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Tribological Analysis of Arachis Hypogaea Powders Reinforced on Epoxy Based Green Composites

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***Abstract:** In this work, the effect of Arachis hypogaea powders, on the wear and morphological analysis of epoxy resin bio powders Potassium permanganate ($KMnO_4$) treated and un treated (Arachis hypogaea shall powder filler loading 5, 10, 15, 20, 25 vol %) had been investigated. Composite Specimens were prepared by using hand layup method. Tests were conducted to evaluate wear properties of the epoxy composite. The results indicated that the Potassium permanganate ($KMnO_4$) Arachis hypogaea bio filler had significant influence on the wear properties. Surface Morphological properties were examined using the SEM images of wear tested specimen.*

***Keyword:** Epoxy, natural fillers, wear properties, Arachis hypogaea.*

I. INTRODUCTION

Natural fibre reinforced polymer composites have emerged as a potential environmentally friendly and cost-effective option to synthetic fibre reinforced composites. The availability of natural fibres and ease of manufacturing have tempted researchers to try locally available inexpensive fibres 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. With low cost and high specific mechanical properties, natural fibres represent a good, renewable and biodegradable alternative to the most common synthetic reinforcement, i.e., glass fibre. Despite the interest and environmental appeal of natural fibres, their use has been limited to non-bearing applications due to their lower strength and stiffness compared with synthetic fibre reinforced polymer composite. The stiffness and strength shortcomings of bio-composites can be overcome by structural configurations and better arrangement in a sense of placing fibres in specific locations for highest strength performance. During the last few years, a series of works have been done to replace the conventional synthetic fibre with natural fibre composites [1-5].

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Wear is defined as damage to a solid surface, generally involving progressive loss of material, due to relative motion between that surface and the contacting substance or substances [6]. Wear of composites is strongly influenced by the filler loading and operating parameters [7].
The interaction of both parameters influences the abrasive wear behavior. Hashmi et al. [8] investigated the sliding wear behavior of cotton–polyester composites and obtained better wear resistance on addition of cotton fiber reinforcement. For fiber-reinforced polymer composites, the process of material removal in abrasive wear process involves four different mechanisms such as microploughing, microcutting, microfatigue, and microcracking [9].
Less work has been performed in investigating the possi- bility of using natural fibers as reinforcement for tribo- polymeric composites. Such polymeric composite materi- als can be used in many tribological applications such as bearing, cages, and sliding components. In the recent research work by Yousif and Tayeb [10], oil palm fibers were used as reinforcement for tribo-polyester composites. In that work, the introduction of oil palm fibers as rein- forcement significantly reduced the specific wear rate by about three to four times. In addition, higher friction co- efficients and interface temperatures were measured, which contributed to the softening of the polyester regions in the composites at the sliding surface. In another work by Tayeb [11], the abrasive wear performance of sugar- cane fiber-reinforced polyester composites was investi- gated. The lengths of the fibers and their orientation have a significant effect on the abrasive behavior of the compo- sites. Also, long fibers (about 5 mm) provide better sup- port to the matrix than that of short fiber reinforcement. This was due to the less pulling-out of fibers occurring at that length. Besides, when the end of fibers in the matrix was perpendicular to the counterface and antiparallel to the sliding direction, composites showed higher wear per- formance compared with other orientations. This was con- firmed by many published works on synthetic composites. Coir or coconut fibers, one of the commonly used natural fibers, are abundantly available in tropical and subtropical countries. Nowadays, coir fibers are being widely used as reinforcement for many polymeric composites because of their advantages, i.e., low price, low density,reduced tool wear, and high specific strength. Furthermore, they have been used as a substitute for synthetic ones (such as glass and carbon) due to their attractive physical and mechanical properties, durability, biodegrade ability, and a less brittle nature relative to glass [12-14].

II. WEAR TEST SPECIMENS

The friction and wear tests were conducted on a pin on- disc (as per ASTM G-99 standard, Make:B.S. Abdur Rahman Crescent University) wear tester. Sliding was performed under ambient conditions over a period of 30 min at a sliding velocity of 3.5 m/s.

