

WEAR BEHAVIORS OF PTFE REINFORCED PA 66 JOURNAL BEARINGS

M. Turan DEMİRCİ

Faculty of Technical Education, University of Selcuk, Alaaddin Keykubat Kampusu, Konya, Turkey
e-mail: turandemirci@selcuk.edu.tr

H. DÜZCÜKOĞLU

Faculty of Technical Education, University of Selcuk, Alaaddin Keykubat Kampusu, Konya, Turkey
e-mail: hayduzcukoglu@hotmail.com

Abstract

In this study, the effect of sliding velocities, bearing pressure and temprature on friction and wear journal bearings made of PA 66, PA 66 + %18PTFE and PA 66+%20 GFR+%25 PTFE composites were examined at the room temperature conditions. The results of experimets are presented in graphics which proves that the coefficient of friction and wear rate are affected by forming film, increasing temperature, pressure and velocities depending on GFR and PTFE mechanical properties. There are many factors and their widely fluctuation characters on the polymer friction and wear behaviors. The best wear behavior was seen at the PA 66+%20 GFR+%25 PTFE journal bearing.

Keywords: Journal bearing, friction, wear.

INTRODUCTION

Over the past decades, polymer composites have been widely used as structural materials in automotive, manufacturing, aerospace and chemical industries to provide lower weight alternatives and self lubrication to traditional metallic materials. These applications in the many industry sectors are concentrated on tribological machine parts, such as gears, cams, bearings and seals, due to their many advantages of polymer composites as self lubrication [1].

The major problem of the metal journal bearing using at the marine applications is the seizure problem between the journal and bearing when the lubricant film is broken under the heavy pressures, low velocities start and stop periods. In addition, for designing polymer bearings, decision of optimal dimensions and selection of material for a long life and getting lower friction are other problems To solve these problems, polymer composites bearing are widely used many areas. Because the friction coefficients of polymer bearings are lower than metallic bearings under the defined above conditions. However, the polymer materials have low mechanical properties, such as low mechanical

strength, low thermal conductivity and large thermal expansion. Therefore polymer bearings have limited the wide applications. In order to overcome these low mechanical properties of neat polymer, reinforcement fiber are usually embedded in polymers to make composites [2-3].

PTFE (Polytetrafluroethylene) has low coefficient of friction and high termal stability. Low coefficient of friction concludes from the ability of PTFE's extended chain linear to form film layer upon its surfaces and counter faces during sliding and increasing the pressure to PTFE enhances to easily form the film layer and improve tribological behaviour. However, PTFE exhibits poor wear behavior and abrasion resistance. To overcome to inferior low mechanical properties, the addition filler materials (glass, carbon fiber) to PTFE can advance its wear resistance due to increasing the loads. [4-10].

All of above findings suggest PTFE fillers provide the wear resistance, lower coefficient of friction. The aspect ratio of PTFE seems to be very critical parameters to determine the best work conditions for providing wear resistance and low coefficient of friction of polymer journal bearings. In this study, the

tribological behaviors PA 66 + 18% PTFE journal bearings which were run in the experiments under the pressures and velocities were investigated. The results of experiment were presented by graphics and tables and were analyzed. In addition some practical recommendations which are manufacturing process of journal bearing and about experiment were given.

2. EXPERIMENTAL DETAILS

2.1. Experimental Apparatus

The journal bearing test apparatus were designed and modified for tribologic characteristic of polymer journal bearings. The test apparatus were controlled by electronic motor driver which allows obtaining speeds varying in the range of 0-2200 rpm. The parts of journal bearing test apparatus were given in fig. 2.1. The montages of specimens to test apparatus were given in fig. 2.2. The temperatures of friction surfaces were measured by 3 thermometers in hollows in the bearing house (Fig. 2.2).

