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A Review on Effect of Surface Texturing on Tribological Behaviour of Polymer Composites

Navale R.A.[1], Aher V.S.[2], Nagare P.N.[3], Bajaj D.S.[4], Wakchaure P.B[5]

P. G Scholar, Department of Mechanical Engineering, A. V. C. O. E, Sangamner[1]

Assistant Professor, Department of Mechanical Engineering, A. V. C. O. E, Sangamner[2,3,4,5]

Abstract: Surface texturing is feasible option of surface engineering which results in improvement of tribological properties like coefficient of friction, wear resistance, load carrying capapcity etc.In this work attention is given to investigate the effect of surface texturing on tribological properties of polymer composite materials. It also consider effect of various conditions so as to observe the comparative friction and wear behavior of Polymer composite with surface texturing on mating surface under varying loads at varying velocity by using different wear tester like Pin-on-disk tribometer, Ring-on-disc friction testing, needle friction test etc. The test will be carried out for composite materials like Polyamide composites, PTFE composites, HDPE polyblends etc. in dry and wet condition. In this work AISI SS 304 stainless steel disc having surface textured pattern on it will be used as counterpart surface and tests will be carried out at ambient conditions.

Keywords: Surface Texturing, Tribology, Dimples, Polyamide, HDPE, Wear, Friction

I. INTRODUCTION

Tribology is the science of rubbing surfaces in relative motion. It is the study of the friction, wear and lubrication of engineering surfaces with a view of understanding surface interactions in detail and then prescribing improvements in given applications. One of the important objectives in tribology is the regulation of the magnitude of frictional force according to whether we require a minimum or a maximum. This objective can be realized only after a fundamental understanding of the frictional process for all conditions like load, sliding velocity, lubrication, surface finish, temperature and material properties.Adding a controlled texture to one of two faces in relative motion can have many positive effects, such as reduction of friction and wear also increase in load capacity (adding texture to both faces tends to increase friction and cause other negative effects). Early studies recognized the potential of microasperitiesto provide hydrodynamiclift during film lubrication, while later research indicated that small-scale texturing could also provide lubricant reservoirs in poorly lubricated conditions and trap wear particles in boundary and dry lubrication. All of these effects may decrease friction and wear between two sliding surfaces, but some experimental results also show a negative effect from surface texturing. In some cases texturing is not optimized for a given case, in others there is no optimal case any kind of texturing may be worse than a smooth surface.

The wear resistance of Polymers can be significantly improved by addition of suitable filler materials. Besides the type, the shape and size of the materials added also influence the tribological properties. In the past, research in this area has been confined to the Polymer filled with conventional filler materials like glass fibers, graphite, carbon fibers, etc. However, with the growing demand for utilizing polymer in a variety of applications, significant effort is needed towards developing the novel composite materials by adding one or more non-conventional filler materials possessing the potential of increasing the wear resistance. It is established that polamide exhibits significantly low coefficient of friction when sliding against steels.Polyamide and it's composite are widely used because of the combination of good mechanical and tribological properties, especially in dry friction conditions where lubricants cannot be used.Polyamide is extensively used for a wide variety of structural applications as in aerospace, automotive, earth moving, medical, electrical, electronics, computer and chemical industries. On account of its good combination of properties, these are used for producing a number of mechanical components such as gears, cams, wheels, brakes, clutches, bearings, gaskets, seals as well as wires, cables, textile fibers, electronic components, medical implants, surgical instruments etc.

II. POLYMER COMPOSITE MATERIALS

Surface Texturing in Tribology

Various forms and techniques of surface texturing were developed over the years for enhancing Tribological performance. The vibrorolling method was developed by Schneider in 1984, it consists of producing shallow grooves by plastic deformation using a hard indenter on metallic parts. An extensive work has been done on vibrorolling in Eastern Europe that somehow went unnoticed in the western world. They initially used an etching technique which was later replaced by abrasive machining to form grooves that they termed undulated surfaces. Like in the function of the

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undulations is to act as traps for wear debris thereby reducing the ploughing and deformation components of friction and wear. Reactive ion etching (RIE) was employed by a group lead by Kato in Japan to study the effect of surface texturing, in the form of micro-dimples, on parallel sliding faces of SiC in water. Other techniques include Abrasive jet machining, LIGA, and lithography and anisotropic etching. Most of the work described above is experimental, using various types of pin on disk and ring on ring test machines. This is probably due to the fact that the involved phenomena are very complex, and only in limited cases can be described analytically [6].

