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An investigation of tribological performance of polymer based composites under different sliding conditions

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ABSTRACT

Polymer and polymer composites have been increasingly used in various industrial applications such as, aerospace, automotive and chemical industries. This is because these materials provide high strength/weight ratio. In this work attention is given to investigate the effect of surface texturing on tribological properties of UHMWPE & it's composite considering various conditions with & without surface texturing on mating surface under varying load of 184.07 N at velocity 0.12 m/s keeping the rest of the parameters constant by using a pin-on-disc type wear tester at NTP. The test will be carried out for material UHMWPE & it's composite in dry and wet condition. In this work AISI SS 304 stainless steel disc one having plane surface & other one having surface textured pattern on it and tests will be carried out at ambient conditions using a pin-on-disc Tribometer (TR-20LE).

Keywords— UHMWPE-Ultra high molecular weight polyethylene, Pin on disc, Friction ,Wear

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I. INTRODUCTION

Bearing material is basically required for being operated in friction assemblies, where no special lubricant is continuously required.fillers and reinforcements in the resin may provide increasing load withstanding capability, moderated coefficients of friction improved wear resistance, better thermal properties and increased mechanical strength. Internally lubricated composites with thermal stability and high wear resistance are the materials of interest. Toughness of epoxies can be enhanced by the incorporation of a second phase filler like ultra high molecular weight polyethylene (UHMWPE). A property of ultra high molecular weight polyethylene that distinguishes it from other polymers is its highly entangled molecular chains, which makes it wear resistant. UHMWPE is known as a long chain wear resistant polymer with a moderate coefficient of friction against steel counterface [11].

Virginio Quaglini et al. in 2009 [3] investigates the effects of the roughness of the metal counterface (mirror finished or polished) on the coefficient of dry friction for some of the most common engineering plastics used in current bearing technology. The results show that an optimal roughness for minimum friction is likely to exist for any polymer, and it depends on the bulk properties of the polymer itself. ''Soft" plastics characterized by a low modulus of elasticity exhibit better sliding behaviour on very smooth, mirror finished surfaces, whereas for high-modulus plastics lower friction is measured in combination with rougher, polished counterfaces. The influence of the contact pressure and sliding velocity are also investigated and found to depend on the layout of the tribological system.

Micro-dimple array has been generally considered as a valuable texture for sliding surfaces. It can improve lubrication and reduce wear by acting as reservoirs of lubricants and grinding debris. Laser shock processing (LSP) is an innovative process which can not only improve fatigue, corrosion and wearing resistance but also shape metallic parts accurately, [25] L.M. Vilhenaet al. in 2009 [24] Studied Introducing specific textures on a tribological surface can contribute to friction reduction in sliding contacts.Jinyu Zhanget al. in 2012[26] Studied Surface texturing has been viewed as one of the effective surface engineering technologies to significantly improve tribological performance of mechanical parts. Andriy Kovalchenkoet al. in 2009 [27] Studied Laser surface texturing (LST) is an emerging effective method for improving the tribological performance of friction units lubricated with oil.

It is advantageous to replace metal parts in various industries such as manufacturing of cars, airplanes, etc. by PBMs. The advantages include lower density, less need for maintenance, and also lower cost. The main reason for the trend of replacing metal parts by polymers is energy-saving. Density of polymers is generally lower than the density of metals, so that with a certain amount of fuel the car with the polymer parts can travel greater distance compared with a standard car with mostly metal parts; the same applies to airplanes.[5]
Boon-Peng Changet al. in 2013 [8] Studied ultra-high molecular weight polyethylene (UHMWPE) reinforcedwith micro-zinc oxide (ZnO) and nano-ZnO under different filler loads. The wear and friction behaviors were monitored using a pin-on-disc (POD) test rig & he observed that UHMWPE reinforced with micro- and nano-ZnO would improve the wear behaviour. The average coefficient of friction (COF) for both micro- and nano-ZnO/UHMWPE composites were comparable to pure UHMWPE. Dangsheng Xionget al. in 2001 [10] Studied Friction and wear behavior of ultra-high molecular weight polyethylene (UHMWPE) sliding against Al2O3ceramic under dry sliding, and lubrication of fresh plasma, distilled water and physiological saline were investigated with a self-made pin-on-disk apparatus & he observed that The wear rate of UHMWPE under dry sliding is the highest and under plasma lubrication is the lowest.
The aim of this work is to study the influence of surface texturing on properties of UHMWPEby adding fillers on it & also To find out the behavior of the polymer based composites from wear &frictionpoint of view and the effect of sliding speed and load on it under dry & wet conditions.In this work AISI SS 304 stainless steel disc is usedone surface is plane& other surfacehaving textured pattern on it and tests will be carried out at ambient conditions using a pin-on-disc Tribometer (TR-20LE).

