EVALUATION OF WEAR PROPERTIES OF INDUSTRIAL WASTE(SLAG) REINFORCED POLYPROPYLENE COMPOSITES

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Abstract - Lot of waste is produced by industries and they are piled up on land which creates land and environmental problem. Government policies and regulations force us to look for alternatives. Therefore researchers are trying to utilize these wastes as reinforcement in composites. Slag is an industrial waste reinforced in polypropylene composites. Wear resistance of material is an important requirement for many of the industries like automotive, aircraft and aerospace. The effects of variation in sliding velocity and applied load on the wear behaviour of polymer composites are studied in the present work. Composite specimens are prepared by injection moulding machine with varying particulate weight percentage of 0%, 10%, 20% , 30% & 45%. The pin-on disc wear testing machine has been used to study the friction and wear behaviour of the polymer composites. The wear loss and coefficient of friction are plotted against the normal loads and sliding velocities.

Keywords—Polymer composite, wear, coefficient of friction, industrial waste

I. INTRODUCTION

Environmental awareness today motivates the world wide researchers on the studies of industrial waste reinforced polymer composites. The availability of industrial waste and government regulations have promoted researchers to try for industrial waste reinforced composites. With low cost, ease of manufacturing and high mechanical and other properties, industrial waste represents a good alternative to the most common composites. By appropriate usage of these industrial wastes, physical and mechanical properties of the conventional polymer materials will be enhanced. The role of the reinforcement in a composite material is fundamentally one of increasing the mechanical properties of the neat resin system e.g. in a continuous fiber-reinforced composite, the fibers provide virtually all of the strength and stiffness. All of the different fibers used in composites have different properties and so affect the properties of the composite in different ways.

The slag is reinforced with polypropylene due to its low density, high corrosion resistance, ease of fabrication and low cost. The major advantages offered by polymer composite materials are their increased specific strength, stiffness, high hardness and wear resistance. The low coefficient of thermal expansion, superior dimensional stability, versatility to designer, good forming characteristics, easy availability of cheaper reinforcements along with the availability of comparatively low cost, high volume production methods are the additional advantages.

Polymers have generated wide interest in various engineering fields including tribological applications, in view of their good strength and low density as compared to monolithic metal alloys. Being lightweight they are the most suitable materials for weight sensitive uses, but their high cost sometimes becomes the limiting factor for commercial applications. Use of low cost, easily available fillers is therefore useful to bring down the cost of components. Study of the effect of such filler addition is necessary to ensure that the mechanical properties of the composites are not affected adversely by such addition. Available references suggest a large number of materials to be used as fillers in polymers [1]. The purpose of use of fillers can therefore be divided into two basic categories; first, to improve the mechanical, thermal or tribological properties, and second, to reduce the cost of the component. There have been various reports on the use of materials such as minerals and inorganic oxides (alumina and silica), mixed into widely used thermoplastic polymers like polypropylene [2, 3] and polyethylene [4, 5]. But very few attempts have indeed been made to utilize cheap materials like industrial wastes in preparing particle-reinforced polymer composite.

Many attempts have been made in the past to study fiber reinforced composites for tribological applications. Reference [6] investigated the influence of graphite inclusion on the friction and wear behaviour of moulded epoxy resin using pin-on-disc wear unit under dry sliding conditions. They concluded that the tests conducted on the composite containing 3 wt % or more of graphite yielded extremely small amounts of wear. Hard powders are reinforced in epoxy matrix [7]. They investigated the wear resistance of three types of composite materials containing epoxy resin matrix, epoxy filled with silica and epoxy filled with tungsten carbide powders and observed that the matrix filled with the tungsten carbide powders had highest value of wear resistance in more severe wear conditions. Reference [8] presented an experimental study on friction and wear behaviour of C-E and G-E composites when sliding against a hardened steel counter face under various loads and sliding velocities using pin-on-disc wear test machine. They concluded that increasing in sliding velocity or decreasing in load results in lowering the coefficient of friction and the slide wear behaviour of C-E sample are superior to G-E samples. Influence of coupling agent on abrasive wear behaviour of jute fiber-reinforced polypropylene composites are studied [9]. Reference [10] investigated friction and wear behaviour of fly ash filled vinyl ester resin matrix composites and also the unfilled resin, under three different normal loads using pin-on-disc wear test machine. They observed better wear resistance for 40% filled composites with a lower wear loss and a minimum value of the coefficient of friction. They also observed that the difference between the coefficients of friction of 40% and 50% filled composites decreased with the increase in the normal load. Tribological performance of sugar cane fiber-reinforced polyester (SCRP) composites are investigated [11]. Their wear test results revealed that the SCRP composite is a promising material for adhesive wear applications. Flue dust is reinforced in unsaturated polyester and studied wear behaviour [12]. Addition of filler increases wear resistance.

