Dual-Body and Triple-Body Rubbing Wear Behavior of Polyamide66 Composites as a function of Fiber and Filler Loading

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***Abstract*: This paper investigates the effects of fiber and filler addition on the rubbing wear changes of polyamide66 (PA-66)composites on two and three bodies. Polyamide66 (PA-66) +Polytetrafluoroethylene (PTFE), (PA-66+PTFE+GF) and (PA-66+PTFE+GF+SiC+Al2O+MoS_2+nano fillers) were employed to investigate the rubbing wear behavior phenomenon. Abrasive wear tests were performed using several grades of Sic abrasive paper at various abrading distances (1, 2 and 3 m) and a constant load of 10 N. (80 and 150 grit size). Using a rubber wheel abrasion test setup made of dry sand, low stress (triple-body) rubbing wear tests on (PA-66) composite was conducted. Experiments were performed using angular silica sand with a experimental size of 212 as the dry and loose abrasive, at a speed of 200 rpm with a continuous load of 40 N, at varied abrading distances (150, 300, and 450 m). PA-66 loaded with PTFE outperformed other composites in terms of wear resistance.**

Keywords:- Polyamide66 (PA-66), Polytetrafluoroethylene (PTFE), Three body abrasive wear.

I. INTRODUCTION

Due to its exceptional qualities such as lightweight, great strength, no complex of production, low cost, and great thermal steadiness, along with solvent resistance, engineering polymers are widely employed at mechanical engineering as structural applications [1]. Polymer composites are employed in a variety of applications, including bearings, pipelines, cams, and brakes, as well as the automobiles, aero field, sports, and electrical industries. Wear is described as Relative motion between contacting surfaces causes harm to a solid body surface, which commonly results in material loss. Material qualities, experimental circumstances, and the wear system all influence wear.

Abrasion, adhesion, erosion, fretting, and fatigue are the five basic forms of wear that are typically encountered in practical circumstances [2]. Rubbing wear is one of most important of all types of wear, since it accounts for over 63 percent of all wear costs in factories [3]. Rubbing wear can be one or more than two bodies, or both- body rubbing. Two body fixed rubbing wear is defined as wear caused by a hard bump on one surface that can only pass through the other or by the rolling and sliding of hard free particles on solid surfaces, whereas two body free abrasive wear is defined as wear caused by rolling and sliding of hard free particles on solid surfaces [4]. In a triple-body system, particles are caught between two solid surfaces, because only about 10% of the time, The solid surfaces between which the loose abrasive particles are positioned while sliding are abraded by the loose abrasive particles. while they spare about 90% of the time rolling in dual-body abrasive wear, the amount of material removal is one order of magnitude lower than in dual-body fixed rubbing wear [2,4]. dual-body abrasives are permanently Triple-body abrasives are free to roll, emphasizing the presence (triple-body) or lack (dual-body) of a distinct counter face present as a second body supporting the abrasive. [5].

Three alternative material combinations were created using a plastic injection molding technique. The primary purpose of this research was to compare wear patterns. [7] of the materials under dry sliding against Sic abrasive paper (two-body) and under three-body condition against rubber wheel [8], in order to investigate the effect of fiber and fillers on tribological performance and wear mechanism of PA-66 based composites. The impact of fiber, fillers, lubricant, and nano fillers on three-body and two-body features of PA-66 composites was studied in this study, and it was discovered thatthe PA-66+PTFE ratio had a greater impact on wear resistancethan the adding of fiber and fillers to the PA-66 composite. According to the study, increasing in the abrading distance.

II. EXPERIMENTAL WORK

A. Materials

Polyamide66 (PA-66) was chosen as a main thermoplastic in this study because it is widely utilized on injection molded components and has powerful commercial advantages such as decreased manufacturing costs. The high mechanical strength, stiffness, and superior wear resistance of glass fibre reinforced material (GF) make it an appealing choice for bearing applications. To reduce friction and wear, PTFE is utilised as a thermoplastic polymer with max strength, toughness, and self-lubrication. Fillers such as Sic and Al2O are included to composite materials to reduce usage of high costly binder materials are to improve the strength, hardness, and other qualities of the combination material The solid lubricant molybdenum di-sulphide (MoS_2) is well-known. To boost performance, nano fillers are used. PT (PA-66+PTFE), GPT (PA-66+PTFE+GF), and FGPT (PA-66+PTFE+GF+SiC+Al_2O+MoS_2+nano fillers) were the three compositions used in this study.

