A Review on Tribological Wear Behaviour of PTFE and Its Composites

Ms. Shingavi A. A.  
P. G Scholar  
Department of Mechanical Engineering  
P.R.E.C., Loni

Prof. Nimbalkar S. R.  
Associate Professor  
Department of Mechanical Engineering  
P.R.E.C., Loni

Prof. Belkar S. B.  
Associate Professor  
Department of Mechanical Engineering  
P.R.E.C., Loni

Prof. Dige Y. S.  
Associate Professor  
Department of Mechanical Engineering  
SRES College of Engineering, Kopargaon

Abstract

In this paper a review and recent progress of PTFE and various fillers. Polytetrafluoroethylene (PTFE) is an important engineering material. When rubbed or slide against a hard surface, PTFE exhibits a low coefficient of friction but a high rate of wear. So to enhance the wear rate of PTFE, different fillers are added PTFE is a thermoplastic polymer, which is a white solid at room temperature, with a density of about 2200 kg/m3. Its melting point is 600 K. Owing to its low co-efficient of friction, it is used for applications where sliding action of parts is needed: plain bearings, gears, slide plates, etc. The wear behaviour of polytetrafluoroethylene filled with filler particles was studied on a pin on disc test rig. The parameters considered for the study were applied load, sliding speed and sliding distance and weight percentage of fillers. The experimental results indicate that the weight loss increases with increasing load, sliding speed and sliding distance, as expected. Sliding distance has more effect on weight loss followed by applied load. The dominant interactive wear mechanisms during sliding and its composites are discussed in this paper. The above four factors are selected on the basis of Effect–Cause analysis and literature survey.  

Keywords: Filler materials, Pin on disc, PTFE composites, Wear

I. INTRODUCTION

Polytetrafluoroethylene (PTFE) is one of the most promising polymers for engineering applications as structural and lubricating materials, such as shaft seals, sliding bearings, piston rings, etc. It is a semi-crystalline polymer with the lowest friction coefficient, high melting point (~330 °C), excellent chemical resistance and outstanding anti-aging performance. However, the poor wear resistance is one of the largest drawbacks limiting the application of PTFE. Since, over nearly a half century it has been a research focus for enhancing its tribological behaviors in various ways. Nevertheless, it has some serious drawbacks from an application perspective. The poor mechanical performance (including severe creep behaviors) limits its utility as structural and lubricating materials in harsh operating conditions especially under high PV (the product of normal pressure and linear velocity) conditions. These can be achieved by fabricating PTFE composites by adding fillers and solid lubricants. The most commonly used fillers and solid lubricants for tribological applications are Carbon, bronze, carbon fibers, glass fibers, graphite and molybdenum disulfide in different percentages and sometimes combined between them for improving the friction coefficient and the anti-wear property. What’s more, the type, the shape and size of the fillers added in PTFE also influence the tribological performance.

II. LITERATURE REVIEW

Jaydeep Khedkar et. al.,[1] have explained in the paper entitled „Sliding wear behavior of PTFE composites“, [2002] that the tribological behavior of polytetrafluoroethylene (PTFE) and PTFE composites with filler materials such as carbon, graphite, E glass fibers, MoS2 and poly-p- phenyleneterephthalamide (PPDT) fibers, was studied. The present filler additions found to increase hardness and wear resistance in all composites studied. The highest wear resistance was found for composites containing (i) 18% carbon + 7% graphite, (ii) 20% glass fibers + 5% MoS2 and (iii) 10% PPDT fibers. Scanning electron microscopy (SEM) was utilized to exam in ecomposite microstructures and study modes of failure. Wear testing and SEM analysis showed that three-body abrasion was probably the dominant mode of failure for PTFE + 18% carbon + 7% graphite composite, while fiber pull out and fragmentation caused failure of PTFE + 20% glass fiber + 5% MoS2 composite. The composite with 10% PPDT fibers caused wear reduction due to the ability of the fibers to remain embedded in the matrix and preferentially support the load. Differential scanning calorimetry (DSC) analysis was also performed to study the relative heat absorbing capacity and thermal stability of the various composites in an effort to correlate these properties to the tribological performance. The results indicated that composites with higher heat absorption capacity exhibited improved wear resistance. The dominant interactive wear mechanisms during sliding of PTFE and its composites are discussed in view of the present findings.
Fuzhi Song, Qihua Wang, Tingmei Wang et. al [2] has reported in Materials and Design (2016) In this work, tribological behaviors and PV limit of chopped carbon fiber, glass fibers and MoS2 reinforced PTFE composites were investigated. The experiment results revealed that single incorporation of MoS2 could improve anti-wear property significantly under low velocity but shown a failure at 3 m/s. However, glass fibers deteriorated the wear resistance of the PTFE composite drastically as single filler. A synergistic effect was found for the combination of MoS2 and glass fibers, which lead to the best tribological properties with the highest PV limits of 9.5 MPa•m/s at 1 m/s and 15 MPa•m/s at 2 m/s. The synergistic effect of MoS2 and glass fibers has great effect on improving tribological behaviors and PV limit of composite E. The anti-wear property and PV limit are improved significantly when combines MoS2 particulates with glass fibers especially under higher velocities. Polytetrafluoroethylene (PTFE) is one of the most promising polymers for engineering applications as structural and lubricating materials, such as shaft seals, sliding bearings, piston rings, etc. It is a semi-crystalline polymer with the lowest friction coefficient, high melting point (~330 °C), excellent chemical resistance and outstanding anti-aging performance. However, the poor wear resistance is one of the largest drawbacks limiting the application of PTFE MoS2 reduces the wear rate significantly by reducing counterface scratch damage and stress concentration on fibers, which alleviates the fibers pulling out from the resin acting as hard abrasive particles. Meanwhile, the composite C presents the best anti-wear properties at 1 m/s (0.78×10-6 mm3/Nm) and 2 m/s (1.50×10-6 mm3/Nm) under 4 MPa•m/s, respectively, but the wear rate of C increases greatly at 3 m/s due to the failure of transfer film and material surface failure. Composite C is suitable to operate in low velocity conditions. The PV limit is 6 MPa•m/s under 1 m/s, and the highest possible PV values under 1 m/s is 5.5 MPa•m/s with low wear rate (1.58×10-6 mm3/Nm) and friction coefficient (0.113). Glass fibers show poor reinforcement in improving anti-wear property of PTFE composite D due to severe abrasive wear. Composite D shows the worst anti-wear property range from 1 m/s to 3 m/s, while it performs the lowest friction coefficient (0.083 at 1 m/s under 6 MPa•m/s). However, the glass fibers provide a tough and homogeneous transfer film with good interfacial compatibility above 2 m/s, which provides counterface with an effective support and protection from scratching and reduces the wear rate of transfer film dramatically. The synergistic effect of PTFE MoS2 and glass fibers has great effect on improving tribological behaviors and PV limit of composite E. The anti-wear property and PV limit are improved significantly when combines MoS2 particulates with glass fibers especially under higher velocities. The PV limit of composite E is reached to 9.5 MPa•m/s (1 m/s) and 15 MPa•m/s (2 m/s), respectively. It is suitable to operate in high velocity conditions and 2 m/s is the best.

