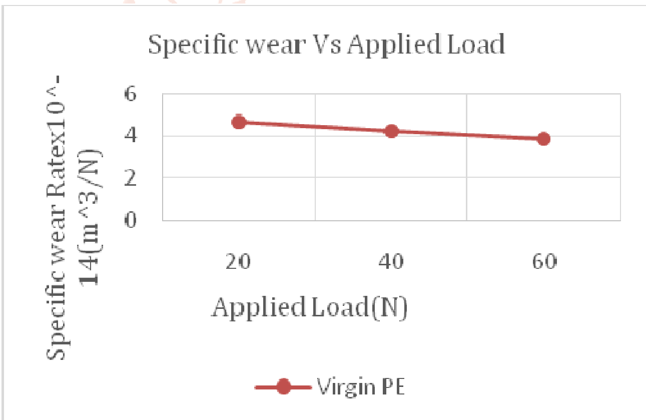

Fig.4. Specific wear Rate Vs Applied Load for Virgin PE

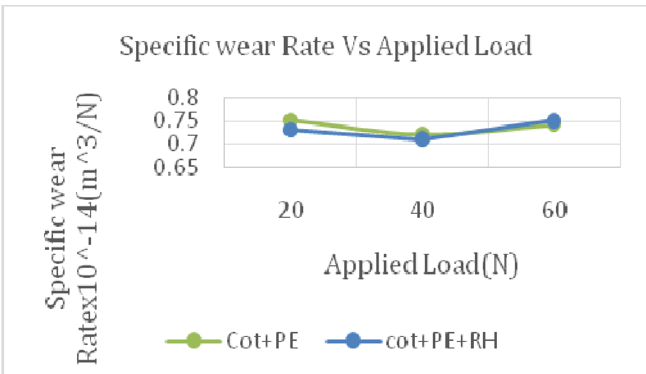

Fig.5. Specific wear Rate Vs Applied Load FOR COT+PE, COT+PE+RH

V. CONCLUSIONS

The conclusion of this study is as follows:

A. Addition of cotton fiber reinforcements in the unsaturated polyester resin matrix enhances the structural integrity of material under sliding wear condition. The incorporation of rice husk filler in the cotton-polyester composites further enhances the coefficient of friction of the material to withstand against sliding wear test.
B. The virgin polyester composites showed reductions in specific wear rates against the normal load in the specimens.
C. The specific wear rate of Cotton reinforced polyester resin decreased with the addition of further load.
D. The specific wear rate of rice husk filled composite is below the level of the cotton-polyester composite.
E. The rice husk filled cotton-polyester composite showed the coefficient of friction increased suddenly and stabilized in the peak.

VI. References

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