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Wear Behaviour of Coconut Shell Powder and Coir Fibre Reinforced Polyester Composites

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ABSTRACT*: The experiments are carried out to investigate the wear performance in the coconut shell powder (CSP) and coir fibre reinforced polyester resin composites. Pin-on-disc machine is used to investigate the abrasive wear property of the polymer matrix composites against 400μm grit size abrasive paper with the velocity of 2.0 m/s and the varying load conditions are applied like 5N, 10N, 15N, 20N and 25N. The effect of the coconut shell powder and coir fibre concentration and sliding distance on the weight loss of composites has been analyzed. The result shows that the coefficient of friction increases with the increase of load in the CSP and coir fibre containing polymer matrix composites. It is observed that the wear rate is increases with the increases in the applied load. The wear rate is decreases with the addition of CSP and coir fibre. Whenever the applied load is increases, the friction at the contact surface of the material and rotating disc is also increases. The addition of the CSP and coir fibre is act as reinforcement in the polymer matrix composites. Due to this addition, the wear resistance increases.*

Key words*— Coconut shell powder, coir fibre, polyester, composite, abrasive wear.*

I. INTRODUCTION

The decades from 1920s to 1930s and in the early 1940s research was carried out on natural fibre reinforced composites. Later a revolutionary work was done on natural fibre reinforced polymer composites for light weight material which is used in aircraft primary construction today. In the previous decades, some drastically changes are occurred in the usages of materials in the engineering applications. When the natural fibre reinforced polymer composite is competitive with the synthetic composite materials. The amalgamation of natural fibre such as jute, sisal fibre, hemp, flax, various grasses, and coir fibre are mixed with polymer in various proportions to produce the polymer matrix composites [1-8]. The natural fibre is an environmental friendly substance as well as economic factors which is easily available. So the biological based polymers and materials are prepared over to the glass fibre [9-16]. Many investigation and surveys reveals that the natural fibre reinforced thermosetting composites and thermoplastics composites are used in various manners of fields. The thermoplastics materials and thermosetting materials such as polyethylene, polypropylene, polyester, polyvinyl chloride, polystyrene, epoxy resin and polylatice acid have been amalgamated with the natural and biological fibre such as coir fibre, wood, kenaf, sisal, rice husk, hemp, ridge guard fibre, cotton and chicken feather etc. [17-25].

When the hard irregular surface material is sliding over the soft surface material, the abrasive wear occurs significantly which causes the loss in the material. There is lot of evidence for this occurrence in the abrasive wear such as automobile field, agricultural field, mining field and the moving components in earth. According to the nature of contacts and the environment of contacts, the abrasive wear is generally classified into two types such two-body abrasive wear and three-body abrasive wear. In two-body abrasive wear, the hard irregular surface material slid over the soft material in which material is removed by the cutting action and the pull out action. In three-body abrasive wear, the abrasive bits are sliding between the surfaces to the roll and slid down the surface [26].

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II. EXPERIMENTATION

A. Specification of the Ingredients

Coir fibre and coconut shell powder are the reinforcing agent in the composite. The diameter of the coir fibre is 0.8mm and the length of the coir fibre is 50mm. The coconut shell powder mess size is 100 μm. Cobalt Naphthanate and Methyl Ethyl Ketone Peroxide are used as the accelerator and catalyst respectively which act as a hardener. Orthothlic polyester resin is used as a binding agent. The mixing ratio of the resin and the hardener is 10:1. The weight percentage of the resin and reinforcing agent is 70% and 30%.

B. Sample preparation

Hand-layup method is used to fabricate the natural fibre polymer matrix composite material. The specimen is prepared as per ASTM G 99 standard. The releasing agent is coated on the mold. Polyester resin and hardener are thoroughly mixed with the ratio of 10:1. 15 weight % of coconut shell powder is mixed with 70 weight % of resin and hardener mixing. 15 weight % of straightened coir fibre is placed over the mold. Then the resin and coconut shell powder mixture is poured into the mold. The roller is used to spread the resin over the coir fibre evenly. Then the top plate of the mold is placed over and is tightened. Then the load is applied evenly. After 24 hours, the resin and mixer are getting curing and combined which is called composite material. The composite material is separated from the mold material is tested as per ASTM standard.