Marcelo Kawakame, Jos’e Divo Bressan [3] has reported in his literature has investigated Normal load, velocity, velocity and air relative humidity were investigated in the wear tests. The friction and the wear mechanisms are briefly reviewed. Various polymeric materials containing solid lubricants inside its microstructure were investigated. The self-lubricating characteristics of the added charge as well as the polymeric matrix were considered in the composite selection. Discs of pure PTFE (Teflon), composites PTFE + graphite, PTFE + MoS2 + glass fibres, PTFE + bronze were tested against pins of quenched and tempered SAE 1045 steel. Pins of PTFE + MoS2 + glass fibres were also tested against 1045 steel disks. In all tests, debris and flakes of worn materials were deposited on the pin counter face and these particles defined the wear mechanism. Through the analyses of micrograph taken by scanning electron microscopy, the following conclusion can be drawn: friction and wear in polymers are fundamentally different from the mechanisms which occurs in metals and ceramics, although they are due to the same wear micro-mechanisms: micro-plowing, micro-cutting and flake delamination. A very important conclusion on wear resistance of polymers and composites is its strong dependence on the environmental relative humidity and normal load. Variations observed in the relative air humidity from 50 to 70% can duplicate the lost volume by wear and, consequently, to double the wear rate. Among the tested materials, the composites PTFE with additive graphite or MoS2 and glass fibres have shown the greatest sliding wear resistance. Finally, analyzing the results from the pin-on-disc tests, it can be concluded that the reinforced PTFE with 15% glass fibers type E and additive with 5% of solid lubricant molybdenum disulphide (MoS2) and the PTFE additive with 15% graphite presented the best characteristics for polymer wear resistance, in such case they are more indicated to be utilized in lip seals in electrical motors.

P.D. Pansare et al [4] “Tribological behaviour of PTFE composit material for Journal bearing” in IJIERT [2015] in this study, the effect of load and sliding velocity on friction and wear of materials made of PTFE and PTFE composites with filler materials such as 25% carbon, 35% carbon, 40% bronze, 15% glass fiber, 15% glass fiber + 5% MoS2 have studied. The experimental work has performed on pin-on-disc friction and wear test rig and analyzed with the help of Design Expert software. The results of experiments are presented in tables and graphs which shows that the addition of carbon, bronze, glass filler to the pure PTFE decreases wear rate significantly and there is slight increase in coefficient of friction. The highest wear resistance was found for 15% glass fiber + 5% MoS2 filled PTFE followed by 35% carbon, 25% carbon, 15% glass fiber, 40% bronze and pure PTFE. Through this study, we can suggests the best suitable self lubricating material for sugarcane milling roller journal bearings to enhance the wear life.

S.M. Yadav et al [5] “Studies on wear resistance of PTFE filled with glass & bronze particle based on Taguchi techniques” in [2013] An attempt has been made to study the influence of wear parameters like applied load, sliding speed, sliding distance on the dry sliding wear of PTFE, PTFE+25% Glass and PTFE+40% Bronze composites. A plan of experiments, based on techniques of Taguchi, was performed to acquire data in controlled way. An orthogonal array and the analysis of variance were employed to investigate the influence of process parameters on the wear of composites. The experimental results shows that sliding distance and applied load were found to be the more significant factors among the other control factors on wear. The objective is to establish a correlation between dry sliding wear of composites and wear parameters. These correlations were obtained by multiple regressions. A good agreement between the predicted and actual wear resistance was seen.
III. CONCLUSION

All types of PTFE composites under experimental investigation register the stability in wear loss with time after the faster initial wear. For the selected range of normal load and sliding velocity, the wear increases with increase in load. At constant load the coefficient of friction is slightly increases with increase in sliding velocity History of Polytetrafluoroethylene and its evolution as a bearing material is discussed in above information. Literature survey gives a brief idea about how much work on this topic has already done. It also indicates future scope for PTFE composites.

REFERENCES