B. Techniques

Figure-1, a multi-pass two-body abrasive wear tester rig machine used for abrasive wear on two bodies (bi-directional single pass condition) tests (as per ASTM G-99 standards, make: magnum engineers, bangalore). the test specimen was made by punching a circular surface and glueing it on a pin with an 8mm diameter and a 25mm length. the water proof abrasive paper sic, which was placed on a stiff plate, was used to abrade the composite sample. the test sample is abraded by the inserted hard sic particles [9]. the pin assembly was first weighed in an electronic balance to an accuracy of 0.0001g (mettler toledo). the difference between the original and end weights is used to compute sliding wear loss.

Figure.1: Schematic diagram of multi-pass two bodyrubbing machine tester rig.

Triple body rubbing wear investigations of PA-66 and their composites were performed on a dry sand/rubber wheel abrasion test. (RWAT) rig (TR-50-M1, DUCOM, Bangalore) as shown in figure 2.

Figure.2: Rubbing wear testing equipment using dry sandand rubber wheels

1.Nozzle, 2. Rubber-coated wheel, 3. Specimen, 4. Silica sandis a type of sand that is made up of silica, 5. Assistive device,

6. Weights.

This exam was thought to be the most accurate representation of the real tri-bo system. The sample was inserted in a specimen holder and forced against a rotating wheel by a lever arm at a specific force. Between the test specimen and the rotating wheel with chloro-butyl rubber tyer, abrasives were introduced. A hopper in the abrasive feeding system allows silica sand to flow down a narrow throat and on to the silica wheel via gravity. A motor rotated the silica wheel through a timing belt, and the motor speed determined the rate of silica sand discharge. Thecontact face of the rubber wheel turned in such a way that the sand flow changed direction. The lever arm's pivot axis is perpendicular to the rubber wheel surface and parallel to the horizontal diameter along which weight is applied [10]. The bearer of the specimen was meant to ensure that samples were taken and changed throughout each test, ensuring that the wear scar remained in the same location. The wear was calculated by converting the weight loss into wear volume using the density data acquired.

The wear volume (ΔV) was determined using the following formula:

$$\Delta V = M/D \text{ mm}^3 \quad (1)$$

M is mass loss in grams, D is the density in gm/mm^3

The specific wear rate (Ks) was calculated from the equation

$$Ks = V/(L*D) \text{ mm}^3/\text{Nmm}.$$

Where V is the volume loss in m, L is the load in Newton andD is the abrading distance in meters

III. RESULTS & DISCUSSIONS

Dry sliding rubbing wear volume

Figures 3(a) and 3(b) demonstrate the changes in rubbing wear volume of composites worn on 80 and 150 grit Sic paper at 10N against varied abrading distances in a bi- directional single pass condition (in a two-body wear test). The wear volume of the composite increases linearly with increasing abrading distances and is substantially influenced by the grit size of the abrasive paper, according to the wear data.

Table 1: In this investigation, the test conditions were

Test framework	Two-bodytest	Three-body test
Load	10 N	40 N
Speed	200 rpm	200 rpm
Distance	1, 2, and 3m	150 300 and 450 m
Size of the specimen	6 mm x 2.5mm	61 mm x 40 mm
Abrasivepaper/ particles	Sic of 80 and 150 gritsize	Silica sand, angular 212µm
Sand flowrate	-	343 ± 5g/min
Diameter of rubber wheel	-	228.6 mm

