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Friction and Wear Performance of PTFE and its Composites: A Review

Prashant Vishwas Parab[1]
Prof.V. L. Firke[2]
Dept. Mechanical Engineering
J.T.Mahajan College of Engineering Faizpur, Jalgaon

Abstract: **Polymers and its composites are gaining ground over metals in the field of engineering applications mainly in tribology. PTFE is a high performance plastics which is widely used in engineering industry due to is properties like low density, low coefficient of friction, self lubrication, resistivity for higher temperatures and chemically neutral. But pure PTFE exhibits poor wear resistance. The wear resistance of pure PTFE can be considerably improved by addition of fillers like graphite, glass fibers, carbon ,aluminum,MoS2 and bronze. Addition of different fillers in various percentage can affects the mechanical and thermal properties of composites. In this review paper we studied various papers in which various testing's are carried out to study wear behavior of PTFE and its composites on Tribometers under different parameters.**

Keywords: PTFE, PTFE composites, friction & wear

1.INTRODUCTION

PTFE is a high performance engineering plastics which is widely used in engineering field,medical field. It is used for manufacturing toys, small gears, wheels,cams, seals and so many products . Its use as sliding bearing material is now days increasing due to its properties such as low coefficient of friction, high resistivity against tempreture, chemically neutral, self lubricating, light weight etc. Its costs compaired with metallic sliding bearing material is low. But having so many good properties the pure PTFE has certain limitations to use as sliding bearing material due to its poor resistance against wear and abrasion.Therefore considerable experiments have been done to reduce wear damage by developing PTFE composites as a bearing material by reinforcing or filling many additives to pure PTFE in certain proportions. The conventional PTFE fillers are bronze, graphite ,carbon, glass fibers,MoS2 & aluminium nano particles etc.The tribological properties of PTFE are affected by environmental and operating conditions.In most papers it is found that the tests were carriedout on pin-on disc tribometer at ambient conditions. Some tests were carried out at dry sliding conditions and some were at wet sliding conditions.

2. FACTORS AFFECTING ON TRIBOLOGICAL PROPERTIES OF PTFE AND ITS COMPOSITES:

2.1 Sliding Velocity: The higher velocity leads to increase in tempreture of rubbing surfaces which decreases hardness of PTFE or its composites which increases wear rate.

2.2 Load: As the load increases the frictional force goes on increasing and hence the temperature of rubbing surfaces which increases wear rate. An increase in load can result a transition from mild wear to severe wear. The load carrying capacity of PTFE composites must be sufficient as per the applications specially as bearing materials.

2.3 Temperature: Higher temperatures can affect the hardness of composites and hence increase in wear rate. The variation in temperatures can affect the lubricating properties of some additives in composites.

2.4 Counter surface Roughness: The smoother the counter surface, lower the wear.

2.4 Contact area:It is directly related to surface contact stresses . Incorrect match of load and surface contact area may result high friction and wear.

3. LITERATURE SURVEY

Talat Tevruz [2] "Tribological behaviors of carbon filled polytetrafluoroethylene [PTFE] dry journal bearing'', wear 221[1998] 61-68 .In this paper a complete setup for testing a sliding bearing is given. A tribological behavior of 35% carbon filled PTFE bearings are experimentally studied. In this study the effects of sliding distance ,bearing pressure and sliding velocity is studied. The various results are shown graphically, it shows that friction coefficient increases as the velocity increase & friction coefficient decreases as bearing pressure increase. Friction Coefficient of 35% carbon filled bearing is 1.2 to 1.6 times that of pure PTFE.

Alireza Khoddamzadeha et el[8] "Novel polytetrafluoroethylene [PTFE] composites with newly developed Tribology alloy addive for sliding bearing'' , Wear 266 [2009] 646-657.This paper is useful for making the specimens of composite material with different contents & in different percentages. We can know the mechanical properties of pure PTFE & given fillers. In this paper there are various graphs which show how the fillers affects the certain properties of pure PTFE. The various test are also given in this paper. The conclusion in this paper is that the fillers enhance the hardness of pure PTFE by 17%, addition of fillers significantly improves the wear resistivity of PTFE while the ductility of it decreases.The corrosion rate of PTFE increases after addition of fillers. The wear resistance of all developed composites are much higher than pure PTFE with very low coefficient of friction.The composite with 15 % of T-401 and 45% of bronze exhibits the best wear performance.

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H. Unal et al [5] "Sliding friction and wear behavior of polytetrafluoroehylene and its composites under dry conditions'' , Materials & Design 25[2004] 239-245. In this paper the wide applications of polymers are given with its disadvantages. In this paper the influence of test speed & load values on friction & wear behavior of pure PTFE, glass reinforced PTFE, bronze & carbon filled PTFE material is studied. In this study under various load & speed the friction coefficient of pure PTFE & its composites decreases when applied load increases. The maximum reduction in wear rate and coefficient of friction were obtained by PTFE composite with 17 % glass fibres and considered as a best tribo-material among the others i.e. pure PTFE, PTFE with 25% bronze and PTFE with 35% carbon. The test is carried out in dry condition at room tempreture on Pin-on –Disc machine.

