Analysis of Composite Bearing Properties

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Abstract: *Large portion of the energy produced in the universe is consumed by friction only and the friction is always accompanied by wear. Polytetrafluoroethylene (PTFE)(Teflon) is self-lubricating material & it has very low friction coefficient, good stability at high-temperature as well as chemical stability. But it has poor mechanical properties therefore it cannot be used as anti-wear material alone. Accordingly several fillers tried in combination with MOS_2, silicon, graphite, copper, steel. This evaluates the influence of independent parameters such as normal load, sliding distance, velocity, filler content on wear performance of Molybdenum Disulphide (MoS_2) reinforced Polytetraflouroethylene (PTFE) composites using a statistical approach.*

Keywords: Bearing, Wear, Coefficient of Friction, Polytetrafluoroethylene, Molybdenum Disulphide

1. INTRODUCTION

Bearing materials are extraordinary type of materials, which convey a moving or pivoting spare slightest erosion or wear. One in all the vital troubles in build up an honest bearing material is that the 2 essentially clashing necessities are to be fulfilled by an honest bearing material. The fabric must be delicate with to a good degree low shear quality and also it must be sufficiently solid to assist substantial dynamic burdens. This can be for the foremost part accomplished either by having an orientation material with a metallurgical structure innately fusing both hard and delicate constituents.

In an in depth number of general designing practices where greasing up conditions are moderately poor and administration conditions don't seem to be exceptionally demanding, thick strong course are utilized with a duplex structure. the sort of bearing relies upon the heap, speed and also the working conditions during which it's to be utilized.

Thus, thanks to the relative delicate quality of PTFE, it's normal that its heap conveying capacity and its wear opposition could also be expanded by the expansion of reasonable fillers. As needs be, some fillers attempted in blend with this plastic including graphite, fiber glass, dental silicate, silicon, titanium of dioxide, silver, copper, tungsten and molybdenumdisulphide.

2. LITERATURE REVIEW

Koji Kato et al explained the Soft or hard film coating, multi-phase alloying and composite structuring are developed to regulate wear and friction by improving materials and surfaces with some aspects for better properties of friction and wear. On the opposite hand, it's well recognized recently that the coefficients of friction and wear don't seem to be material properties but two sorts of responses of a tribo-system. they're always reasonably related with one another when the required functions of the tribo-system are well considered. Typical wear behaviors of representative materials of coatings, composites, metallic alloys and ceramics are reviewed in respect to their friction behavior's, and fundamental mechanisms of damage are confirmed for the technical development of damage control. Friction and wear are responses of a tribo-system. Friction and wear, as two sorts of responses from one tribo-system, must be exactly related with one another in each state of contact within the system, although a comprehensive simple relationship mustn't be expected. the aim of this paper is to return to the overall understanding of damage mechanisms by reviewing the characteristics of damage and friction of very different materials. For the technical development of damage control within the near future, the characteristics of damage of coatings, composites, metallic alloys and ceramics were reviewed in respect to their frictional characteristics. [1]

David L. Burris et al, explained during this paper PEEK filled PTFE composite that exhibits low friction and ultra-low wear. all-time low average friction coefficient of $\mu = 0.111$ was obtained for 3 samples having a PEEK wt. you look after The composite incorporates a wear rate below unfilled PTFE and PEEK for each sample tested. all-time low wear rate of $K=2\times10^{-9}$ mm3/ (Nm) was obtained for a 32 wt. % PEEK filled sample. This sample was 900 times as wear resistantas the unfilled PEEK and 260,000 times as wear resistant because the unfilled PTFE. Samples having PEEK content greater than 32 weight% had no wear transients. the wear and tear rates were observed to extend with increasing PEEK content approaching that of unfilled PEEK. [2]

