INTERNATIONAL JOURNAL OF RESEARCH IN AERONAUTICAL AND MECHANICAL ENGINEERING

ISSN (ONLINE): 2321-3051

Vol.3 Issue.4,

April 2015.

Pgs: 19-27

Comparative Testing of Poly Tetra Fluoro Ethylene (PTFE) with different material composition in Bearing

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Abstract

Bearing materials are special type of materials, which carry a moving or rotating component with least friction or wear. One of the principle difficulties in developing a good bearing material is that the two practically conflicting requirements are to be satisfied by a good bearing material .the material must be soft with extremely low. Shear strength as well as it must be strong enough to support heavy dynamic loads. This is generally achieved either by having a bearing material with a metallurgical structure inherently incorporating both hard and soft constituents. The soft, low melting constituents helping easy running of moving parts and the hard constituents bear the load, alternatively these might be strong metal coated with a very thin overlay of soft metal. In present investigation we have tested various types of Composite polymer materials such as PURE PTFE, 25% carbon filled PTFE, 25% bronze filled PTFE, 25% glass filled PTFE.

1. Introduction

PTFE composites are technically suspensor and economically cheaper friction material as compared to conventional bearing materials. These are superior because of the following properties,

- Higher tensile strength.
- Lower specific weight.
- Easy machine ability.
- Longer life.

The low-friction characteristics of PTFE (Poly Tetra Fluoro Ethylene) were largely responsible for the inception of this project. This resin is waxy in appearance, and white or gray in color, except that thin sheets are transparent. It is a crystalline solid with good stability from -320° to +500° F, and is chemically inert to known reagents and solvents except molten alkaline metals and gaseous fluorine under pressure. Its relative softness and poor heat conductivity limit. Its suitability as a bearing material to applications involving low speeds and low unit pressures. Because of the relative softness of PTFE, it is logical to expect that its load-carrying ability and its wear resistance might be improved by the addition of suitable fillers.

Accordingly, several fillers were tried in combination with this plastic, including graphite, molybdenum disulfide, bronze, carbon, fiber glass, dental silicate, silicon, titanium dioxide, silver, copper, tungsten, and molybdenum.

2. LITERATURE SURVEY:

PTFE, because of its properties is used in a very large number of applications. Some of its properties can be improved and/or modified by adding suitable fillers allowing the use of PTFE in fields otherwise precluded to this polymer. The treated PTFE is generally known as filled PTFE. The fillers most commonly used are: glass fiber, carbon, bronze or graphite, in the form of powder intimately mixed with the PTFE other fillers are molybdenum disulphide, metal powders, ceramics, metal oxides and mixtures of two or more additives.

Talat Tevruz, has explained in the paper entitled, "Tribological behaviors of carbon filled poly tetra fluoro ethylene (PTFE) dry journal bearings" that his paper gives brief idea about testing materials, wear testing machine, testing procedure and it includes the graph of wear analysis. The results of experiments are presented in tables and graphics which prove that the coefficient of friction and the wear are strongly influenced by the thickness and composition of these films depending on the adhesion between steel and composite surfaces, the cohesive properties of the polymer used, pressure and the sliding distance. Taking into consideration the large number of factors, and their widely fluctuating characters and effects on the friction and wear; an optimum bearing
construction may only be achieved through experiments [I]. **D.S.Bajaj,** explained in the paper entitled, "An Investigation of Tribological Behavior of PTFE+Glass Fiber against Variable Surface Roughness of Counter Surface", Indian Journal of Tribology Vol. 3 No.2 July-December, 2008 that the progress and development in materials technology have been resulted in several new materials [2]. The Tribological properties of PTFE can be improved by adding some filler materials such as glass fibers, carbon, bronze, graphite. Friction and wear are very important surface phenomenon. This paper describes the dependency of wear and friction on surface roughness, sliding velocity and contact pressure for PTFE and its composites using a Pin-On-Disc Tribometer. The parameters studied include wear rate and coefficient friction under varying load and for different surface roughness.