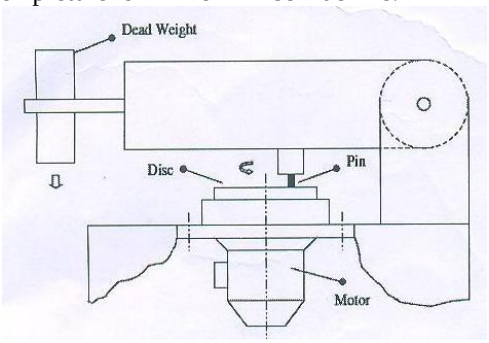

Fig.1 Friction & wear testing apparatus[5]

The load range is from 5 N to 30 N and sliding speeds ranges from0.32 m/s to 1.28m/s. The coefficient of friction of pure PTFE and its composites decreases when applied load increases. Pure PTFE shows higher wear.The wear behavior of PTFE and its composites is less affected by change in sliding speeds.

W. Gregory Sawyer et al. [7] "A study on the friction & wear behavior of PTFE filled with alumina nanoparticles'', Wear 254[2003] 573-580. In this paper a friction & wear test was carried out with filler as nano particles of alumina. The various results are given in tables & analyzed with graphs. Here the mixture of powder is blended with PTFE by jet milling apparatus. A composite with filler [20wt %] has greater wear resistance than pure PTFE and it increaseing filler concentration.In this test the composites were tested against stainless steel counterface on a reciprocating tribometer.

David L. Burris et al.[4] "A low friction & ultra low wear rate PEEK/PTFE composite'', Science Direct, Wear 261[2006] 410-418. In this paper PEEK is used as filler to PTFE. The friction coefficient & wear rate of this composite material are evaluated with the help of linear reciprocating tribometer with different samples with different percentage of PEEK. In this paper there are several graphs as coefficient of friction Vs sliding distance, volume loss Vs sliding distance etc. The results of this test shows that the composite material has low coefficient of friction & low wear rate than pure PTFE.

Jaydeep Khedkar et al. [3] "Sliding wear behavior of PTFE composites''Wear 252 [2002] 361-369.In this paper a tribological behavior of pure PTFE & its composites with fillers such as carbon, graphite, glass fiber, and MoS2 & PPDT fibers is studied. These fillers increase the hardness & wear resistance of pure PTFE. Friction & wear test is carried on computerized pin on disc type tribometer.The highest wear resistance was found for composite containing 18% carbon and 7% graphite. In this paper DSC studies suggest a co-relation between heat of fusion & wear resistance. The wear process of composites depends mainly on three factors stability, thermal conductivity & characteristics of the filler materials.

N.V.Klass et al. [1] "Tribological behavior of glass filled polytetra fluoroethylene''

Tribology International 38 [2005] 824-833.In this paper glass filled PTFE by using reciprocating wear testing machine and concluded that the wear rate of PTFE composites was an order of two magnitudes higher in water than under dry sliding conditions.Three forms of glass as glass fibres**,** glass beads and glass flakes each with a content of 25 % weight were used in this study.

Deepak Bagle et al. [10] "Wear analysis of polytetrafluoroethylene and its composites under dryconditions using Design expert'',International Journal of Scientific and Research Publications. In this paper the effect of sliding velocity,

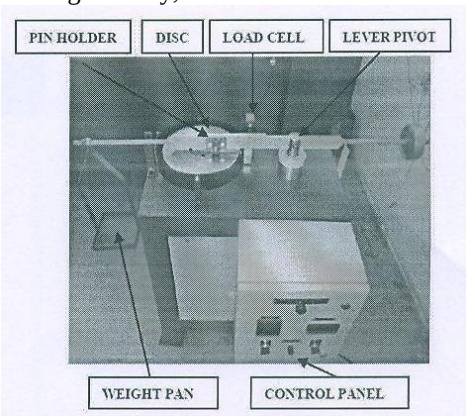

Fig.2 Pin-on-Disc arrangement for friction & wear testing[10]

sliding distance and load on tribological behavior of PTFE and its composites is studied under dry conditions by using pin-on-disc apparatus concluding that the composites exhibits low wear.

H. Unal et al [9] "Tribological performance of PTFE Bronze filled composites under wide range of application conditions'', Journal of Reinforced plastics and composites 29,pp.2184-2191,2010. studied the friction and wear behavior of pure PTFE and its composite with Bronze in different percentage 25 %, 40 % & 60 % under wide range of applied loads from 5 to 200 N and sliding speed ranges from 0.32 m/s to 2 m/s. The test taken on pin -on - disc type machine.The results shows that coefficient of friction of pure PTFE and its composites decreases when the load increases. The PTFE filled with 60% bronze showed higher wear resistance than other samples.Thus in this investigation it is concluded that for a given range of parameters the coefficient of friction and wear rate is less sensitive for change in sliding velocities and more sensitive for change in applied load.

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4. CONCLUSION:

For selected range of speed and applied load, the applied load is more sensitive on wear behavior of PTFE and its composites than the sliding velocity.

The Coefficient of friction of pure PTFE and its composites decreases as the load increases.

The addition of filler materials like bronze, carbon, glass fibers, graphite,MoS2 or combination of above to the pure PTFE increases the hardness and wear resistance.Due to addition of fillers the self lubricating property of pure PTFE is decreasing.The value of Coefficient of friction is slightly affected.

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