PTFE Composites

Self-lubricating materials for bearing applications are introduced for economical, ecological and even for some technical reasons. In this way external lubricants such as oil or grease can be excluded, and the design can be simplified.Solid self-lubricating composites have been widely used in many fields when oils or greases do not meet the advanced requirements of modern technology under severe sliding conditions. As material and energy shortages develop, there will be greater demand for longer product lives, increased wear resistance, and reduction in energy consumption through lubrication and accordingly lower friction.

Recently, a number of new applications have arisen that have prompted renewed interest. The new requirements are primarily long-term life and broad-temperaturerange capacity[1].Polytetrafluoroethylene (PTFE) is one of the most commonly used and well known self-lubricating materials which exhibits very low coefficient of friction. In order to reduce wear loss of PTFE, PTFE filled with the micro/nano inorganic particulates or the fibers has been extensively studied.PTFE with various weight fractions of carbon, graphite, glass fibers, MoS2 and poly-phenyleneterephthaamide (PPDT) fibers.

The highest wear resistance was found for composites containing (i) 18% carbon+ 7% graphite, (ii) 20% glass fibers + 5% MoS2 and (iii) 10% PPDT fibers. Sawyer et al. [8] filled PTFE with alumina nanoparticles[1]. Due to high chemical resistivity, low coefficient of friction and high temperature stability of Polytetrafluoroethylene (PTFE) is extensively used in high performance mechanical seals[2].

PA46/HDPE polyblends

Tribological properties of polyblends is one of the important characters in industrial application. The application of polyblends in tribological fields is tendingto be more and more with the development of new technology.Therefore, it is need to understand the effects of internalstructure on the tribological properties of polyblends.

High density polyethylene grafted with maleic anhydride (HDPE-g-MAH) wasadded into polyamide (PA) for preparation PA/HDPE polyblendswith different phase structures. Itwas found that PA46/HDPE polyblendswith a better compatibility associated with a lower wear.

It is well known that both PA46 and HDPE are crystalline polymers,thus the crystalline characteristics may also influence thetribological properties of PA46/HDPE polyblends. The main objective of the study is to understand therelationship between the crystalline form and crystallinity of component polymers in the polyblends on their tribological properties [4].

Polyamide 6 composites

PA6 isahighperformanceengineeringplasticusedin electrical/electronics, automobile, packaging, textilesandconsumer applications becauseofitsexcellentmechanical properties [5]. However,limitationsinmechanicalpropertieslevel, thelow heatdeflection temperature,highwaterabsorptionanddimensionalinstabilityofpurePA6havepreventeditswiderangeofapplications.

Hence, solidlubricantswereaddedtopolyamide6towidenandto increase itsapplicationrange.Graphite,carbonandwaxfilledPA6 have foundtheirapplicationinfieldhighvelocityapplications, withouttheneedforexterior lubrication [5].In recent years, various micro-features have been applied on mechanical seals, automotive components, cutting tools and other mechanical components to improve friction behaviour and wear performance as well as to extend the life of mechanical components. Under dry sliding conditions, micro-features are able to trap loose wear debris from the contact surface[6].