Talat Tevrüzet al, explained during this paper the coefficient of friction and therefore the wear are strongly influenced by the thickness and composition of those films counting on the adhesion between steel and composite surfaces, the cohesive properties of the polymer used, pressure and therefore the sliding distance. Taking into consideration the massive number of factors, and their widely fluctuating characters and effects on the friction and wear; an optimum bearing construction may only be through experiments. [3]

Yunxia Wang et al, explained during this paper the PTFE-based composites containing 15 vol.% MoS2, graphite, aluminium and bronze powder, were respectively prepared by compression moulding at temperature and subsequent heat treatment in atmosphere. Transfer films of pure PTFE and these composites were prepared on the surface of AISI-1045 steel bar employing a friction and wear tester in a very pin on disk contacting configuration. Tribological properties of those transfer films were investigated using another tribometer by sliding against GCr15 steel ball in a very point-contacting configuration. Morphology of the transfer films and worn surface of the steel ball were observed and analysed using SEM and optical microscopy. it absolutely was found of these fillers improved wear resistant capability of the composites. Compared with pure PTFE, introduction of the fillers made the corresponding transfer films have longer wear life. This is often mainly attributed to strongly adhering transfer film and smaller wear debris particles lead by addition of the fillers. These smaller debris particles are vulnerable to stay longer at the contacting region during the friction process. Introduce of fillers is useful to enhance load bearing capability of the transfer films when sliding against steel ball which are favourable to prolong the wear and tear lifetime of the transfer films. Tribological properties of those transfer films are sensitive to load change. Generally, increased load shortened wear lifetime of transfer film. [4]

Wojciech Wieleba et al, explained during this paper the state of strain varies in a very polymer material during sliding against steel. The explanations for this are, among other things, imperfections of shape of the surface of the contacting steel element and therefore the oscillatory character of the friction force. The viscoelastic nature of polymer materials (considerable internal friction) implies that under such conditions a specific amount of friction energy is dissipated within the type of heat inside these materials, contributing to their heating up. For this reason the interior friction for selected PTFE composites has been investigated, similarly because the temperature distribution on the surface of PTFE samples sliding against steel under dry friction conditions. It absolutely was observed (using a thermo vision system) that the very best temperature occurred inside the polymer material, at far from the friction surface. That testifies to the generation of warmth during friction, not only on the contact surface of the sliding materials but also inside the polymer material. Both thermo vision investigations and computations demonstrated the essential role that internal friction plays in polymer materials during their sliding against metals. The number of energy dissipated as a result of internal friction during the cyclic strain of PTFE composites is sufficient to heat up the polymer material by about 12 ◦C. Though a computation of the number of energy dissipated is approximate thanks to the assumptions made; it reflects the importance that internal friction has within the process of warmth generation in polymer materials during sliding against metals. The imperfections of the surface of the steel element and therefore the oscillatory character of the friction force contribute to the formation of a variable state of strains within the polymer material during its rubbing against steel. Combined with a high value of internal friction for these materials it causes additional internal heating of the polymer material. The result's the occurrence of a neighborhood of increased temperature inside the polymer material, at far under the sliding surface. Thanks to the low thermal conductivity of polymers, this area remains present all the time during the friction process of a sliding couple polymer–metal. Determination of the dependence between the parameters describing the surface roughness along with the errors of shape and therefore the amount of internal heat generated within the process of polymer friction requires further detailed investigations. [5]

C.G. Dunckle et al, presented investigations on the tribological behaviour of PTFE composites against steel at cryogenic temperatures. It is stated that thermal properties of the cryogenic medium have a major influence on the tribological performance of the polymer composites. The generation of a gaseous film round the friction contact decreases significantly the cooling ability of the environment. Therefore, the effect of the low temperatures on the fabric properties was more clearly detected at low sliding speed, with a change in wear mechanism from adhesive to abrasive. Chemical analyses show the presence of iron fluorides all the way down to 4.2 K. The XPS results suggested that these fluorides lay directly at the surface of the disc and are covered by a layer of PTFE. No influence of the metal fluorides on the tribological performance can be determined here, but results from other works suggest we should always pursue these investigations. [6]