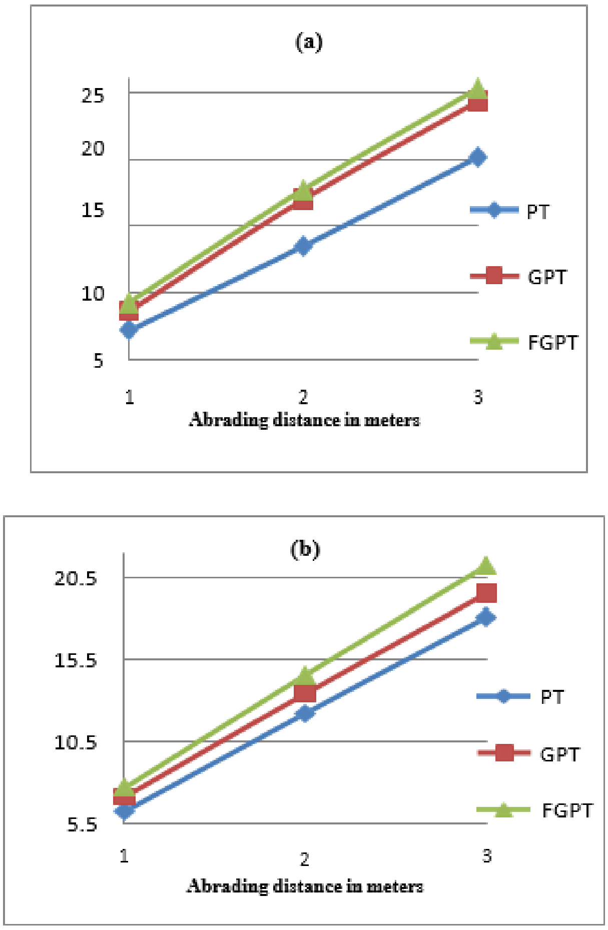


Figure.3: Wear volume variation under varied abrading conditions distances of PA-66 composites at (a) 10 N, 80 grit SiC paper and (b) 10 N, 150 grit SiC paper.

Figure.3 With increasing abrading distances, the number of composites worn on two different surfaces Sic sheets rose. The wear volume of PT is substantially lower than that of other composites, and it also grew as the percentage weight offiller was increased. Furthermore, specimens worn on 80 gritsSic have the maximum wear volume.

As shown in figure 3, the wear volume of the composite is 13.82% times higher in 80 compared to 150 grit size. The wear volume is less in PTFE filled with PA-66 because of self-lubricating nature of PTFE.

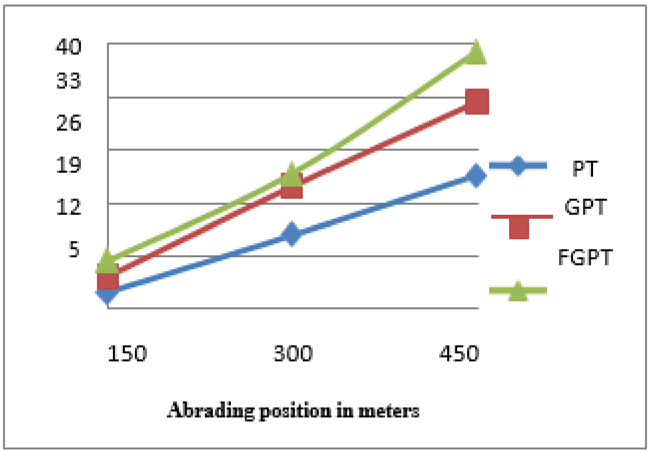


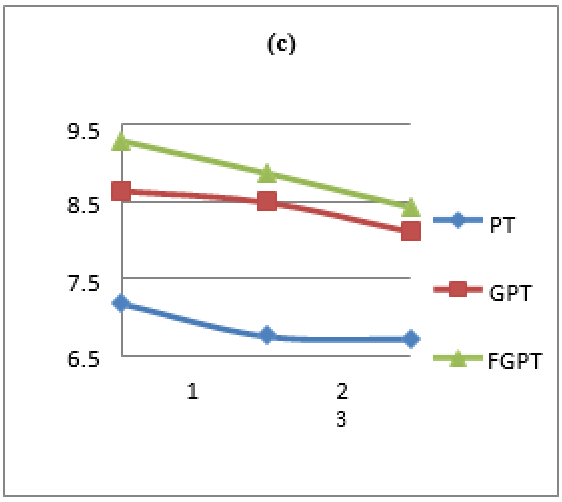
Figure 4. Changes in wear volume of PA-66 composites at40 N load versus varied abrading distances