Alireza Khoddamzadeh has explained in the paper entitled, "Novel Poly tetra fluoro ethylene (PTFE) Composites with Newly Developed Tribology Alloy Additive for Sliding Bearings. “Journal of Wear vo1.266 (646-657) that this paper gives several ideas about filler materials as such; the filled PTFE composites have lower tensile strength than pure PTFE. The corrosion rate of PTFE increases when it is filled with fillers. Addition of filler materials significantly improves the wear resistance of PTFE. The wear behavior of PTFE composites is a complex phenomenon which depends upon the fillers and content level of filler present and their morphology [3].

H. Unal has explained in the paper entitled, "An approach to friction and wear properties of poly tetra fluoro ethylene composite" that in this study, the effect of applied load and sliding speed on friction and wear behavior of 25 wt% bronze filled poly tetra fluoro ethylene(PTFE) composite is experimentally examined and analytically analyzed. Friction and wear tests of PTFE composite against AISI 440C stainless steel were carried out under dry conditions using a pin-on-disc arrangement. Regression analysis was carried out to develop an equation in which the wear behavior of the material is expressed in terms of applied load and sliding speed. It was observed that, at both low and high sliding speed values, the coefficient of friction of PTFE composite decreases with the applied load increase. In addition, for the range of applied load and sliding speeds of this investigation, applied load was found to be the most significant factor affecting the coefficient of friction of the 25% bronze filled PTFE. Sliding speed seemed to have the least effect on the coefficient of friction of the 25% bronze filled PTFE. Furthermore, the specific wear rate for 25% bronze filled PTFE decreases linearly with an increase in load and its values were in the order of 10 5 mm3/N m. [4].

"Standard Test Method For Wear Testing With a Pin-On-Disk Apparatus", ASTM International, Designation G 99-05". This test method covers a laboratory procedure for determining the wear of materials during sliding using a pin-on-disk apparatus. Materials are tested in pairs under nominally non-abrasive conditions. The principle areas of experimental attention in using this type of apparatus to measure wear are described. The coefficient of friction may also be determined [5].

Analysis of various types of bearing materials using wear testing machine & to suggest a suitable material for various applications like printing press machine bearing, Xerox machine bearing by considering following points:

- Study of friction behavior of various types of bearing materials.
- Study of wear of various types of bearing materials under condition of load.
- Comparison of Wear rate of various types of bearing materials.

3. FRICTION AND WEAR

FRICTION THEORY: - Friction may be defined as the resistance to motion which exists when a solid object is moved tangentially or otherwise against the surface of another object with which it touches or when an attempt is made to produce such a motion. Any effort to create relative sliding motion between mating parts is always opposed by resisting force is called as frictional force which acts in the plane of sliding motion.

LAWS OF FRICTION

Friction is quantitatively expressed as a force and frictional force is the force exerted by either of the contacting bodies tending to oppose relative tangential displacement of the other body.

First Law of Friction: - Friction always opposes motion and its maximum or limiting value is proportional to the normal reaction between the contacting surfaces. Let, normal reaction be 'N', then we can write,

$$F = \mu N$$

Where, μ = coefficient of friction

Second Law of Friction:-

The friction force and hence coefficient of friction is independent of the apparent area of contact but it depends on real area of contact. Deviation to this law is very minor and occurs only with very smooth & very clean surfaces where the real area of contact becomes equal to the apparent area of contact. Also, second law holds good for materials having definite yield point.

Third law of friction:-

The force of friction is independent of sliding speed or more precisely kinetic friction has week dependence on sliding speed. Friction force is independent on sliding speed. It is now well known that force required to starts sliding is normally greater than the force required to maintain sliding. This gives to coefficient of friction

- Static coefficient of friction which is for surface at rest
- Kinematic coefficient of friction which for surfacing motion

SLIDING FRICTION:-

As the contacting surfaces move relative to one another work is done by the forces causing the motion and possibly there is energy loss at the contacting surfaces.
Following factors and their combined effect cause sliding friction.

1) Surface Interaction :-
It takes place due to

a) Contact of two bodies under load.
b) Adhesion between the flat surfaces.

2) Dissipation of energy during friction
It takes place due to

a) Energy loss during elastic deformation of asperity.
b) Energy loss during plastic deformation.
c) Energy loss in fracture of asperity.