III. EXPERIMENTAL SETUP

The Pin-on-disc wear testing is advanced regarding the simplicity and convenience of operation, ease of specimen clamping and accuracy of measurements, both of wear and frictional force. The machine is designed to apply loads up to 20 kg and is intended both for dry and lubricated test conditions. It facilitates study of friction and

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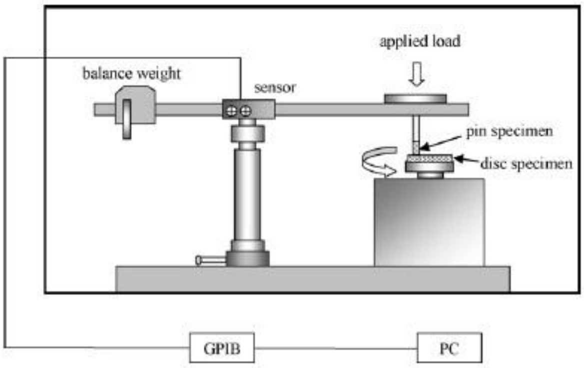

Figure 1. Experimental setup of Pin-on-Disc Tribometer [3]

wear characteristics in sliding contacts under desired test conditions within machine specifications. Sliding occurs between the stationary pin and a rotating disc. Normal load, rotational speed and wear track diameter can be varied to suit the test conditions. Tangential frictional force and wear are monitored with electronic sensors and recorded on PC. These parameters are available as a function of load and speed. The wear disc is mounted on the spindle top and is driven by a AC motor through a timer belt, which provides high torque drive with low vibration. The loading lever with specimen holder fixed at one end and at other end, it carries a wire rope for suspending dead weights to apply normal load on specimen. The frictional force produced between specimen pin and disc is directly measured by the load cell at other end. The specimen pin is placed inside a hardened split jaw and clamped to specimen holder. To clamp different sizes of specimens, individual jaws are provided for different sizes of pin specimens. The oil for test is supplied by a lubrication unit fixed at base of machine to leak proof lubrication chamber [3].

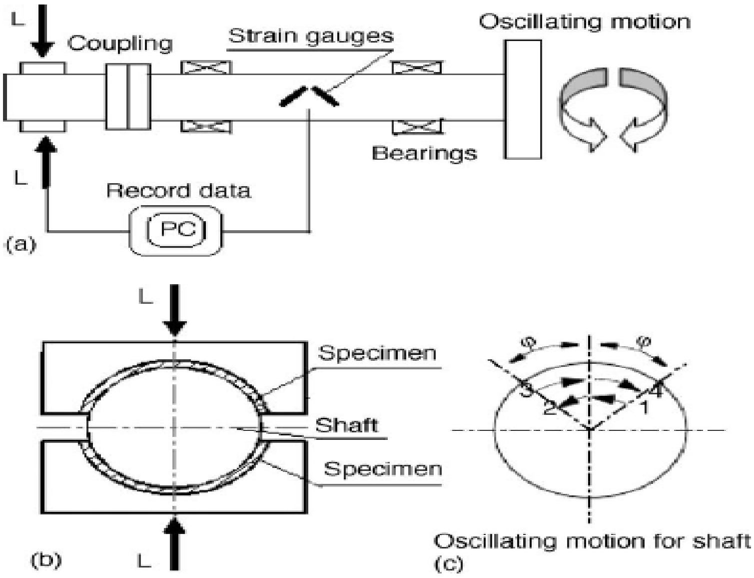

Figure 2 : Schematic diagram of Oscillating Tribotester [1]

Sliding experiments were carried out in laboratory airusing a computer-controlled oscillating tribotester. Figure 2shows the schematic representation of the part related to loadingof the apparatus. The coefficient of friction was measuredwith the aid of two linear variable strain gauges and wasrecorded automatically throughout the tests connected to a PC [1].

IV. CONCLUSION

In this review paper, tribological behavior of PTFE composites, Polyamide composites, HDPEpolyblends has been analyzed. It is observed that,

1. PTFE is widely used for high performance mechanical seals due to its high chemical resistivity, low coefficient of friction and high temperature stability.
2. The coefficient of friction of PTFE is slightly increases with increasing load values.
3. The compatibilizer HDPE-g-MAH enhanced the physical bondingbetween PA46 and HDPE phases.

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4. Frictional heat has significant effect on the tribologicalbehaviors of polymer–polymer combinations under dry friction, external oil lubrication reduces the frictional heat during sliding process, and hence decreases the friction and wear. The higher wear of PA66 under oil lubrication may due to the mechanical strength reduction because of the oil diffusion into the surface layer.

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