The ambient temperature was roughly 238 C, and the relative humidity was 50.65%. The surface of composite specimen comes in contact with a hardened alloy steel disc with hardness value of 62 HRC and surface roughness (Ra) of 0.54 lm. Dimension of Wear Testing Specimen (ASTM) and the contact schematic diagram of the counter surface and the sample is shown in Fig.1. The test parameters are as follows: the normal load was 5, 10, 15 N, the sliding velocity was 1 m/s, and the maximum sliding distance was 500 m. Before testing, the test samples were polished against a 600 grade SiC paper to ensure proper contact with the counter face. The surfaces of both the samples and the disc were cleaned with a soft paper soaked in acetone and thoroughly dried before the test. The pin assembly was initially weighed to an accuracy of 0.0001 g in an electronic balance. The difference between the initial and final weights is the measure of sliding wear loss. Two samples were run for each combination of the test parameters employed. The wear was measured by the loss in weight, which was then converted into wear volume using the measured density data. The specific wear rate (Ks) was calculated from the equation:

Wear loss = (Initial weight – final weight) / initial weight *100

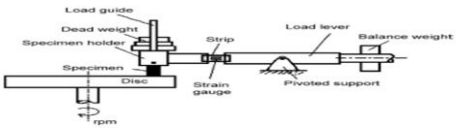


Figure 1 Schematic diagram of pin-on-disc test apparatus

III. RESULT AND DISCUSSION

At a time of 60 sec, upon varying the load & speed the corresponding graph were drawn below. From the graph, co-efficient of friction and frictional force values are tabulated. Three different types of composites were processed and planned to study the wear properties with varying parameters of Load (N), Speed (rpm) and Time (min) which was listed in table

TEST PARAMETERS

No	Applied load(N)	Sliding velocity(m/s)	Sliding distance(m)
1	5	1	500
2	10	1	500
3	15	1	500

The table above shows the test parameters of the samples used for the wear testing. The samples are tested according to three different parameters. Three different loads are used for testing and the sliding velocity and the sliding distance are maintained constant. Samples used for testing purposes are of three different compositions with 5, 10, 15, 20, 25 Vol of treated and un treated Arachis hypogaea shall powder mixed with the epoxy mixture.

Fig -5 Un Treated Arachis hypogaea Shall Powder Reinforced Epoxy Composite

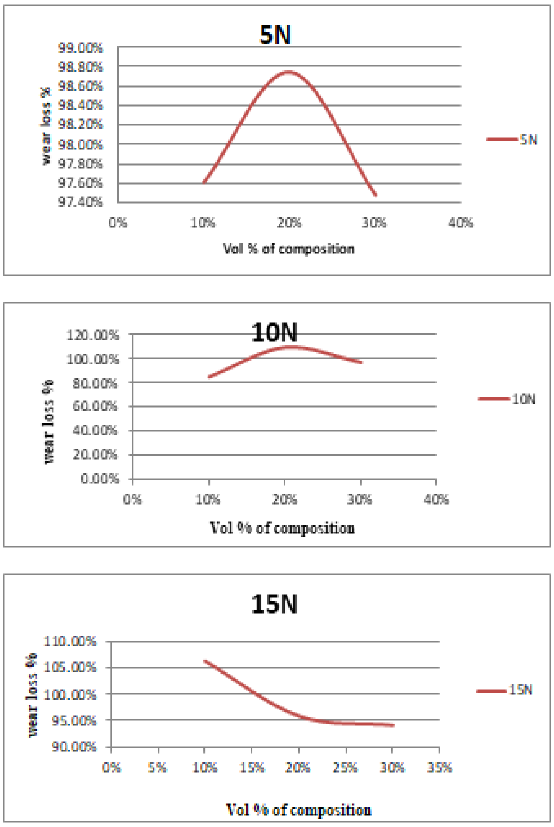


Fig-6 Treated Arachis hypogaea Powder Reinforced Epoxy Composite

IV. THE FRICTION COEFFICIENT

The Coefficient of friction the variation of the coefficient of friction with sliding distance for KmNO4 treated and un treated (Arachis hypogaea) composites sliding against steel surface having surface roughness of 0.54 lm (Ra).