Figure 4 shows the relatively behavior of all the composites erode at various positions with a sliding speed of 200 rpm and a weight of 40 N. Wear volume rises in a linear relationship with abrading distance and is heavily impacted by induced load. The neat PT had the least amount of wear, whereas the other composites had a lot. Sand particles collide with the polymer matrix, which eventually wears away from the surface, leaving a roughened, worn surface. There has been very little work on triple-body abrasive examinations of polymers and their composites, according to the literature survey [11-13]. Budinski [10] Abrasion resistance was examined of 21 different polymers and discovered that polyurethane outperformed the rest. Engineering polymers that are hardened and filled were likewise found to have insufficient rubbing resistance to silica sand (215–300 m).

Giltrow [14] tried to establish a link between thermoplastic polymer rubbing wear rates and cohesive energies (cohesion between polymer chains). The complicated high strain rates involved in the abrasion process, nature of polymeric materials, and decreased polymer chain mobility were all blamed for the non-linear relationship. Giltrow [15] also stated that thermoplastic polymers having a high degree of crystallinity and high cohesive energies are possible to have good abrasion resistance. Amorphous polymers, on the other hand, have lower cohesive energy and abrasion resistance. In this investigation, PT outperformed other thermoplastic materials in terms of abrasive wear resistance. Voss and Friedrich [15] found that harder thermoplastic matrices had greater abrasive wear resistance than fragile thermoplastic matrices. The literature has shown that thermoplastic polymers are more resistant toabrasive wear than thermosetting polymers.

Dry sliding abrasive specific wear rate

Figures 5 demonstrate the comparison of specific wear rates of PA-66 and its composites as a function of varying abrading distances under dual-body and triple-body rubbingwear circumstances. Under one pass conditions, the specific wear rate (Ks) for two-body rubbing wear decreases non linearly with increasing abrading distances, whereas thespecific wear rate (Ks) for triple-body abrasive wear increases non linearly with increasing abrading distances



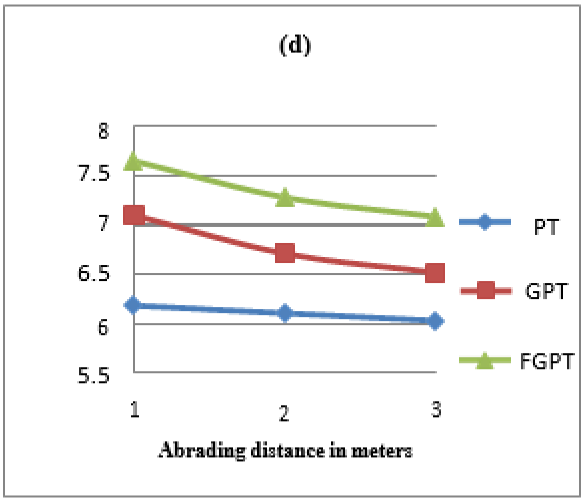


Figure 5. Changes in the specific wear rate of PA-66 composites with different abrading distances at a load of 40N

When triple-body abrasive wear occurs, the for all materials, a particular wear rate increases as the load increases. The material weakens slightly as a result of the rapid sliding speed, causing crack propagation. subsequently, the specific wear rate rises.

IV. CONCLUSIONS

The following conclusions can be made from experimental observations of dual and triple body abrasive wear of PA-66 based composites.

- For dual-body (single pass condition) and triple-body rubbing wear, wear volume increases linearly with increasing sliding distance
- Figure 3 shows the All composites abraded under dual & triple body rubbing wear were compared in terms of wear performance. situations at various distances. When compared to the other two rubbing wear conditions, the two-body abrasion one pass condition (grit size 80) was found to be more effective in removing material.
- It was noticed that dual-body rubbing wear (one pass condition) has a higher specific wear rate than triple-body rubbing wear. The particles or asperities in the dual-body rubbing process are tightly attached to the secondary body, but the abrasiveparticles in the triple-body rubbing process are free to roll. Dual-body rubbing is projected to result in higher wear rates than triple-body abrasion. abrasion conditions because the rubbing particle and the wearing surfaces make sliding rather than rolling contact.

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