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Study of Three Body Abrasive Wear Behavior of Glass Fiber– Polyester Composite at Different Filler Loading

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Abstract: The use of graphite as a filler material on three-body abrasive wear behavior of glass fiber – unsaturated polyester composites has been tested and analyzed. Dry sand abrasion test was carried out at 200rpm, a standard speed. The test was carried out at 23 and 33N loads by varying the abrading distance from 270 to 1080m in increments of 270 m. The worn-out samples were measured for there volume losses by a precise digital weighing balance. The wear losses in glass fiber-unsaturated polyester composite in which, graphite filler was used, which showed good resistance towards wear at specific percentage of it. The studies indicate the reason for good wear resistance is due to varying percentage of graphite filler in this composite material.

Key Words: Abrading distance, polyester, graphite, filler.

1. Introduction

In mechanical components such as gears, cams, bearings, bushes, bearing cages, etc polymers and the composites present in that form a very vital class of tribo-engineering materials and are used where the wear performance in not in lubricated condition and it is a important parameter for the material selection (Hutchings, 1992). In many applications, Polymer composites are subjected to abrasive wear (Harsha and Tewari, 2002). Abrasive wear is a type of wear, in which under load hard asperities on one surface slide across a soft surface, penetrate and take away material from the soft surface, leaving grooves (Gates, 1998). In mining and earth moving equipment's, chute liners in power plants most of the abrasive wear problems arise.

Three-body abrasive wear is of reasonable practical importance, for example in coal handling apparatus's in gear pumps handling industrial fluids and agro- cultural machine modules, but appears to have received less care than a two-body abrasion. Very little is reported on the effect of fiber reinforcement on three-body abrasive wear performance of polymer composites (Budinski, 1997; Chand et al., 2000; Tripathy and Furey, 1993).How could such composites achieve in abrasive wear situations, needs a proper indulgent.

In latest years, much research is dedicated to exploring the potential gain of thermoset matrix for combined applications (Cirino et al., 1988; Suresha et al., 2007). Polyester is one such matrix, which has a place in the family containing the thermoset engineering polymers owing to its type of inexpensive, relaxed processing and durability. Polyester resin is a Synthetic resin, in its viscous form, they are highly flammable and skin irritant – something we expect from a styrene based fluid. Manufactures mix their own blend of cobalt and other conditioner addivities to help the curing process; they are compatible with any type of fiber glass. Notable advance in the polymer industry has been the use of fiber and particulate fillers as reinforcements in polymer matrix (Bijwe et al., 1999; Ramsteinerand Theysohn, 1984). Particulate fillers are of substantial interest, not from an economic lookout, but as modernizers especially the physical assets of the polymer.

The properties of filler used are as shown in Table. This filler chosen cover a range of physical properties.

SL. No	Property	Range
1	Bulk Density (g/cm^3)	1.3 – 1.95
2	Porosity (%)	0.7 – 53
3	Modulus of Elasticity (Gpa)	8 – 15

4	Compressive Strength (Mpa)	20 – 200
5	Flexural Strength (Mpa)	6.9 – 100
6	COTE ($x10^{-6}$ °C)	1.2 – 8.2
7	Thermal Conductivity (W/m k)	25 – 470
8	Specific Heat (J/KgK)	710 – 830
9	Electrical Resistivity (Wm)	$5x10^{-6}$ – $30x10^{-6}$

The above results are based on, either arbitrarily oriented or unidirectional oriented fiber amalgams. Woven fabric-reinforced mixtures are gaining acceptance because of their stable properties in the fabric plane as well as their ease of management during fabrication (Viswanth et al., 1991) and Mody et al. (1988) have shown that the concurrent existence of parallel and perpendicular oriented carbon fibers in a woven shape leads to a synergistic result on the improvement in the wear resistance of the given composite. The aim is a better understanding of the part of particulate fillers (graphite) in glass fiber strengthened unsaturated polyester matrix amalgams under various abrading distances/loads for tribological applications.