S. Manjunath Yadav et al, studied the influence of damage parameters like applied load, sliding speed, sliding distance on the dry sliding wear of polytetrafluroethylene (PTFE),PTFE + 25% glass and PTFE + 40% bronze composites. Experiments, supported the techniques of Taguchi, and were performed to amass data in a very controlled way. An orthogonal array and therefore the analysis of variance were employed to analyze the influence of process parameters on the wear and tear of composites. The worn surfaces were examined using scanning microscope (SEM). The experimental results show that sliding distance and applied load were found to be the more significant factors among the opposite control factors on wear. the target is to determine a correlation between dry sliding wear of composites and wear parameters. These correlations were obtained by multiple regressions. [7]

2.1 Summary of Literature Review

In all above papers studied by different authors analyze the performance of bearing material all told varying conditions is restricted to reasonably three different compositions.

We are composing the fourth one material having 80% of PTFE with 20% of MoS2 and analyzing that whether the graph of coefficient of friction against increased percentage of MoS2.

3. OBJECTIVES OF PRESENT WORK

MoS2 is taken into account as a filler material and is added to PTFE. It gives good sliding and wear characteristics, good thermal conductivity, low coefficient of friction and high resistance. MoS2 has high wear resistance & relative hardness. When it's filled in PTFE it'll reduce the wear and tear rate. While forming the composite, it should increase the frictional resistance, but reduction in wear rate may need greater influence. Hence, problem is defined as follows

To improve properties tribological of bearing material of plain PTFE & Analysis of composites PTFE material i.e. when 5%, 10%, 15% and 20% MoS2 is filled in it, using wear testing machine.

3.1 Objectives of the Project

1) To find the effect of MoS2 filler in PTFE.
2) To select most better weight percentage of filler in base material to boost its tribological properties.
3) To study the behavior of the chosen materials in wear and obtained coefficient of friction under the experimental conditions.

These are the various objectives of given project work.

4. METHODOLOGY

Metal to metal contact regularly happens relative movement of pivoting parts and these are subjected to wear and grinding. We will examine wear and get in touch with properties of bearing material with the assistance of "Wear Testing Machine".

1) Geometry of reaching surfaces
2) Materials for 2 reaching surfaces.
3) Lubricants used
4) Sliding speed of the bearing.
5) Load applied

Based on geometry of reaching surfaces we decide pin or stick of the testing material on plate or disc strategy the rule of which is appeared in figure.

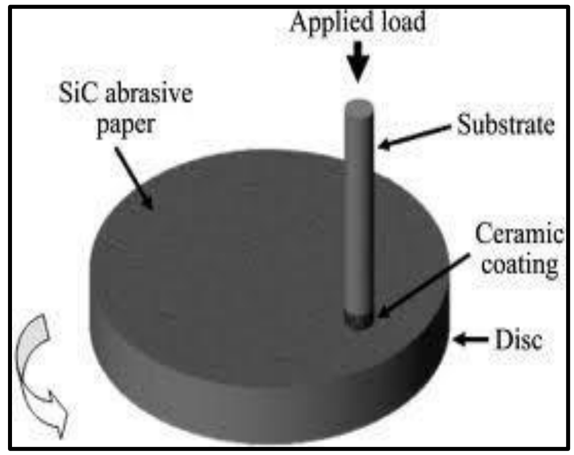

Fig -1: Pin on disc setup

Outline of trial is that the effective investigation apparatus for demonstrating and breaking down the impact of the control factors on the execution yield. The foremost vital stage within the outline of investigation lies within the determination of the control factors. We completed the trial consider on Pin on plate founded.