The wear resistance of material is an important requirement for many of the components. In the present work wear behaviour of polymer composites with different tests were studied.

II. EXPERIMENTAL DETAILS

A. Materials used

Slag an industrial waste, collected from LANCO industries, Srikalahasthi, India. This material sieved to obtain a particle size in the range 0-25µm. Matrix material consist of polypropylene (H110MA) supplied by reliance industries limited, Hyderabad. India.

B. Specimen Preparation

Slag particles of 25µm in size are weighed with proper ratio of (10%, 20%, 30% & 45%). This percentage of slag mixed with polypropylene pallets to form a slag composition. This slag composition of weight ratios is poured in to the 2.5 ton hydraulic injection moulding machine, model JIM-1supplied by texier plastics limited, Coimbatore, India. Slag composites of different weight fractions are prepared under a pressure of 1100 kgf at 210ºc temperature. A mild steel die has been used for this purpose. Die cavity dimensions are 100mm in length and 10mm in diameter. Specimens of suitable dimension are cut for further physical characterization and wear test. The contact surface of the specimen is polished with an emery paper of 600 grit size to ensure uniform contact with the rotating disc.

C. Experimental Procedure

Experiments have been conducted in the Pin-on-disc type friction and wear monitor (DUCOM) with data acquisition system which was used to evaluate the wear behavior of the composite, against hardened ground steel disc (En-32) Surface roughness (R_a) 0.5µm. It is versatile equipment designed to study wear under sliding condition only. Sliding generally occurs between a stationary Pin and a rotating disc. The disc rotates with the help of a D.C. motor; having speed range 0-2000 rev/min with wear track diameter 100 mm, which could yield sliding speed 0 to 10 m/sec. Load is to be applied on pin (specimen) by dead weight through pulley string arrangement. Wear tests have been conducted at different sliding velocities (50cm/s, 75cm/s and 100cm/s) by applying normal loads of 4 Kg, 6 Kg and 8 Kg.

III. RESULTS AND DISCUSSION

Table 1 shows weight loss between the rotating disc and the stationary specimen pin in the case of slag reinforced in polypropylene at different loads, weight fractions and at 50 cm/s velocity. Figure 1 shows graphical representation of results shown in table 1. From the graph it is observed that with the increase in load weight loss decreases. It is also observed that the addition of filler weight loss increases. Table 2 & 3shows weight loss at 75 & 100 cm/s sliding velocity respectively. From the figures 2, and 3, it is observed that increase in sliding velocity weight loss also increases.

Table 1: Weight loss at different loads and at 50 cm/s sliding velocity.

Load(Kg)	0%	10%	20%	30%	40%
4	4.6	4.7	5.4	5.2	5.6

6	4.3	4.5	4.6	4.7	4.4
8	2.4	3.3	3.5	3.8	4.2

Table 2: Weight loss at different loads and at 75 cm/s sliding velocity.

Load(Kg)	0%	10%	20%	30%	40%
4	5.3	5.5	5.6	5.7	5.8
6	4.6	4.7	4.8	4.9	5.1
8	2.5	3.6	3.7	4.5	4.9

Table 3: Weight loss at different loads and at 100 cm/s sliding velocity.