II. EXPERIMENTAL PROCEDURE

A. Experimental set up

Experimental set up of a pin-on-disc Tribometer (TR-20LE) was used for the readings of a wear and frictional force.The TR-20LE 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 along with lubrication and environmental facility.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 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.

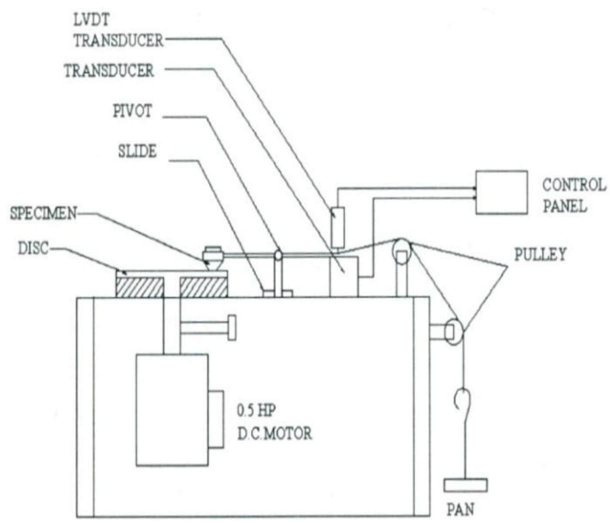

Fig.1 Experimental setup of Pin on Disc Tribometer

Experimental set up which is available in Amrutvahini College of Engineering, Sangamner is as shown in following photograph. Using a pin-on-disc Tribometer (TR-20LE) readings will taken.

B. Material

TABLE 1

PROPERTIES OF UHMWPE

Sr. No.	Property	Unit	Value
1.	Density	gm / cc	0.93
2.	Tensile Modulus	Psi	125000
3.	Maximum operating temperature	°c	82
4.	Thermal conductivity	°c	10.06
5.	Hardness	Shore D	62-66
6.	Compressive Strength	Psi	2000

C. Testing Facilities

Experimentation can be done by rubbing each of the test pins (diameter 10 mm and length 30 mm) of UHMWPE & its composites against different material disc surfaces in dry & wet conditions using a pin-on-disc Tribometer (TR-20LE) at NTP.Testing samples would be of different type of filler added to engineering plastics.

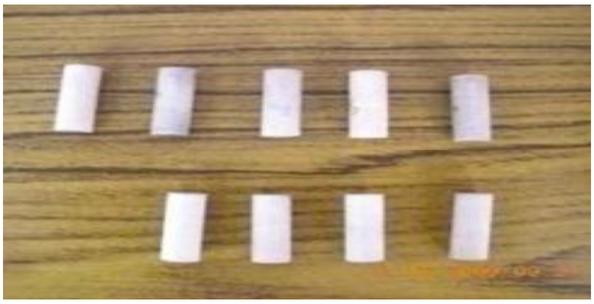

Fig. 2 Specimenspins

Counterface-2 will the disc material made up of AISI SS 304 stainless steel with surface finish of 0.1-0.4 µm. Its material compositions are listed in Table 2

TABLE 2

MATERIAL COMPOSITION OF AISI SS 304 (04CR18NI10) STAINLESS STEEL DISC.

Content	C	Si	Mn	P	S	Cr	Ni
Percentage	0.08	0.75	2.00	0.045	0.03	18	10

III. EXPECTED OUTCOME

1. As the fillers added to the polymer its strength would increase and thereby wear rate may decrease, similar result are expected from the polymer based composites used for investigation in this project.
2. There will be a chance of Improvement in wear resistance and reduction in coefficient of friction of polymer composites.
3. Also there will be a chance of significance improvement in the life of component.
4. 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).

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REFRENCES

1) Shyam Bahadur ‘The development of transfer layers and their role in polymer tribology, wear 245 (2000) 92-99
2) M.H.Chon, Sangil Park, 'Micro CNC surface texturing on polyoxymethylene (POM) and its tribological performance in lubricated sliding'.Tribology International 44 (2011) 859-867.Virgino Quaglini, Paolo Dubini, Daniela Ferroni, Carlo Poggi ‘Influence of counterface roughness on friction properties of engineering plastics for bearing applications Material and Design ‘30(2009) 650-658
3) Virgino Quaglini, Paolo Dubini, Daniela Ferroni, Carlo Poggi ‘Influence of counterface roughness on friction properties of engineering plastics for bearing applications Material and Design ‘30(2009) 650-658
4) Prof Dr. G.J.Vikhe, Prof Y.R. Kharde, Prof D.S.Bajaj An investigation of tribological behaviour of PTFE+glass fibre against variable surface roughness .Indian journal of tribology 3 (2008) 47-54
5) Witold Brostow, Vera Kovacevic, DomagojVrsaljko And Jenna Whitworth, `Tribology of Polymers And Polymer Based Composites',Journal of Materials Education Vo1.32,(2010),273-290.
6) Boon-Peng Chang a, HazizanMd. Akil, Ramdziah Bt. Md. Nasir “ Comparative study of micro- and nano-ZnO reinforced UHMWPE composites under dry sliding wear ” Wear 297 (2013) 1120–1127.
7) Y. R. Kharde and K. V. Saisrinadh “Effect of various fibre on tribological property of (PTFE) in dry condition”, International journal of maths, science and engineering application (IJMSEA) ISSN 0973-9424 vol 3 No 11(2009), 311-328.

