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A Review on Friction and Wear Behaviour of Polymer

S P Thorat[1], Prof. V S Aher[2], Prof. A K Mishra [3]

PG Scholar, Department of Mechanical Engineering, Amrutvahini College of Engineering Sangamner, India[1]

Associate Professor, Department of Mechanical Engineering, Amrutvahini College of Engineering Sangamner, India [2,3]

Abstract: Energy used to overcome unwanted friction is causing millions of tons of CO2 emission per year. In passenger cars, for example, about a third of the entire fuel consumption is spent to overcome friction [1]. Since the early 1990 s it is realized that one potential way to reduce frictional losses is the improvement of the surface topography of sliding surfaces by micro-texturing. The aim of micro-texturing is either to increase or to decrease friction. Communicating textures, like channel so crossed channels are reported to do both, increase or decrease friction, depending on the tribological conditions. Furthermore, for non- communicating textures like dimples the effect to reduce friction is reported, especially under hydrodynamic lubrication conditions. When filler materials like carbon, graphite, glass fibres are added in the PTFE, a composite is formed which improves mechanical & thermal properties of that composite. It increases hardness and wear resistance, while the coefficient of friction is slightly affected and remains low. In this survey, we study various papers in which various methods & experiments were carried out for calculating friction & wear resistance of various compositions of polymers. So it is easy to understand properties & behaviour of polymers under various test conditions.

Index Terms: Composites, PTFE, friction, wear.

I. INTRODUCTION

Poly tetrafluoroethylene (PTFE) is an important polymer based engineering material. When rubbed against a hard surface, PTFE exhibits a low coefficient of friction but a high rate of wear. It is white or gray in colour. It is an ideal bearing material for heavy and light load pressures with medium and low surface speeds. The development of the fluoro polymer industry began with the discovery of the poly tetrafluoroethylene (PTFE) by Dr. Roy J. Plunkett (1910-1994) at DuPont in 1938 and introduction as a commercial product in 1946 [10]. Poly tetrafluoroethylene (PTFE) is a high performance engineering plastics which is widely used in industry due to its properties of self-lubrication, low friction coefficient, high temperature stability and chemically resistant. While PTFE exhibits poor wear and abrasion resistance, leading to early failure and leakage problem in the machine parts. To minimise this problem, various suitable fillers added to PTFE. Generally, reinforcements such as glass fibres, carbon fibres and solid lubricants are added internally or incorporated into the PTFE. Its relative softness and poor heat conductivity limit its suitability as a bearing material to applications involving low speeds and low unit pressure, the tribological behaviour of polymers is affected by environmental and operating conditions and by the type, size, amount, shape and orientation of the fibres. A relationship between the wear of the polymers and operating parameters is desirable to obtain the better understanding on the wear behaviour [1, 2].

In 1953, a new fluoro polymer, poly chlorotrifluoroethylene (PCTFE) was commercialized by M. W. Kellog Company under the trade mark Kel-F. PCTFE is produced by the free radical polymerization of chloro tri fluoro ethylene (CTFE) with a linear polymer chain structure [10].

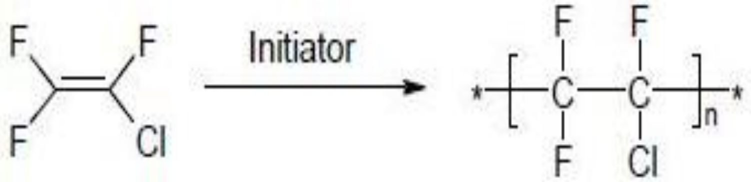

Figure 1: Polymerisation of CTFE

1.1 Test Conditions:

Load: Load is important factor when we consider friction & wear. As we know, Friction & wear is directly proportional to the applied load.

Velocity: When it’s deal with friction and wear testing machine, it is very necessary to consider the velocity of the

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specimen. Generally, frictional resistance decreases with increasing velocity.

- Temperature: Environmental temperature also affects the accuracy of the experiment.
- Contact Area: Contact area between mating parts is important. Contact area in all conditions must be same.

1.2 Properties to Study:

PTFE & CTFE has good properties such as low coefficient of friction, low wear rate, heat resistance, electrical insulation properties and chemical inertness**.** PTFE + Carbon Composite, PTFE + Bronze Composite, CTFE may show excellent properties.

1.3 Parameters in Wear Testing:

Load, Velocity, Temperature, Contact Area, Surface Finish, Sliding Distance, Environment, Material, Hardness of counter face. The 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.

1.3.1 Coefficient Of Friction

The coefficient of friction is generally depends on the Load, sliding speed. Material should possess low coefficient of friction.

1.3.2 Wear rate

Wear is the removal of material from either or both of the contacting surfaces. Material shouldhave improved wear resistance under load andpermanent deformation.