Load(Kg)	0%	10%	20%	30%	40%
4	5.6	5.8	6.1	6.4	6.5
6	4.3	4.8	5.2	5.6	5.8
8	2.7	3.7	4.3	4.6	5.1

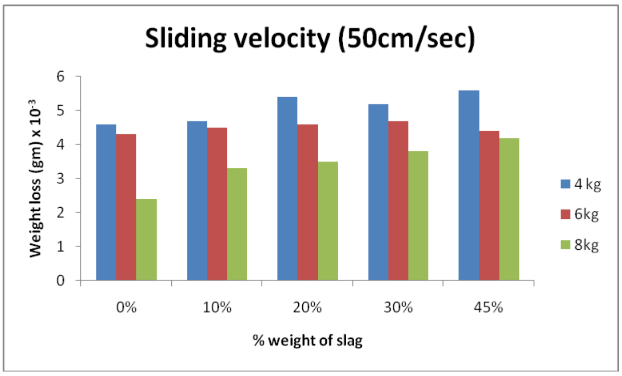

Figure1: Weight loss at different loads and at 50 cm/s sliding velocity

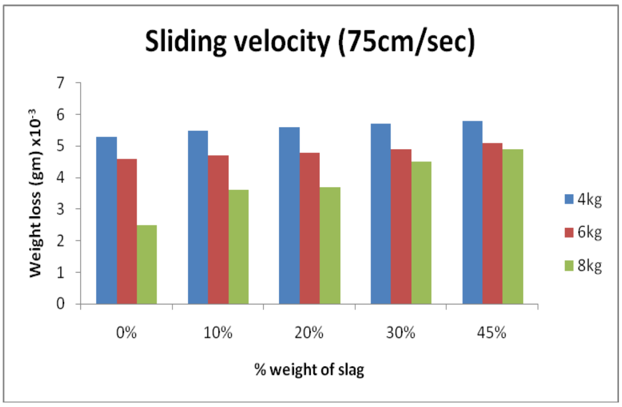

Figure2: Weight loss at different loads and at 75 cm/s sliding velocity

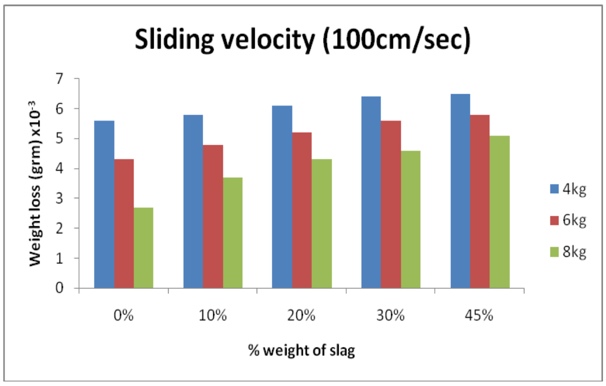

Figure3: Weight loss at different loads and at 100 cm/s sliding velocity

Table 4 shows the friction coefficients between the rotating disc and the stationary specimen pin in the case of slag reinforced in polypropylene at different loads, weight fractions and at 50 cm/s velocity. Figure 4 shows graphical representation of results. From the graph it is observed that with the increase of load coefficient of friction decreases. It also shows that addition of filler increases the coefficient of friction upto 30%. Further addition of filler ie at 45% coefficient of friction decreases. Figure 4 and 5 represents coefficient of friction at 75cm/s and 100cm/s respectively. It is observed that the coefficient of friction increase with the addition of filler upto 30% at 75cm/s sliding velocity. At 45% coefficient of friction reduces. However at 100cm/s coefficient of friction is increasing with the addition of filler.

Table 4: Coefficient of friction at different loads and at 50 cm/s sliding velocity.

Load (Kg)	0%	10%	20%	30%	45%
4	0.5335	0.53625	0.5972	0.6097	0.5252
6	0.5088	0.5330	0.5615	0.6050	0.5206
8	0.4263	0.5227	0.5340	0.5473	0.5098

Table 5: Coefficient of friction at different loads and at 75cm/s sliding velocity.