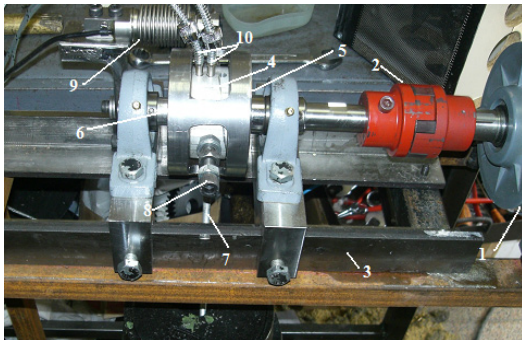


Fig. 2.1. The dry Journal bearing test apparatus
1. Electric motor, 2. clutch, 3. sledge, 4. aluminum bearing house, 5. ball bearing, 6. steel cage, 7. weight hanger, 8. screw rod to hold and loadcell measuring the polymer journal bearing, 9. loadcell, 10. thermocouples.

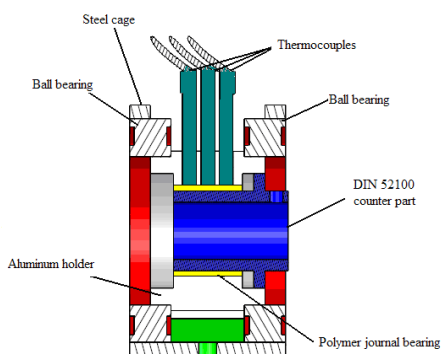


Fig. 2.2. The montage of polymer journal bearing

2.2. Materials and Experimental Conditions

The polymers which were used as journal bearings materials is PA 66 + 18% PTFE. Firstly, for using the journal bearing specimens from these polymers, the die of journal bearing as its dimensions were manufactured by designing with SolidWorks 3D program and cutting via CNC machine. The tensile tests for materials of journal bearings were required to get information about their stress and the effect of manufacturing fault occurring at manufacturing process. For tensile tests, ASTM D 638 tensile die were designed.

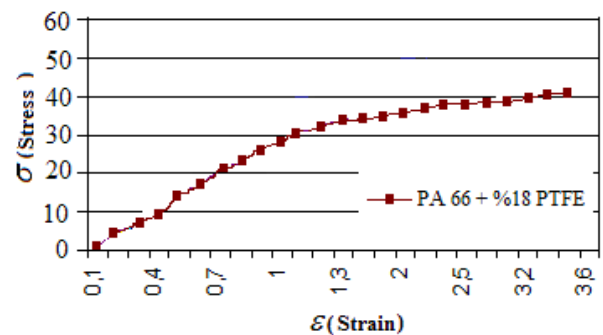


Fig. 2.3. Tensile strength of journal bearing specimens

The counter parts which montage on the shaft were DIN 52100 steels. The heat treatment was applied to DIN 52100 steel parts to be so hard surfaces. Its hardness were measured 62 HRC. The average roughness of steel counter surfaces is about 0.05 μm (Fig. 2.3). The journal bearing of dimensions were give in fig. 2.4.

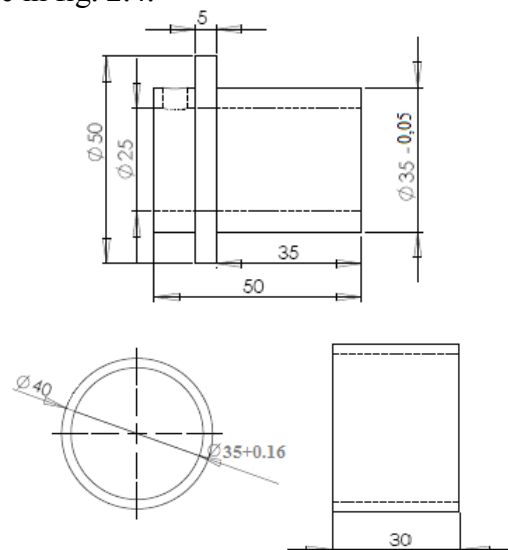


Fig. 2.4. Bearing and counter parts dimensions

The aim in the experiments is to investigate the effect of load and velocity on tribological behaviors. According to this aim, bearing loads and velocities were chosen. The applied loads and velocities in the experiments are given in Table 1.

