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Effect of Fillers on Tribological Properties of PTFE: A Review

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Abstract- Polytetrafluoroethylene (PTFE) is a widely used engineering material as it exhibit favorable properties like low coefficient of friction, chemical resistant and high temperature stability. However virgin PTFE exhibit a high wear rate. Various fillers like glass fiber, carbon , graphite, bronze are used to enhance its wear resistant. This review paper aims at studying the tribological properties of PTFE and its composite carried out in various research paper.

Keywords- Carbon; Friction; Fillers; Glass Fiber; PTFE; Wear

I. Introduction

Polytetrafluoroethylene also known as Teflon is a polymer widely used as a engineering material. It has a property of very low coefficient of friction which make it a self lubricating material. It also has properties of high temperature stability and chemical resistant. Due to these properties it's a widely used engineering material . It is mostly used as a bearing and seal application [1,2]. One of major limitation of using virgin PTFE is its high wear rate [3]. Various filler has been extensively used to improved the tribological properties of virgin PTFE. Fillers which are mostly used include Glass Fiber, Carbon , bronze and graphite. Tribological properties is also influence by the shape and size of filler used [4].

II. Factors affecting Tribological Properties

These factors has a significant affect on the tribological properties of PTFE and its composites.

A. Normal Load: As we increase the load, the wear rate will increase. At low load condition we will experience mild wear and with increase in load condition of severe wear can be observed.

B. Sliding Velocity: As we increase the sliding velocity, temperature will increase due to increase in friction between the two surfaces.

C. Temperature: As we increase the temperature, the hardness of material will be affected which leads to high wear rate.

D. Counterpart Topography: A rough counterbody can lead due more friction which will result in high wear rate.

E. Contact Area: As we increase the contact area, contact stress developed between the two mating surfaces will decrease which will result is low wear rate.

So all the parameters should be studied in finding out the optimum parameters.

III. Literature Review

Pasha [4] studied the dry sliding wear of virgin PTFE, PTFE + 25 % Glass and PTFE + 40% Bronze composite under the influence of wear parameter like applied load , sliding speed and sliding distance. The analysis was done using a Taguchi design to acquired data in a controlled way. Analysis of variance was also employed to study the influence of each parameter. The result shows that sliding distance and applied load are two dominant factors affecting tribological properties. Regression analysis was done to obtain the correlation actual and predicted value and a good relation between the predicted and actual value was observed.

Khedkar [5] studied virgin PTFE and PTFE composite which include filer material like carbon, graphite, glass fiber, 2 MoS

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and poly-p-phenyleneteraphthalamide (PPDT) fiber.. Wear resistance was found to be maximum for composite containing 18% carbon + 7% graphite, 20% glass fiber + 5% 2MoS + 10% PPDT fibers. Wear and SEM analysis were performed to studied the failure mode for PTFE composites.

Tevruz [6] studied tribological behavior of carbon filled PTFE used as a dry journal bearing under the influence of parameter like sliding distance, bearing pressure, medium and low speed. Bearing material is made up of 35% carbon filled PTFE. The effect of load and sliding velocity on wear can be reduced by making bearing cold. He also said that many factors play an important role on friction and wear of PTFE composite.

Sonam [7] studied three composites PTFE, PTFE + 25% C and PTFE + 35% C by varying parameters like load, sliding distance, sliding velocity and filler content. The plan of experiment is based upon Taguchi design to get data in controlled way. The result conclude that composition of filler is the most influence of the wear rate. Also by varying different parameters like load , sliding distance and sliding velocity on PTFE + 35% C to get the minimum wear rate.

H. Unal [8] studied friction and wear of PTFE, glass fiber filled PTFE, bronze filled PTFE and carbon filled PTFE. The test was conducted on Pin on disc tribometer. Parameters varied were sliding speed and normal load. The sliding speed used were 0.32, .064, 0.96 and 1.28 m/s and load were 5, 10, 20, 30 N. The result shows us that coefficient of friction decreases with increase in load. Adding filler material result in decreasing wear rate. Also wear rate is more sensitive to load as compared to sliding velocity.