C. Wear test

Wear occurs due to the surface contact between the two components. In these two components, one is fixed and other one is movable or both the components are movable in opposite direction. Controlling the friction and the wear during the movable member of the equipment is one of the critical factors in the industrial department. It is essential to contain the analysis of comparable data with the variables such as moisture, temperature and lubricant. The most universal test assemble utilize either a pin or a ball to press against the flat face of the disc.

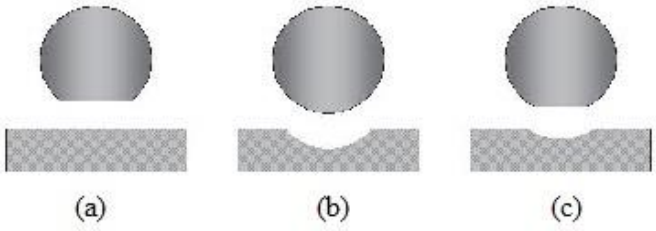

Fig.1 Pictorial representations of probable conditions of the wear occurrence in pin and disc

The wear occurs while the pin directly contact with the flat rotating disc. This can be occurs in three possible ways. The probable paths are (a) the wear occurs only in the pin, (b) the wear occurs only in the disc and (c) the wear occurs on both the pin and the disc.

The specimen is tested as per the testing standard ASTM G99 to investigate the abrasive wear rate. The force is applied on the flat rough surface rotary disc through the testing specimen. The testing specimen is weighted before the wear test. The testing specimen is held by the chuck. The rotating disc is has the abrasive paper with the grit size of 400μm. The normal load is applied to the testing specimen. The specimen is contacted with the rotating disc. Due to the contact between the specimen and rotating disc, the friction is occurs. The specimen is getting the wear. The testing specimen is soft compared to the rotating disc. This is the reason for the testing specimen to get the wear. The rotating disc speed is 2.0 m/s. The sliding distance is 100m. The load is applied in various ranges such as 5 N, 10 N, 15 N, 20 N and 25 N.

As per ASTM standard, determine the wear rate by measuring proper dimensions of both the specimens such as the ball and the disc before and after the experiment, or by means of weighing both the specimens in the pretest and posttest. During the test even the linear measurements must be noted down. Fig.2 is represented the schematic view of pin-on-disc arrangement.

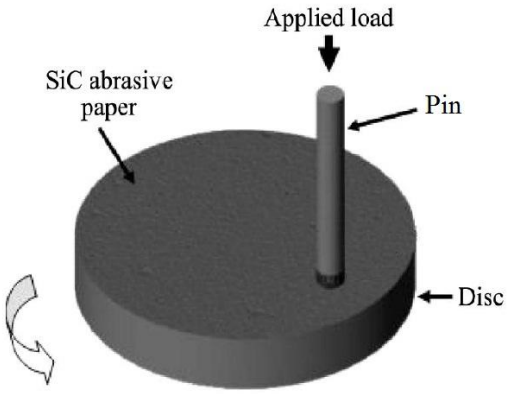

Fig. 2 Representation of pin-on-disc setup

Wear rate is calculated by the equation (1).

$$W.R=\frac{(Wb-Wa)}{(\rho \times Sd)} \quad \text{---------- (1)}$$

Where, W.R is the wear rate in cm^3/m, Wb and Wa are the weight of the specimens before and after the abrasion test in gm, ρ is the density of the composite and Sd is the sliding distance in m.

The cross sectional area of wear path is measures in different places in the wear path with the help of Stylus profilometer.