The experiments were done in the following order. Firstly, the specimens were cleaned by a piece of cloth that absorbed methyl alcohol and dried by oven at 80°C and 1 hour. Humidity is problem for polymer materials. Before tests, the bearing specimens were weighed and its weight noted. The weight for applying to pressure give in Table 1 was put on the load hanger. The motor was started and controlled by motor control driver as give in Table 1. Variations temperatures of friction surfaces were observed during the experiments. The experiments were tested at room temperatures (23- 27 °C). When 1 km sliding distance was reached, the experiment was ended and specimen was dismounted. Then the counter part and specimen surface was cleaned by a piece of cloth that absorbed methyl alcohol and the specimen was dried 80°C in oven to release the humidity. Specimen was weighed and wear determined and noted.

Table 2.1. The experimental parameters of specimens.

Polymer Materials	0.095 MPa (100 N)		0.195 MPa (200 N)	
	0.5 m/s	1 m/s	0.5 m/s	1 m/s
PA66 + 18 PTFE				

3. RESULTS OF EXPERIMENTS

These results are given in Figs. 3.1-3.12 as curves. The following results are obtained from curves. At the beginning 1 km sliding distances, the friction coefficient increases quickly with operation time. For under 0.095 MPa pressure and 0.5 m/s sliding, PA 66 + 18% PTFE specimens until the about 200m sliding distance, friction coefficient increased quickly. After the 200 m sliding distances, the coefficient of friction of them get a stable value. We can understand from their stable

values of coefficients of friction that the transfer film forms on the counterpart surface. Their unstable values of coefficient of friction give in fig 3.1, 3.3, 3.5, 3.7, 3.9, 3.11 shows that discontinuous transfer film forms on the counterpart surface.

The coefficient of friction decreases as bearing pressure increases as 0.195 MPa When we compare the fig. 3.1, 3.3, this situation is seen easily. This situation is similar for most polymers [5,6,7,8,9,10]. Decrease of friction with increase of bearing pressure results from transfer film more continuous dispersion and provide to increase of film thickness. However increase of bearing pressure causes increase of temperatures contact surface which is between bearing surface and counter part surface. Increasing the bearing pressure increase the holding ability of the film on counter surfaces [5,6].

Increase of temperature causes to increase of coefficient of friction (Fig. 3.2, 3.4, 3.6, 3.8, 3.10,3.12) [5,6]. Increase of temperatures prevents to form transfer film on the counter surfaces. In addition increasing bearing pressure provides to rise the surface temperatures. PTFE has lower thermal conductivity and mechanical properties. These disadvantages reflect to wear behavior. Lower conductivities of polymer materials which added PTFE reason from unwell wear behaviors which were expected from them [4, 5, 6, 8].

When the sliding speed was increase, coefficient of friction increased and increasing sliding speed causes to increase surface temperatures (fig 3.7 – 3.12) [4, 5, 6, 8, 9]. Increase in heat on the contact surface leads to disrupt forming transfer film layer. It observed that increasing temperatures of specimens disrupted film layer and caused to discontinuous film bands on counter surfaces. Accumulated heat on journal bearing surfaces couldn't be distributed. Therefore coefficient of friction of PA 66 + %18 PTFE journal bearings presented to high values [5,6].

Wear rate with increasing pressures and velocities increases. PTFE has poor abrasive wear. To overcome to this unwell wear behavior, glass fiber reinforcement was used [4, 8]. Glass fiber increases the wear resistance of journal bearing. SEM of wear surfaces of journal bearing specimens are given in fig. 3.16.