1.3.3 Dielectric Properties

Teflon has high dielectric strength over many different frequencies, low dissipation factor and surface resistivity.

II. METHODOLOGY

Various test methods are available for friction &wear testing. Some of them are explained below,

1. H. Unal et al presented the influence of test speed and load values on the friction and wear behaviour of pure polytetrafluoroethylene (PTFE), glass fibre reinforced (GFR) and bronze and carbon (C) filled PTFE polymers under ambient conditions in a pin-on-disc arrangement. Schematic Diagram of wear test rig is as shown in fig.

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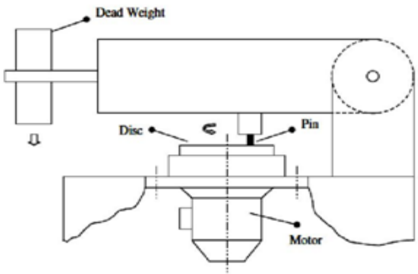

Figure 2: Wear Test Rig [1]

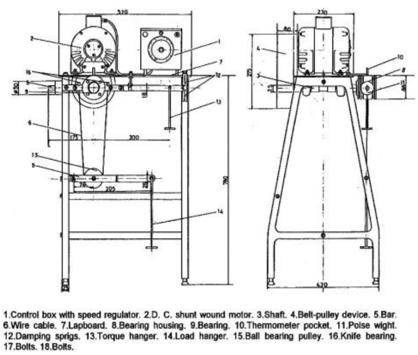

Figure 3: Apparatus for Experiment [4]

3. Experiment by Li Chang, Klaus Friedrich. The wear tests were conducted on pin on disc apparatus [5]. During the

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test, the friction coefficient was recorded and calculated by the ratio of tangential force to normal load. The reduction in specimen's height was measured by a displacement transducer, which could be used to characterize the development of the wear process. An additional monitoring of the temperature rise during testing was carried out by an iron– constantan thermocouple positioned on the edge of the Figure 4: Pin-on-Disc Arrangement for wear test

4. N.V. Klaas et al in his experiments carried out the friction and wear tests on a reciprocating sliding wear rig which consists of a wear pin sliding perpendicular to the grinding marks on a flat counterface [6]. This is a standard wear rig used for friction and wears and is fully described elsewhere. Each test was performed on a new wear track covering a totalling sliding distance of 5 km. The linear reciprocating sliding wear rig reproduces the reciprocating motion typical of many real-world mechanisms, thus, the apparatus is frequently used to test wear performances of materials.

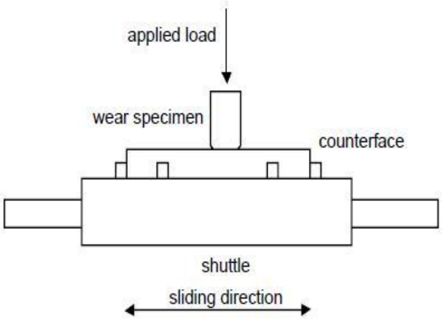

Figure 5: Reciprocating wear tester [6]

5. W.G. Sawyer et al in his experiment used reciprocating pin-on-disk Tribometer for wear testing. A schematic diagram is as shown in figure below [7].

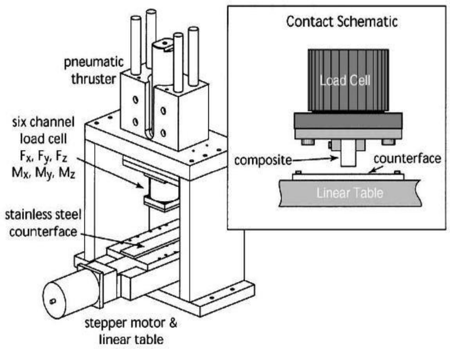

Figure 6: A schematic of the reciprocating pin-on-disk Tribometer [7]

6] Deepak Bagle et al in his experiment used pin on disc apparatus for wear testing of different composites sample. Experimental setup for of their work is shown in figure below [8].

Figure 7: Experimental Setup of Friction and Wear test rig

IV. CONCLUSION

From the overview of above study concludes that, Addition of filler materials such as bronze and carbon to PTFE causes an increase in wear resistance, while the coefficient of friction is slightly affected.

- The friction coefficient of pure PTFE and its composites decreases by increasing applied load, which can be improved by reinforcement PTFE with glass fibres.
- For the specific range of load and speed, the load has strosnger effect on the wear behaviour of PTFE and its composites than the sliding velocity.
- Addition of filler materials such as carbon, graphite, glass fibers and PPDT to PTFE causes an increase in hardness and wear resistance, while the coefficient of friction is slightly affected and remains low. Filler materials in general are effective in impeding large-scale fragmentation of PTFE, thereby reducing the wear rate.

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