2. Experimental details

2.1. Experimental materials and manufacturing method

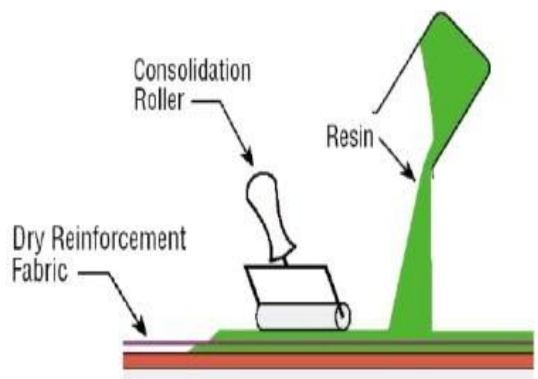

Figure 1. Schematic diagram of Hand Lay-up Method.

Glass fiber woven mate (E-glass and Density 200 g/cm^3) in unsaturated polyester composite was being used as a strengthening material. The matrix substantial of unsaturated polyester resin and Methyl ethyl ketone peroxide (MEKP) as accelerator and cobalt as a catalyst and graphite as a filler material were used, respectively. The properties of filler that are used are as shown in Table 1. The filler is chosen to cover a series of physical properties.

With respects to the processing, on large granite stone, a release film existed placed first and it were coated with anti-adhesive agent. On top of that, Glass fiber woven mat is placed, on which a blend of matrix system (comprises of matrix material of unsaturated polyester resin and Methyl ethyl ketone peroxide (MEKP) as accelerator, plus cobalt as a catalyst and plus graphite as a filler material) is covered with help of a hand brush. Dry hand lay-up method was employed to manufacture the composites. The piling procedure was followed by placing of the glass fiber woven mat one above the other along with the mixture arranged well on it and casing film was again used to finish the stack. To guarantee approximate depth of the sample, a 2.5mm spacer was used. At the end again release film coated with anti-adhesive agent was being kept and on it another large granite stone was again placed over it to apply enough load on it was also coated with anti-adhesive agent in order to help the ease of parting on curing. Enough load was guaranteed and then it was allowed to cure for a time at room temperature. Dry sand Abrasion test samples according to ASTM G65 (ASTM,1994)of size 75mm × 25mm ×6mm were prepared from the cured sheet using cut-off machine.

2.2. Abrasive wear test:

The figure of dry sand abrasion test set up is as shown in Figure 2. Silica sand is used as the abrasive in the present study. The abrasive particles of two hundred microns of silica sand were angular in shape along with sharp edges. The abrasive fed at the contacting face between the rotating rubber wheel and also the test sample. The trials were lead at a rotational speed of 200 rpm.

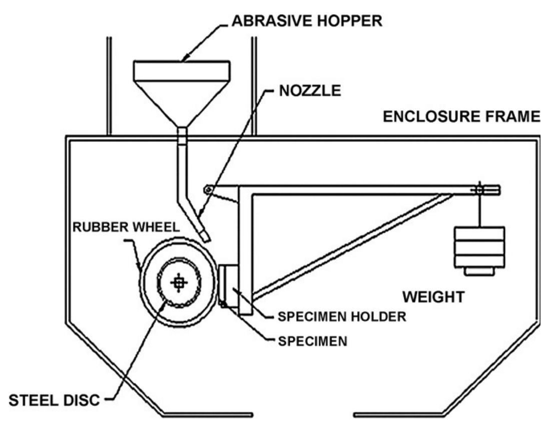

Figure 2. of Dry sand abrasion Testing Unit.