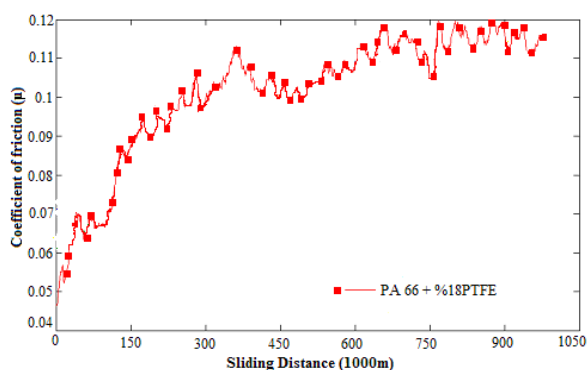


Fig 3.1. The coefficient of friction graphic at 0.5 m/s and 0.095 MPa under bearing pressure

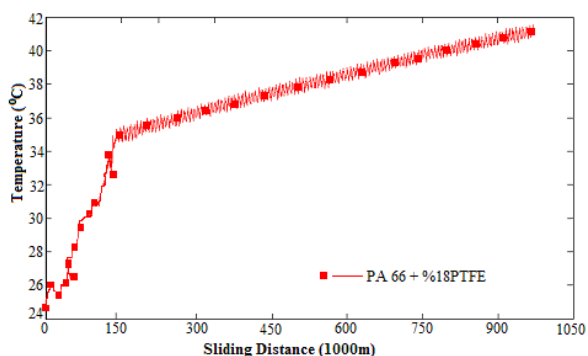


Fig 3.2. The temperatures of bearing surface at 0.5 m/s and 0.095 MPa under bearing pressure

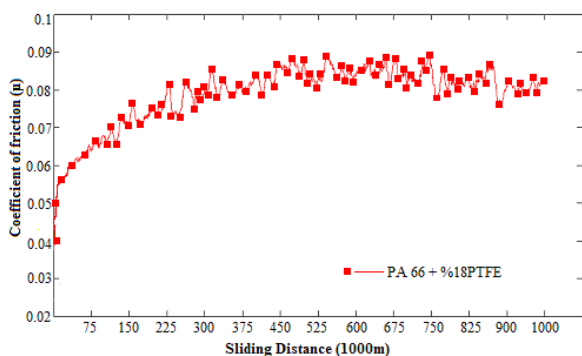


Fig. 3.3. The coefficient of friction graphic at 0.5 m/s and 0.190 MPa under bearing pressure

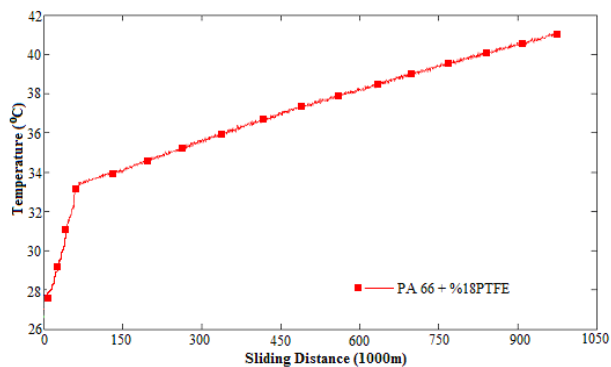


Fig. 3.4. The temperatures of bearing surface at 0.5 m/s and 0.190 MPa under bearing pressure

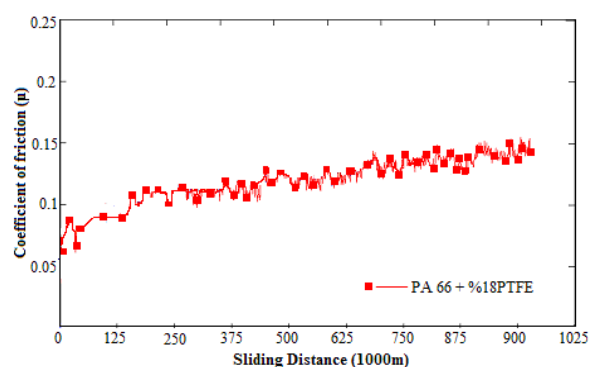


Fig. 3.7. The coefficient of friction graphic at 1 m/s and 0.095 MPa under bearing pressure