Conte [9] studied seven PTFE composite which include PTFE Virgin, PTFE +25 wt% carbon, PTFE +60 wt% bronze, PTFE +15 wt% graphite, PTFE +25 wt% glass fiber, PTFE +20 wt% glass fiber + 5 wt% graphite, PTFE +15 wt% glass fiber + 3 wt% MoS_2. The result shows us that hard particle fillers reduces the wear rate but increases the coefficient of friction. Using both hard and soft matrix enhance both self lubricating and load carrying capacity of PTFE composite.

Patare [10] studied 15% glass fiber and 25 % glass fiber filled PTFE composite under dry sliding condition using pin on disc apparatus. Parameter varied were filler content, sliding distance , test speed and load. Test were carried using taguchi technique to get data in controlled way. The test result shows adding glass fiber filled PTFE reduces wear rate and tribological properties are also improved.

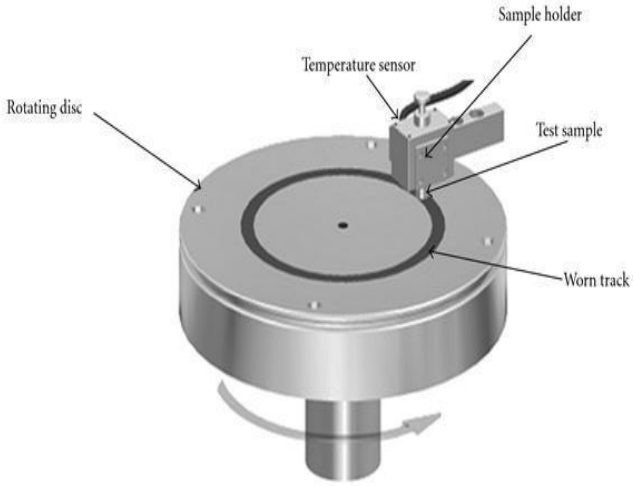

Fig. 1 Pin on disc [10]

Bagale [11] studied three PTFE composite which include virgin PTFE, 40% bronze filled PTFE, 40% carbon filled PTFE. The parameters varied were load, sliding velocity and sliding distance. The load taken in experiment were 1, 2, 3 Kg. Sliding velocity and sliding distance used were 2.62, 3.66, 4.71m/s and 1500, 3000, 4500 m respectively. The experiment were carried out on din on disc apparatus and design expert 7 software were used to analyzed the data. The result were presented in table and graph. Result shows us that addition of bronze and carbon result in decrease in wear rate. Carbon filled PTFE shows more wear resistant as compared to bronze filled PTFE.

Tanaka [12] studied friction and wear properties of PTFE under the effect of heat treatment, speed and temperature. Electron microscope is used to analyze the surface. Result revealed that wear is affected by width of band and coefficient of friction is affected by both width of band and crystallinity. Also film is detached can be easily observed from the surface which result in high wear rate.

Tevruz [13] studied tribological behavior of bronze filled PTFE used as a dry journal bearing under the influence of various parameter like sliding distance, bearing pressure, medium and low speed. Bearing material is made up of 60% carbon filled PTFE. The effect of load and sliding velocity on wear can be reduced by making bearing cold. He also observed that many factors play an important role on friction and wear of PTFE composite.

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Klaas [14] studied the tribological properties of glass fiber filled PTFE. In order to have a low coefficient of friction and wear rate, polymer should transfer film with strong adherence to counterbody. A good transfer of film was observed for glass fiber filled PTFE. For glass fiber PTFE, a transfer film was formed on counterbody where as for glass beard PTFE and glass flakes PTFE, a thicker transfer film was observed resulting in high wear rate.

Quian-qian [15] studied the carbon fibers filled PTFE. The carbon fiber used were surface treated with air oxidation followed by rare earth treatment. The counter body used was GCr15 steel. The test was conducted on reciprocating ball on disk tribometer under oil lubrication condition. SEM was also conducted to analyze worn surfaces. Surface treated carbon fiber PTFE result in low wear rate. Surface treatment improve interfacial adhesion between carbon fiber and PTFE. Also there is a increase friction as compared to virgin PTFE

IV. Conclusion

So it can be concluded from above studies that adding filler material PTFE can significantly reduce wear rate but there is increase of coefficient of friction. So according to the requirement of engineering material, type and amount of filler material can be added to get the desired result.

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