ROLLING FRICTION:-

Rolling friction is a complex phenomenon and much smaller than sliding friction. It is the resistance to motion which occurs when an object is rolled over the surface of the other object. The term 'Rolling friction' is usually applicable to the objects of near perfect shape (spherical or cylindrical) and with small surface roughness. Pure rolling sustains only when contact remains as a point contact. However, in practice, the region of contact is deformed elastically & in some cases plastically, so that the contact is made over a small area. This indicates that pure rolling action is not possible. But the rolling is combined with the small amount of sliding, which is known as 'slip' & this sliding resistance has to overcome to continue with rolling. Example: - fraction drives & drives wheels.

WEAR

Dictionary meaning of wear is damage or loss of quality. Wear may be defined as the removal of material from a surface in bearing under dynamic conditions (sliding, rolling, and fretting). The prime cause of wear is friction, when sliding occurs touching asperities in relative motion. Finally, give rise to wear particles. Wear is highly undesirable as it causes damage to working parts & loss of mechanical efficiency. Like friction wear is also characteristics of the engineering system & it depends on load, speed, temperature, hardness, surface finish, presence of foreign materials and environmental conditions.

Wear is generally divided into five major categories:

(1) Adhesion

(2) Abrasion

(3) Surface fatigue

(4) Erosion

(5) Corrosion

TYPES OF WEAR:-

ADHESION: -

Adhesion is the result of the direct contact of bearing metals. When the applied load is sufficient to rupture any protective surface film (oxides, etc.), the contacting asperities deform elastically, then plastically. Welding of these asperities may occur on contact, but occurs more readily when relative motion takes place. The shearing of these adhesive junctions (elements) produces wear particles. Metal is transferred from one bearing surface to the other in sliding or rolling motion. When adhesive-wear damage is severe, it is referred to as scuffing. Frictional heating causes decomposition and/or desorption of protective films from the surface, the process can become destructive.

ABRASION:-

Abrasion results whenever a hard material slides against a soft one, and may be visualized best as plugging. The most common form of abrasion results when hard articles are interposed between two metal surfaces in bearing. The wear particles generated in both adhesive and in abrasive wear are deleterious because they tend to perpetuate these wear processes and they create points of localized high stress that may mark the onset of fatigue.

SURFACE FATIGUE:-

When bearing surfaces contact each other in rolling motion, after a relatively large number of cycles the result may be surface fatigue, a condition evidenced by localized pitting or flaking. The time to onset of this form of wear is highly dependent on the stress. Local stresses are vastly increased by particulate matter;

Thus, it is important to minimize wear debris generated from hard-surface bearings. In most space applications, surface fatigue is not yet considered a serious problem because loads are light. In future applications the number of cycles required is expected to increase drastically and loads may be much heavier than at present. Considering the extreme difficulty of parts replacement, then, surface fatigue may become a very serious problem

EROSION: -

Erosion is the removal of surface material by the impingement of fluids and/or solids, as in liquid-abrasive blasting. Erosion is occasionally observed in bearings with hydrodynamic lubrication (full oil flow), particularly when filtration is not adequate to remove solid contaminants. One comparable condition on a space vehicle would be the damage caused by the impingement of tiny meteoroids, or space dust, a form of damage which can be minimized by shielding. Future spacecraft are likely to encounter more conventional forms of erosion, for example in tubing walls, valve seats, baffles, or nozzles due to the entrainment of solid contaminants by fuels, oxidizers, breathing gases, and heat exchanger fluids.

CORROSION: -

Corrosive wear is the removal of surface material by chemical action, or by a combination of chemical action and relative motion. The rate of corrosive wear may be increased by increasing the load. Of primary concern in space vehicles,

With respect to corrosion, are

(1) The inadvertent trapping of some corrosive substance within a bearing, housing, or reservoir.

(2) Unnoticed corrosion that occurs prior to launch, usually during storage or shipment.

(3) Fretting corrosion, the wear resulting from low-amplitude oscillation in the presence of oxygen.

The iron oxide formed from the presence of oxygen subsequently causes abrasive wear. Rust, the most common form of corrosion, may be aggravated in earth operations by rolling or sliding motions in air if the lubricant does not contain suitable additives or if the mating surfaces have not been properly selected.