The sample was washed with acetone. Its original weight was dogged in a high precision digital balance (0.1mg accuracy, Mettler, TOLEDO) before it was astride in the sample holder. The abrasives were presented between the test specimen and also rotating abrasive wheel consisted of chlorobutyl rubber tyre (hardness: Durometer-A 58-62). The rubber wheel used is of the diameter of 210mm. The test specimen was pushed against the rotating wheel at a definite force by means of lever arm whereas a controlled flow of abrasives scrapes the test surface. The spin of the abrasive wheel was such that its contacting face moves along with the direction of sand flow. The pivot axis of the lever arm lies in a plane that is approximately tangent to a rubber wheel surface and also normal to the horizontal diameter along which the load is put. In the end of a set test duration, the specimen was removed, thoroughly cleaned and again weighed (final weight). The difference in weight after and before abrasion is noted. At least four tests was performed at specific percentage of graphite filler materials and on the average values which is obtained are used in this case study. For loads of 23N and 33N the experiments were carried out. Further the abrading distances were varied in the steps of 270m from 270 to 1080 m. For the second longer duration test example 540m distance, For the third longer duration test example 810m distance the abrasion tests were carried out on the same wear track where first (i.e., 270 m) shorter runs were used. The wear was measured by the loss in weight.

3. Results and discussion

3.1. Abrasive wear volume Loss

The figure 3 (a) & (b), shows the wear loss in volume of the samples at 23 and 33N loads, respectively. It is clear from these graphs that for all the polymer composites used in this study there is a near linear wear volume loss with abrading distance. It indicates a steady-state wear with a constant wear rate. The highest wear volume is for graphite filler with 6% and 9% and the lowest is for 3% glass fiber – unsaturated polyester composite. In these graphs for different percentage of graphite filler with glass fiber – unsaturated polyester composite. There is an increase in good abrasion resistance for 3% of graphite as filler.

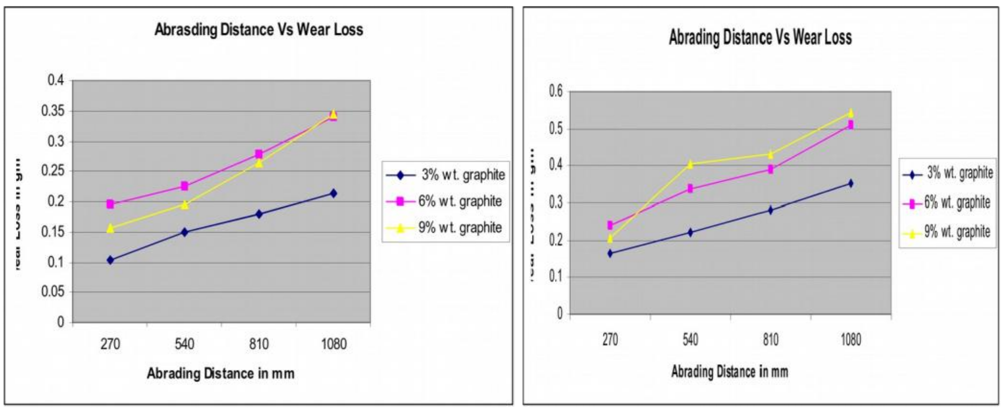

Figure 3. Wear Loss Vs Abrading Distance at different loads.

The effect of fibers and/or fillers on the abrasive wear resistance of clean polymer is much composite and random and mixed trends are stated (Lancaster, 1972; Sole and Ball, 1996). Lancaster (Lancaster, 1972) deliberated 13 polymers strengthened with 30% short carbon fiber and reported that reinforcement enhanced the wear performance of seven composites and that of six composites depreciated. Sole and Ball (1996) studied the consequence of mineral fillers such as talc, CaCO3, BaSO4, and fly ash on abrasive wear of resistance of polypropylene (PP). They stated that the addition of mineral fillers to the PP matrix declines the wear resistance beneath unadorned abrasion conditions. But, below mild abrasion situations the outline and mass of the reinforcing filler influences the wear performance.

Conclusions

After abrasive wear studies of varying percentage of graphite as a filler material in glass fiber – unsaturated polyester composites, the subsequent conclusions are drawn:

- Abrasive wear volume increases with increase in abrading distance/loads for all the samples. However, the 3% graphite as a filler material in glass fiber – unsaturated polyester composite showed better abrasive wear resistance.

- Abrasive wear rate is higher in 6%and 9% of graphite as a filler material in glass fiber – unsaturated polyester composite.

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