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Review on Investigation in Wear of polyoxymethylene composites by using Tribometer

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Abstract—Surface texturing improves load carrying capacity, wear resistance, friction coefficient etc. of the tribological component. We preferred LST. In the recent year laser surface texturing (LST) has emerged as a versatile and high speed surface texturing method that can provide well control surface characteristics for variety of material. Polymer and polymer composites have been increasingly used in various industrial applications such as aerospace automotive and chemical industries. That material provides high strength/weight ratio. There were many different polymers like polyoxymethylene (Delrin), polyester, polyamide, polypropylene, PEEK; PTFE etc. were available. But in this work attention is given to investigate wear and the effect of laser surface texturing on tribological properties of polymer composites material considering various conditions under varying loads at varying velocity by using a pin on disc type wear tester at NTP. Experimental work is to be carried out by varying loads of 20N, 40N, 60N and 80N at sliding velocity 0.1m/s, 0.2m/s, 0.3m/s and 0.4m/s keeping the rest of the parameter constant. The test is to be carried out for material pure polyoxymethylene and its composites like (Polyoxymethylene + 10%, 20%, 30% glass fiber) and (polyoxymethylene + 5%, 10% Kevlar) in dry and wet condition. In this work AISI 304 stainless steel disc one having plane surface and other one having surface textured pattern on it was to be used as counterpart surface and test was to be carried out at ambient condition using a pin on disc Tribometer (TR-20LE).

Keywords-Laser surface texturing, polyoxymethylene, wear measurement

I. INTRODUCTION

Surface texturing was enhancing interest in the dynamic field of surface engineering. It was enhancing the tribological properties of material. Laser surface texturing deals with reduce wear of materials and worn fragment falls into dimples during the sliding motion it also provides counterwork due to hydrodynamic disturbance of lubricant result in an increased coefficient of friction. Surface texturing concave shape was widely studied so the main role was focused on retention property of lubricant. However, texturing with con-vex shape can be used in many areas. For example micro CNC surface texturing on polyoxymethylene and its tribological performance was studied by M.H.Cho et al. [1] Also when lubricant provided that was situated in textured pores for that sometimes dry running condition occurs can avoid abnormal temperature rise. Laser surface texture comprising a distribution of cavities with a flat shape profile improves lubrication in the contact area. Laser surface texturing (LST),

which had involves creation of an array of micro dimples any shape on the seal surface by a material ablation process with a pulsed laser beam was traced on that material.

Polyoxymethylene (POM) resin was a kind of widely used engineering thermoplastic polymer material, which exhibits good fatigue resistance, good creep resistance and high impact strength. Also it had low friction coefficient due to the flexibility of the linear molecular chains. It had good wear-resistant properties because of its high crystallinity and high bond energy, so when sliding against stainless steel it was difficult to transfer to the metal counter-surface or form wear debris in the contact area. Another material we had taken for experimental work was glass fiber and Kevlar. Glass fiber having strong and stiff in tension and compression. Kevlar had been high tensile strength and resilience down to cryogenic temperature in fact slightly stronger at low temperature. In this experimental work we have been perform work on pin on disc apparatus. So we had been made pin of polymer materials and counter surface of stainless steel disc for measuring wear rate. But in this experiment we prepared two stainless steel discs having one disc surface has textured by using laser surface texturing and another disc has plane surface.

1. Experimental Procedure

1. 1. Material and Sample Preparation

Polyoxymethylene (POM) was widely used engineering polymer due to its low friction characteristic and its very good mechanical properties. Polyoxymethylene (POM) was used for surface texturing in that experiment mainly surface texturing by laser and Micro CNC used, POM specimens, 30 mm in diameter and 10 mm in thickness, were prepared to perform experiment and specimen cut on lathe machine. The POM surface was then further finished by abrasion using SiC abrasive paper of grit number 4000, resulting in a surface roughness of about 0.2 mm Ra (MitutoyoSJ-201).The POM sample was then mechanically cleaned by an ultrasonic cleaner with the application of acetone for 10 min time and dried before the machining process. specimen prepared in micro CNC surface texturing on polyoxymethylene and its tribological performance in lubricated sliding by M.H.Cho et al. [1]

Another paper we had referred Granular form of polyoxymethylene (POM) was purchased from Formosa Plastics Corporation Limited. The nano-Al_2O_3 material used was spherical form of α-Al_2O_3 with corundum structure and their average particles sizes were below 40 nm. They were supplied by a Hehai Nano phase Technologies Corporation in Jiangsu Province of China. Silane coupling agent KH-550 was obtained from Yaohua Chemical Plant in Shanghai. Dilute solution of the Silane coupling agent KH-550 of (2 wt. %) with the alcohol. Then later on solution was added with nano-Al_2O_3 particles followed by dry under the vacuum to eliminate alcohol. Blend of the polyoxymethylene (POM) with modification of nano-Al_2O_3 (various contents to polyoxymethylene (POM)). In the SHJ-30 twin-screw extruder was used for that mixturing of the material. These specimens were prepared in study on the friction and wear behavior of POM/Al_2O_3 Nano composites by Lan-Hui Sun et al. [2]