III. RESULTS AND DISCUSSION

Four specimens are prepared for the abrasive wear test. There are variations in the ingredients such as coir fibre (CF), coconut shell powder (CSP) and polyester resin (PR). Four specimens are as mentioned in below. Sample 1 contains polyester resin as 100% of weight. Sample 2 contains 30% weight of coir fibre and 70% weight of polyester resin. Sample 3 contains 30 weight % of coconut shell powder and 70 weight % of polyester resin. Sample 4 contains 15 % weight of coir fibre, 15% weight of coconut shell powder and 70% weight of polyester resin. Table I shows the variations in the wear rate of the various proposed composites for the different applied forces.

Table I
Wear Rate (Cm^3/M) Of Composites For Various Forces

Force in N	**PR**	**CF + PR**	**CSP + PR**	**CF + CSP + PR**
5	0.78	0.65	0.61	0.52
10	0.82	0.68	0.64	0.54
15	0.85	0.72	0.69	0.57
20	0.91	0.75	0.71	0.6
25	0.97	0.79	0.74	0.62

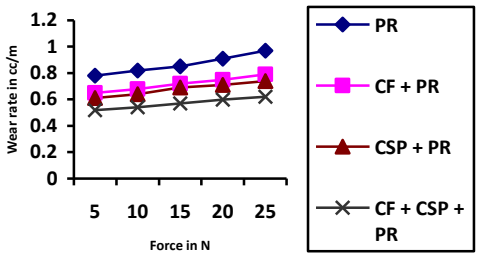

Fig.3 Graphical view of variations in wear rate for different load conditions

The wear rates are investigated in different loading condition for the various specimens. The results are mentioned in Fig.3 as a graphical representation. From the results, the wear rate is analyzed. The wear rate is gradually increases with the increment in the applied normal force. In general, the force is applied on the samples which get deformation due to the contact between the pin and flat rough surface rotating disc. When the applied force is increases the penetration of the pin on the disc is heavier. So the sample particles are worn out. This is the main reason for the increase of the wear rate while the applying force is increasing.

In sample 1 during the test, the polyester resin matrix particles wear out continuously. Because there is no addition of the reinforcement material and also the polyester resin matrix is soft. So the wear rate is higher while compare to the other samples. In sample 2, the coir fibre is incorporate with the polyester resin matrix. The coir fibre acts as a reinforcing agent. In the test, the polyester resin matrix is worn out immediately. But the coir fibre is resisting the occurrence of the wear. So the wear rate decreases compared to the sample 1.

Coconut shell powder and polyester resin are the ingredients in sample 3. In the test, the polyester resin matrix comes out in particles and also worn out the coconut shell powder. The polyester resin matrix is a soft material. So the matrix is worn out soon. In general, the powders have more hardness. Here the coconut shell powder is worn out in the testing. The coconut shell powder acts as a lubricant. So the wear rate is decreases even though the material gets hardened. During the test, the material produces the heat while causes the changes in the material properties.

In the sample 4, the coir fibre acts as a reinforcing agent and the coconut shell powder, as a lubricant. The above mentioned both the materials are incorporated with the polyester resin matrix. When conducting the test, the debris of the polyester resin matrix particles comes out along with the coir fibre and also the coconut shell powder particles are worn out. The coir fibre resists the wear whereas the coconut shell powder particles act as a lubricant. Both the materials increase the wear resistance in the composite in which the wear rate is minimum compared to the other proportion of the composite material.

IV. CONCLUSION

It is observed that the increase in the applied force results in the increase of the wear rate. Because whenever the applied force is increased, the friction between the contact surface of the material and the rotating disc is also increases.

Polyester resin matrix composite is a soft material which produces higher rate of wear out while functioning with neither coir fibre nor coconut shell powder.

The wear rate is reduced lesser with the addition of coir fibre in the polyester resin matrix composite which acts as a reinforcing agent.

The addition of coconut shell powder with the polyester resin matrix composite is to decrease the wear rate, since it acts as a lubricant. If the addition of coconut shell powder is increased the material gets harder which produces the heat.

All the above testing show the increase in the wear resistance while adding both the coir fibre and coconut shell power with the polyester resin matrix composite in which the coir fibre acts as reinforcement material and the coconut shell powder acts as lubricant. So the wear rate is decreases.

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