5. EXPERIMENTAL STUDY

Experiment are often defined because the test or series of test during which forceful changes are made on input variable so as to obverse & analyze the changes in output parameter. so as to scale back the damage rate various filler materials are added to PTFE and these composites are tested on wear testing machine. Here is that the brief introduction of wear and tear testing machine.

5.1 Wear Testing Machine

In stick on-circle tribometer "TR-20", level stick is stacked onto the test with a decisively known weight of 17.63 gr. The stick is mounted on a hardened lever, composed as a frictionless power transducer. The diversion of the profoundly firm flexible arm, without parasitic grinding, safeguards an almost settled contact point and along these lines a gradual position within the erosion track. The grating coefficient is resolved amid the test by estimating the redirection of the flexible arm. Wear coefficients for the stick and plate material are computed from the quantity of fabric lost amid the test. This basic strategy encourages the investigation of grinding and wears conduct of relatively every strong state material blend with or without oil. Moreover, the control of the test parameters, as an example, speed, contact weight and differing time enable a close-by proliferation to the real states of viable wear circumstances.

It likewise encourages investigation of abrasion and wear qualities in sliding contacts under wanted conditions. Sliding happens between the stationary stick and a turning plate.

Ordinary load, rotational speed and It wear track breadth are often shifted to suit the test conditions.

Digressive frictional power and wear are observed with electronic sensors and recorded on PC.

These parameters are accessible as elements of load and speed.

Specification of Pin on Disc Tribometer Setup

- Manufacturer : Magnum Engineering, Bangalore
- Size of Pin : 3 to 12 mm diameter
- Size of Disc :160 mm dia. X 8 mm thick
- Track Diameter for Wear :5 mm to 70 m
- Speed of Sliding Range: 0.25 m/sec. to 10 m/sec.
- Disc Speed (Rotational) :80 to 3000 rpm
- Normal Load Applied: Max 250 N .
- Friction Force :0 to 250 N, digital readout
- Wear Measurement Range :4 mm, digital readout
- Power Required :230 V, 15A, 1 Phase, 50 Hz

Specification of Pin

- Materials : Polytetrafluroethylene (PTFE) & Molybdenum Disulphide (MoS2)
- Filler material content: 5, 10, 15 & 20% by wt.
- Diameter of pin :12 mm
- Length of pin :30 mm

Specification of Disc

- Manufacturer of disc: Magnum Engg.
- Material of disc :EN 32
- Disc dia. :160 mm
- Thickness : 8 mm

Table -1: Contents in EN32

Content	Percentage	Constituent	Percentage
Carbon	0.10-0.18%	Phosphorous	0.05% max
Manganese	0.60-1.00%	Sulphur	0.05% max
Silicon	0.05-0.35%		

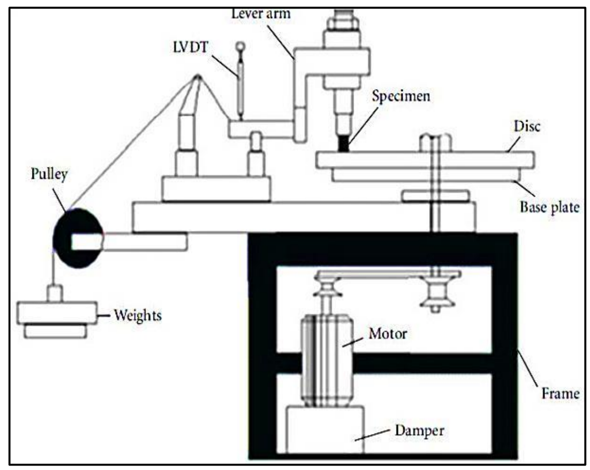

Fig.-2: Actual Setup for Experiment

5.2 Terms Which Are Varying During Wear Testing

1) Velocity of Disc
2) Load on Disc
3) Contact Area
4) Surface Finish
5) Sliding Distance
6) Material

The TR-20 Pin on disc wear testing machine represents a substantial advance in terms of simplicity and convenience of operation, ease of specimen clamping and accuracy of measurements, both of Wear & Frictional force. The machine is designed to apply loads up to 200N and is intended both for dry and lubricated test conditions & Frictional force. The machine is designed to apply loads up to 200N and is intended both for dry and lubricated test conditions

5.2.1 Velocity

It is agreed that the friction force is independent of the sliding velocity. This proposal is valid with a good approximation only in the case where the contact temperature varies insignificantly and, as a result, the interface does not change its behavior.