The specimen of some polymer material like polyamide 66, polyoxymethylene, UHMWPE, PPS+30%GFR, and APK polymer. The specimen having cylindrical pin was prepared of 6 mm diameter and 50 mm length were tested against counter surface AISI D2 steel disc having hardness of 60 HRC and roughness of that steel disc was 0.11 μm Ra. That was prepared in Dry sliding wear characteristics of some industrial polymers against steel counter face by H.Unal et al [3]

The specimen prepared of polyoxymethylene had combination of mechanical and tribological properties. PTFE and silicon oil blend were generated friction for that purpose, which was used as a soft coating purpose. Glass fiber with the reinforced polyoxymethylene was also

considered to determine role of abrasive effect of the filler material which was added on the matrix. (Polyoxymethylene with the combination of 20% glass fiber, 20% Teflon (PTFE) dispersed fibers and micro powder). And another specimen were considered for sliding surface as smooth galvanized (100% zinc) low carbon steel plate (G90 type) with the thickness of film approximately 100 μm and having surface roughness of 0.65μm.second specimen was steel plate coated with electro deposited cathodic epoxy layers known as E coatings. These samples were used for friction and wear of blended polyoxymethylene sliding against coated steel plates by H.Benabdallah. [4]

The specimen used for that testing purpose was polyoxymethylene (POM). The small pins were made up of polyoxymethylene produced by Dupont. So for testing purpose select the basic grade NC010 150 (High viscosity extrusion). The rod of POM was cut by using lathe machine. Cares taken during the machining process on lathe machine, for avoid secondary effect. Counter surface disc was made up of AISI 304 Stainless steel. Disc machined by rod stock to their final dimension. This disc was polished by using 240 grit SiC abrasive papers to create surface roughness Ra - 0.28 μm measured by using Mitutoyo 301 surface roughness instruments. After preparation of specimens cleaned in an ultrasonic acetone bath for 15 min and then dried. Software required for simulation purpose was ANSYS 6.1.these condition given in finite element simulation of the wear of polyoxymethylene in pin on disc configuration by H.Benabdallah et al [5]

1. 2. Sliding Test

M.H.Cho et al performed Sliding test was performed on the apparatus pin on disc which was used for that experiment. To increase the contact area between specimen material of polyoxymethylene and disc pin holder was improvised. The microspores were mainly effective under certain condition of lubrication like hydrodynamic lubrication. For increase contact between two mating solid material was not so easy to achieve that target. So for that purpose one side of the disc was flat and other side of disc was machined into crater shape while the crater used to mate steel ball 12.7 mm in diameter that ball was fixed on ball on disc apparatus. For the sliding test diameter and thickness of steel disc was 6.8 and 1mm. disc material was bearing steel ASTM 52100. Roughness of disc was 0.04 μm Ra. sliding speed was 0.1m/s and contact pressure was 1.35 MPa. Time for that test was 2.78 h. lubricant used for study SAE 5W-30 automotive oil. That lubricant spread on to the surface of polyoxymethylene and entrapped on holes. That sample prepared held on the CNC machine. Now measured the variation in coefficient of friction was recorded by using sliding time. [1]

Lan-Hui Sun et al performed friction and wear test on Amsler friction and wear tester by using block on ring apparatus before test apparatus was cleaned by acetone dipped cotton. For test ambient temperature was about 23^0C and humidity for that was 60%. sliding performed for period of 2 h at sliding velocity 0.42 m/s load for that experimental work was selected as an 98,147,196,245 and 394 N. when oil is entrapped to the contacting surface so that time friction coefficient was calculated. [2]

H.Unal et al performed dry sliding test on the pin on disc type apparatus for friction and wear measurement. In that test they had used pressure range between (0.35-1.35 MPa) and that of sliding speed of 0.52 m/s. in that test we had to measure weight loss measurement was running test for 1000 m of the sliding distance. [3]

H.Benabdallah performed experiment on a pin on disc apparatus in that the plastic samples, which consisting of small hollow blocks had curved contacting surface mounted inside the holder. The holder pivoted with rigid horizontal arm and that arm attached to the load cell

that measures frictional force. Load was applied on samples by using dead weight. Due to reciprocating force variation of force was take place. [4]

H.Benabdallah et al performed test on pin on disc apparatus. Laboratory condition for testing on pin on disc apparatus as ambient room temperature 21 ± 3^0C and 50 ± 10% relative humidity. Each test in experimental work conducted at certain condition load expresses by contact pressure P sliding speed V and sliding distance S, these repeated at least four times. Condition of these sliding tests given bellow in Table 1. [5]