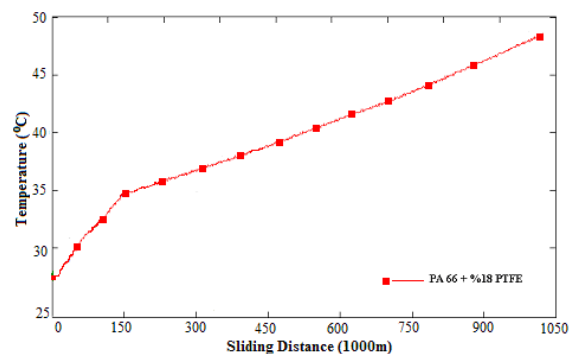


Fig. 3.8. Temperatures of bearing surface at 1 m/s and 0.095 MPa under bearing pressure.

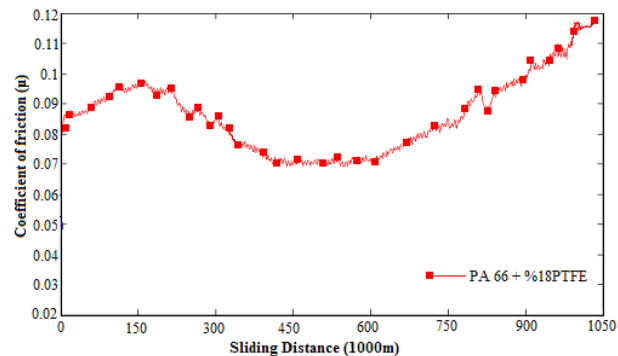


Fig. 3.9. The coefficient of friction graphic at 1 m/s and 0.190 MPa under bearing pressure

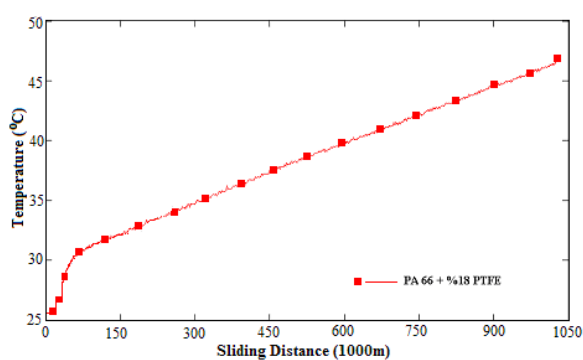


Fig. 3.10. Temperatures of bearing surface at 1 m/s and 0.190 MPa under bearing pressure