5.2.2 Load

It is a common knowledge that the friction force is proportional to the normal applied load (the first law of friction). Load is applied through the lever and the pulley arrangement.

Table -2: Assigning of levels to the variables

Level	Low	Medium	High
Load, (Kg) (A)	1	2	3
Speed (RPM) (B)	300	600	900
Sliding distance (cm) (C)	20	40	60

Table -3: Assigning code for four PTFE materials

Material	Chemical Composition in Wt.%
I	PTFE + 5% MOS2
II	PTFE + 10% MOS2
III	PTFE + 15% MOS2
IV	PTFE + 20% MOS2

5.2.3 Sliding Distance

Sliding distance was constant throughout the experiment for different mating surfaces for all conditions.

6. DESIGN OF EXPERIMENT

It is approach in view of insights and other teach for touching base at a proficient and powerful arranging of tests with a view to get legitimate conclusion from the investigation of trial information. Outline of analyses decides the example of perceptions to be made with at least test endeavors. To be particular Design of examinations (DOE) offers an efficient way to deal with think about the impacts of different factors/factors on items/process execution by giving a basic arrangement of investigation in an outline framework. All the more particularly, the utilization of orthogonal Arrays (OA) for DOE gives a productive and successful technique for deciding the most noteworthy elements and associations in a given outline issue.

Outline of examination is a procedure to get the most extreme measure of decisive data from the base measure of work, time, vitality, cash, or other restricted assets. The data by and large includes the connection amongst item and process parameters and the coveted execution qualities. Taguchi's systems, Statistical relapse investigation, Minitabs,

M. S. Exceed expectations are one the effective devices utilized as a part of the plan of investigations. Taguchi's parameter configuration can streamline the execution qualities through the setting of plan parameters and lessen the affectability of framework execution to the wellsprings of variety. Taguchi's trial strategy has been effectively connected for parametric evaluation in dry sliding wear investigation of polymer composites.

The benefits of Experimental outline are:

1. Improved process yields.

2. Reduced fluctuation and nearer conformance to the ostensible or target necessities.

3. Reduced advancement time.

4. Reduced general expenses.

Uses of Experimental outline in the Engineering Design are:

1. Evaluation and correlation of essential outline designs.

2. Evaluation of material choices.

3. Selection of plan parameters with the goal that the item will function admirably under a wide assortment of field conditions so the item will be vigorous.

4. Determination of key item plan parameters that have affect on the item execution.

Stages for planning Experiments are as recorded beneath:

1. Recognition of an announcement of the issue

2. Choice of components, levels and range

3. Selection of the reaction variable

4. Choice of exploratory outline

5. Performing the trial

6. Statistical examination of Data

7. Conclusions and suggestions

Exploratory outline is a basically imperative instrument in the Engineering scene for enhancing the execution of the assembling procedure.

7. CONCLUSIONS

From the above experiment, we will conclude about the followings.

1. Wear rate is directly proportional to load applied.
2. Coefficient of friction is inversely proportional to the Load applied.
3. White metal gives less wear rate as compared to other material when tested under similar working condition.
4. Coefficient of friction of white metal is very high as compared to other material when tested under similar working condition.
5. Pure PTFE gives very high wear rate as compared to composite PTFE.
6. Composite PTFE has much good mechanical and thermal properties as compared to plain PTFE.
7. Wear increases as roughness of counter surface increases.

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8. BIOGRAPHIES

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