***Table 1. Experimental Condition*. [5]**

V(m/s)	S(Km)	P(Mpa)
1	20	1
1	20	10
1	80	1
1	80	10
0.5	20	1
0.5	40	5
0.5	80	10
0.1	20	5
0.1	40	5
0.1	80	5

RESULT

M.H.Cho et al studied Surface texturing by using laser most kindly used in modern experimentation. But in that work both texturing method was used like laser surface texturing and another was micro CNC surface texturing. The wavelength of laser for surface texturing was 1064 nm and energy for that was varied from 0.5 to 1.5 mJ. That textured hole act as a reservoir of lubricant. Friction coefficient was investigated by the wear of the surface textured polyoxymethylene. In that experiment coefficient of friction increases with the density of surface textured increased. Polyoxymethylene with 10% texturing density had low friction coefficient. [1]

Lan-Hui Sun et al studied comparison of friction and wear properties of polyoxymethylene (POM) and polyoxymethylene mixture with 3% Al_2O_3 Nano composites in dry sliding condition which increase in coefficient of friction and wear volume of polyoxymethylene Nano composites. Under oil lubricated condition polyoxymethylene and 9% of Al_2O_3 Nano composites peeling off from worn out surface over the counter surface which had been decreased the wear resistance of polyoxymethylene Nano composites. The coefficient of friction to the Nano composites decreases with the increase in load application. [2]

H.Unal et al studied sliding speed should be minimum in order to restrict temperature rise of the polymer used. When temperature raises result in a considerable increase in coefficient of friction value. Low specific wear rate was observed in polyamide 66 and highest wear rate in polyoxymethylene polymer. Friction coefficient of polymer linearly decreases with the applied pressure. [3]

H.Benabdallah studied operating condition by bearing load vary from 5 N to 30 N and that of the sliding speed 0.05 to 0.3 m/s had been a significant used of dynamic friction and specific wear rate was calculated. In that study wear rate lower than 4 x 10^{-5} mm^3/Nm were achieved with the friction coefficient was 0.2. For that of testing purpose load and speed lower than 15 N and 0.1 m/s. [4]

H.Benabdallah et al determined friction coefficient as the ratio of measured friction force and applied normal load for that given experiment. Example for calculating purpose of experimental result in that sliding distance was varied when P = 5 MPa and V = 0.1 m/s. wear profile given below Figure 1. [5] After result get-ting they had to perform next step that was simulation. FE simulation by using software package ANSYS 6.1. Predicted a pressure distribution at a contact zone that would also explain experimental wear out profile. Software implemented as a wear equation that updates geometry on an average value of specific wear rate was to be determined. [5]

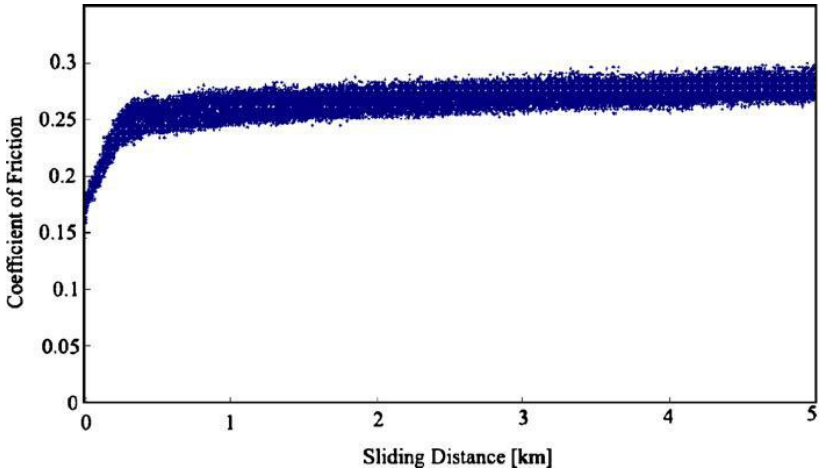

Figure 1. COF variation with the sliding distance; P = 5 MPa, V = 0.1 m/s. [5]

II. RESEARCH GAP

It was cleared that from above reference of research work clear research gap seen no research work on compo-site of polymers. In that polymer composite material like pure polyoxymethylene and in addition to that of glass fiber and Kevlar material was used in some percentage. Such as (Polyoxymethylene + 10%, 20%, 30% glass fiber) and (polyoxymethylene + 5%, 10% Kevlar). Also we had seen effect of surface texturing on tribological properties. And suggest best suitable pattern of surface texturing for application of journal bearing. Develop relationship between the coefficient of friction, frictional force, velocity & load by mathematical modeling using regression analysis.so this research work we have to work under dry and wet lubricated condition on pin on disc Tribometer.

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