GENERAL PROCESS OF WEAR:-

Wear takes place even in properly lubricated mechanisms (ball bearings, gears, bushings, cams, etc.) according to a definite pattern. The initial-wear rate (run-in) is relatively high because the microscopic surface asperities penetrate the lubricant film, particularly during the low speeds of start-up and shut-down. This rate is aggravated by oscillating motion and by increasing loads. If conditions are not sufficiently severe to cause scuffing in this stage, the wear rate is termed "mild". Normal wear begins when the true area of bearing contact (total asperity-contact area) has been substantially increased by plastic deformation and wear to the extent that the lubricant is fully able to support the load; there will then be only occasional metal- to-metal contacts. From this point on, wear occurs at a negligible rate, modified only by such events as lubricant breakdown, sudden rises in temperature (which reduce oil viscosity), shock loads, or a significant reduction in speed. Normal wear may proceed indefinitely, depending on the several controlling variables, until sufficient debris has accumulated to cause one of the following failure modes:

- Tress risers in the path of motion, ultimately initiating fatigue.
- Abrasive wear sufficient to change surface roughness or dimensions appreciably.

WEAR AND FRICTION TESTING

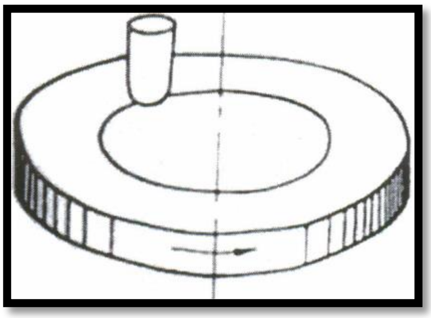
In the field of engineering application metal to metal contact often occurs during relative motion of rotating parts and these are subjected to wear and friction. We are going to analyze wear and friction characteristics of bearing material with the help of "**WEAR TESTING MACHINE".** Purpose of this machine is to study the following:-

- Study of friction behavior of various types of bearing materials.
- Study of wear of various types of bearing materials under condition of load.
- Study of basic laws of friction and wear

Wear can be measured by following methods:-

Pin on disc: - Axis of rotation of disc is usually vertical. Load is applied by dead weights or by hydraulic devices.

Figure1: Pin on disc



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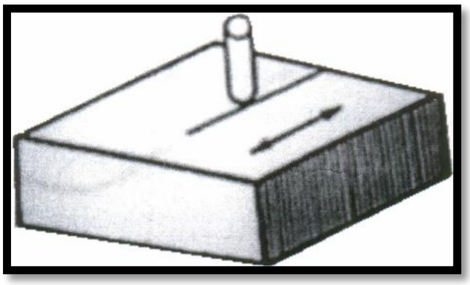
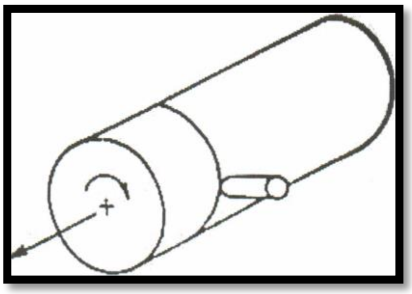
Pin on flat: - Straight line or oscillating motion is used. Hence, wear thread shows a higher wear rate compared to pin on disc machine.

Figure2: Pin on flat



Pin on cylinder: - Two types of configuration are available viz. pin riding on the surface of the cylinder and pin riding against the inside surface of the hollow cylinder

Figure3: Pin on cylinder



4. CONCLUSION AND FUTURE SCOPE

In this work we have studied Wear characteristics and CoF for the load 3kg, 4kg and 5kg for different track radius as well as for different pin diameters for PTFE + 25% of Carbon Black, Bronze and Glass Fibers.

1. Composite PTFE has much good mechanical and thermal properties as compare Plain PTFE.
2. Wear is independent of area of contact.
3. Carbon black filled PTFE gives high wear
4. Glass filled PTFE gives low wear rate

5. Bronze filled PTFE gives intermediate wear rate

Hence, Glass filled PTFE is best suited for bearing applications because of its wear rate, low cost, better mechanical properties than other materials.

In this Research we have studied various properties of PTFE + 25% of Carbon Black, Bronze and Glass Fibers. The percentage of these materials can be varied and other combinations can be studied for desirable properties. Even we can change the filler material and study their properties to improve the performance of the material.

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