It can be seen that the coefficient of friction for composite is 0.25 at the onset of sliding velocity to 1 m/sec at 500 m sliding. Further increase in sliding distance beyond 500 m makes it reach steady state. In the case of composites, the coefficient of friction at the beginning of sliding is higher than that of KmNO4 treated un treated (Arachis hypogaea) and assumes a stable value in the steady state of sliding. This is mainly because a un treated composite contact with the steel surface and a series of ridges is formed on the treated composite surface in the running-in period. While in the steady-state period, the ridges on the un treated (Arachis hypogaea) surface disappear, wear debris cover the surface and the transfer film on the counterpart is formed, and the coefficient of friction is lower as described. A minimum point of friction coefficient is formed for the un treated (Arachis hypogaea) composite as shown in Fig. 5a, and the minimum friction coefficient is 20% of that of Arachis hypogaea composite. The hard phase in the soft polymer matrix, natural filler can reduce the true contact area with the countersurface under a certain load. As a result, they exhibit an important influence on reducing the plow and the adhesion between them. In this work, *$KMnO_4$* un treated (Arachis hypogaea) composite exhibits lower coefficient of friction since the reinforcing filler can effectively reduce the adhesion force and the plow. Addition of the treated filler strengthened the combination of the interface between the fibers and the matrix and increased the Young's modulus of the composite.

Fig-10 Treated hybrid shall Powder Reinforced Epoxy Composite

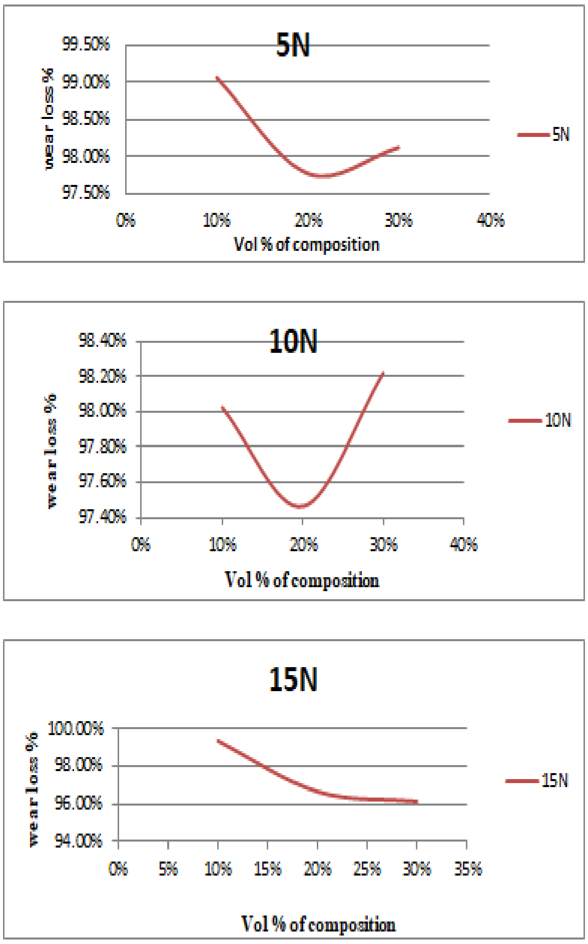
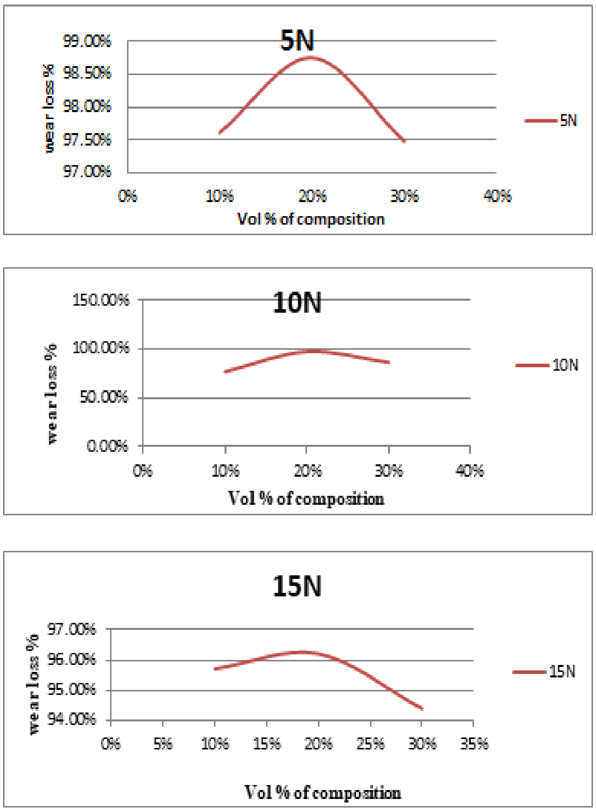