Load (Kg)	0%	10%	20%	30%	45%
4	0.5365	0.5380	0.6195	0.6270	0.6190
6	0.5216	0.5335	0.5925	0.6135	0.5628
8	0.4771	0.5303	0.5921	0.6002	0.5628

Table 6: Coefficient of friction at different loads and at 100cm/s sliding velocity.

Load (Kg)	0%	10%	20%	30%	45%
4	0.6087	0.6212	0.6357	0.6492	0.7667
6	0.58116	0.5861	0.6121	0.6188	0.6593
8	0.5658	0.5701	0.5718	0.5735	0.6197

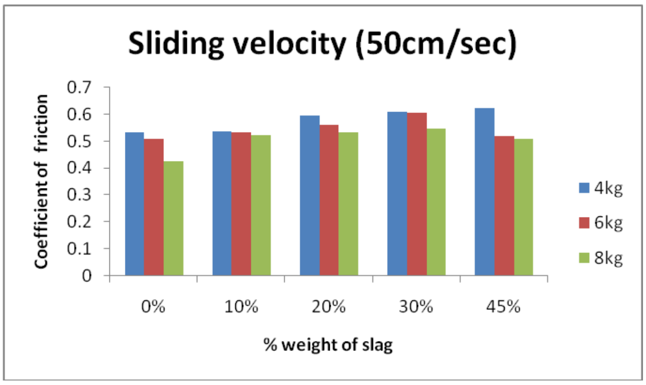

Figure 4: Coefficient of friction at different loads and at 50cm/s sliding velocity

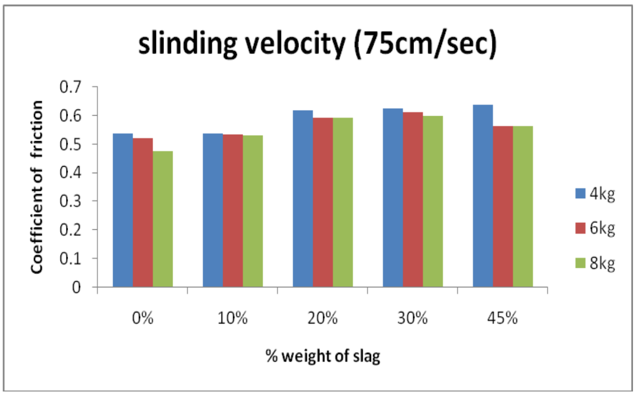

Figure 5: Coefficient of friction at different loads and at 75cm/s sliding velocity

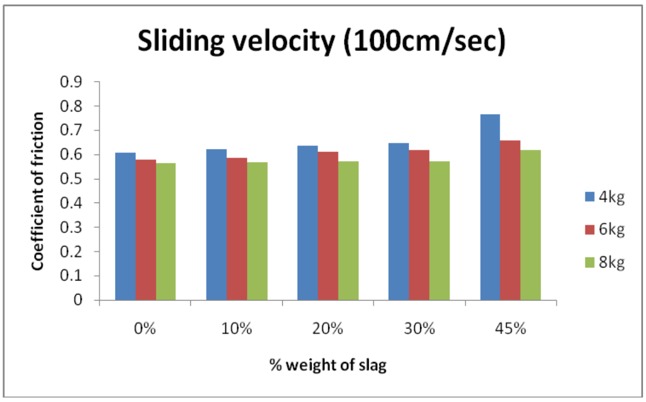

Figure 6: Coefficient of friction at different loads and at 100cm/s sliding velocity

IV. CONCLUSION

Based on the present study the following conclusions are drawn

- Slag, an industrial waste, can be used as a potential filler material in polypropylene
- It has significant effect on wear properties of composites.
- Incorporation of filler results in increases in weight loss and coefficient of friction of slag composites.
- Wear loss and coefficient of friction of slag composites decreases with the increase in normal loads.
- Wear loss and coefficient of friction increases with the increase in sliding velocities.
- In future, this study can be extended to other industrial wastes reinforced with polypropylene composite materials.

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