8) Shirong Ge "Increasing the wear resistance of UHMWPE acetabular cups by adding natural biocompatible particles "Wear 267 (2009) 770–776.
9) Xinlei Gao, Meng Hua ,Jian Li, Wanzhen Gao "the tribological properties of ultra-high molecular weight polyethylene modified with a Schiff base complex "Materials and Design 31 (2010) 254–259.
10) Dangsheng Xiong, Shirong Ge "Friction and wear properties of UHMWPE/Al2O3 ceramic under different lubricating conditions" Wear 250 (2001) 242–245.
11) Navin Chand, U.K. Dwivedi, M.K. Sharma "Development and tribological behaviour of UHMWPE filled epoxy gradient composites " Wear 262 (2007) 184–190.
12) Bharat Panjwani" Tribological characterization of a biocompatible thin film ofUHMWPE on Ti6Al4V and the effects of PFPE as toplubricating layer " journal of mechanical behaviour of biomedical materials 4 (2011) 953-960.
13) Weston J. Wood a, Russ G. Maguire b, Wei Hong Zhong a, "Improved wear and mechanical properties of UHMWPE–carbon nanofiber composites through an optimized paraffin-assisted melt-mixing process "Composites: Part B 42 (2011) 584–591.
14) Adrian Lopez-Cervantes, Ivan Domınguez-Lopez, Jose´ Dolores Oscar Barceinas-Sanchez, Adrian Luis Garcıa-Garcıa " Effects of surface texturing on the performance of biocompatible UHMWPE as a bearing material during in vitro lubricated sliding/rolling motion " Journal mechanical behaviour biomedical materials 20 (2013) 45-53.
15) C.F.Gutiérrez-González." Tribological behavior of a novel alumina/nano-zirconia/niobium biocomposite against ultra-high molecular weight polyethylene "Wear 303 (2013) 211–215.
16) Sandip B. Chaudhari. Prof. S.P. Shekhawat "Wear Analysis of Polytetrafluoroethylene (PTFE) and it's Composites under Wet Conditions" IOSR Journal of Mechanical and Civil Engineering Volume 8, Issue 2 (Jul. - Aug. 2013), PP 07-18.
17) Yemei Liu a Wear performance sand wear mechanism study of bulk UHMWPE composites with nacre and CNT filler sand PFPE overcoat" Wear 300 (2013) 44–54.
18) Boon Peng Chang. " Comparative study of wear performance of particulate andfiber-reinforced nano-ZnO/ultra-high molecular weight polyethylenehybrid composites using response surface methodology "Materials and Design 63 (2014) 805–819.
19) Daniel Braun et al. "Efficiency of laser surface texturing in the reduction of friction under mixed lubrication "Tribology International 77(2014) 142–147.
20) Ning Liu, Jianzhang Wang, Beibei Chen, Gaofeng Han, Fengyuan "Enhancement on interlaminar shear strength and tribological properties in water of ultra high molecular weight polyethylene/glass fabric/phenolic laminate composite by surface modification of fillers "Materials andDesign 55 (2014) 805–811.
21) Fehim Findik "Latest progress on tribological properties of industrial materials "Materials and Design 57 (2014) 218–244.
22) J. A. Puertolas "Evaluation of carbon nano tubes and graphene as reinforcements for UHMWPE-based composites in arthroplastic applications "journal of the mechanical behaviour of biomedical materials 39 (2014) 129-145.
23) Taisho Hasegawa, " Tribology research trends " Nova science publishers , ISBN 978-1-60876-331-3 (E-Book) TJ1075.H38 2008.
24) L.M. Vilhena, "Surface texturing by pulsed Nd:YAG laser " Tribology International 42 (2009) 1496–1504.
25) " Experimental study of micro dimple fabrication based on laser shock processing " Optics & Laser Technology 48 (2013) 216–225.
26) Jinyu Zhang, Yonggang Meng∗ "A study of surface texturing of carbon steel by photochemical machining " Journal of Materials Processing Technology 212 (2012) 2133– 2140.
27) Andriy Kovalchenko "The effect of laser surface texturing on transitions in lubrication regimes during unidirectional sliding contact " Tribology International 38 (2005) 219–225.