Fig-11 Un Treated hybrid shallPowder Reinforced Epoxy Composite



The table above shows both the initial and final weight of all the three composites. The initial weight and final weights are noted for the weight loss calculation. The final weight of one composite tested with a load is the initial weight if the composite tested with another load. The composites are tested with all the three loads and the wear loss is calculated

Wear loss calculation

The wear loss calculation is calculated from the initial and final weight values of the specimen after the test has been conducted. The wear loss is calculated by using the formula

Wear loss = (initial weight – final weight) / initial weight *100

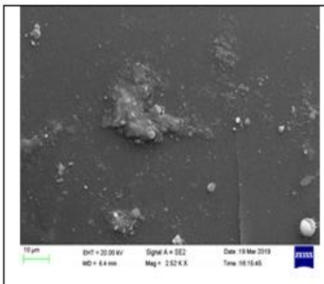


Fig 12 SEM image of un treated testing fractured morphology filler evenly distribution.

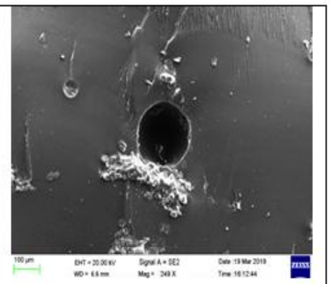


Fig 13 SEM image of treated testing fractured morphology filler pul out condition

SEM Studies of the Worn Surfaces

Studies on worn surface topography were performed to understand the friction and wear mechanisms. Frictionand wear in polymer composites are generated by number of different phenomena acting simultaneously

Specific Wear Rate

Specific Wear Rate present the specific wear rate (Ks) of the treated and untreated composites as a function of sliding distance. Untreated (Arachis hypogaea) composites showed higher Ks due to poor adhesion of (Arachis hypogaea) filler. These filler were found to contain impurities (waxy layer), and globular particle was embedded in the (Arachis hypogaea) Ks values of the un treated (Arachis hypogaea) composites decrease with the sliding distance. Furthermore, there is an initial drop in Ks toward the steady state at 500 m sliding distance. In contrast, at the initial stage of sliding, un treated (Arachis hypogaea) shows lower Ks when compared with treated (Arachis hypogaea) composite. Furthermore, the indicates that un treated (Arachis hypogaea) polyester composites exhibit lower Ks than the treated (Arachis hypogaea). The poor result of un treated (Arachis hypogaea) is due to the brittle nature of the filler reinforced composite. Owing to this fact,at high interface results. It seems that treated (Arachis hypogaea) into un treated (Arachis hypogaea) decrease the Ks, for all the composites. The reduction in the Ks was caused by the strong adhesion between the filler and epoxy matrix.

V. CONCLUSION

In this work, composite specimens were prepared using hand layup technique. Totally 6 specimens were produced are made of 10 %, 20 %, 30 % treated and un treated natural filler composite. The fabricated specimens were cut according to ASTM standard for wear test. The specimens are tested in pin on disc apparatus by varying load and speed parameters to find out the wear loss, frictional force and coefficient of friction. Results reveal that upon evaluating the wear behavior, the coefficient of friction value tends to lie between zeros to one. From the results, the minimum coefficient of friction for treated 20 volume % filler and matrix interaction results in good interfacial adhesion between filler/matrix and fewer voids in the composite. Generally, high filler content results in good composite performance, but at a certain limit, the matrix does not adhere well with a saturated amount of filler, and the composite wear strength decreases. However, the wear of rice husk shall powder is not affected by excess filler content.

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