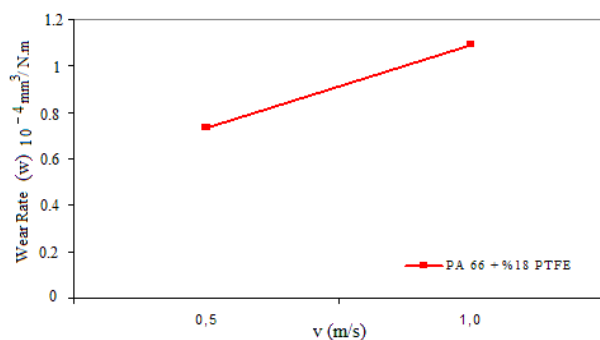


Fig. 3.13. Wear rate of polymer journal bearing under 0.095 MPa bearing pressure

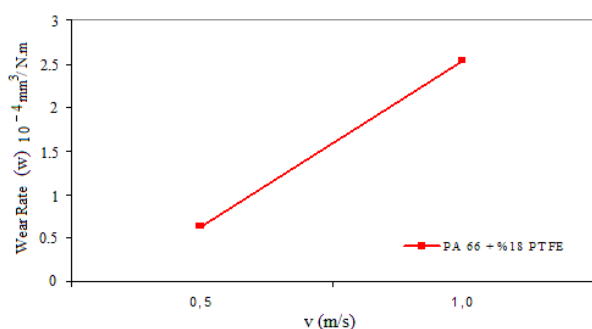


Fig. 3.14. Wear rate of polymer journal bearing under 0.190 MPa bearing pressure

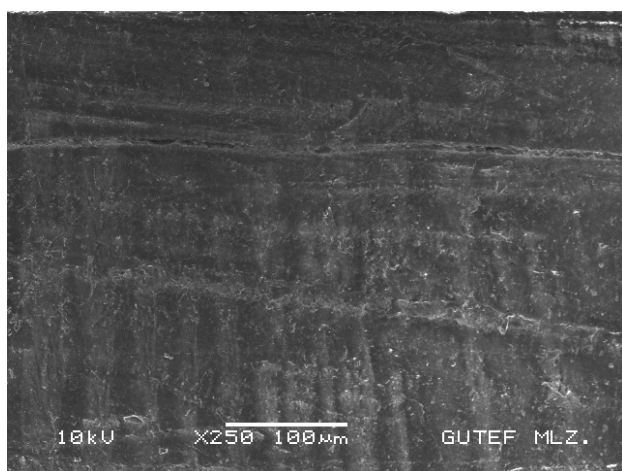


Fig. 3.16. SEM of worn surfaces of journal bearing specimens PA 66 + %18 PTFE

4. CONCLUSIONS

The following conclusions can be drawn from the present study [11].

- Increase of bearing pressure causes decrease of coefficient of friction.
- The coefficient of friction with increase of sliding velocities increased for journal bearings.

- Increasing bearing pressure at the 1 m/s sliding velocity caused to rise temperatures for all journal bearings. Increasing temperatures of surfaces affected to negatively to form film layer
- PTFE provided to form transfer film easily but heat dissipation of PTFE additive occurred negative effect at the high temperatures of journal bearings.

5. REFERENCES

- [1] Chang L., Zhang Z., Schlorb A.K., On the sliding wear of nanoparticle filled polyamide 66 composites, *Composites Science and Technology*, 2006; 66: 3188-3198.
- [2] Kim Su Seang, Park D. L., Lee D. G., Characteristics of carbon fiber phenolic composites for journal bearing materials, *Composites Structures* 2004; 66: 359-366.
- [3] Kukureka S. W., Hooke C. J., Rao M., Liao P., Chen Y. K., The effect of fiber reinforcement on the friction and wear of polyamide 66 under dry rolling – sliding contact, *Tribology International*, 1999; 66: 107- 116.
- [4] Khedkar J., Nagulescu J., Meletis E. I., Sliding wear behavior of PTFE composites, *wear*, 2002; 252: 361-369.
- [5] Tevrüz T., Tribological behavior of carbon filled polytetrafluoroethylene (PTFE) dry journal bearings, *Wear*, 1998; 221: 61-68.
- [6] Tevrüz T., Tribological behaviours of bronze-filled polytetrafluoroethylene dry journal bearings, *wear*, 1999; 230: 61-69.
- [7] Feyzullah, E., Şaffak, Z., The Tribological Behaviour of Different Engineering Plastics Under Dry Friction Conditions, *Materials and Design*, 2008; 29: 205 -211.
- [8] Unal H., Mimaroglu, A., Abrasive wear behaviour of polymeric materials, *Materials and Designs*, 2005; 26: 750 – 710.
- [9] Ünlü, S. B., Atik, E., Yılmaz, S. S., Tribological Behaviour of Polymer Based Journal Bearings Manufactured From Particle Reinforced Bakelite Composites, *Materials and Design*, 2009; 30: 3896-3899.
- [10] Yu, S., Hu, H., Yin, J., Effect of Rubber on Tribological Behaviours of Polyamide 66 Under Dry and Water Lubricated Sliding, *Wear*, 2008; 265: 361-366.
- [11] Demirci, M. T., Experimental Investigation of Tribologic Properties of Journal Bearing Based on Polymer, Selcuk University, Natural Science Institution, Konya, 2009 (in Turkey).