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The Behavior of Treated Metal Curvature Cup: Improving Friction in Hard on Hard Sliding Contact

D.M.Razak[ab*],S.Syahrullail[a],Y.Azli[c]

[a]Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310, Skudai, Johor, Malaysia
[b]Depatment of Mechanical Engineering, Politeknik Tuanku Sultanah Bahiyah, 09000, Kulim, Kedah, Malaysia
[c]Faculty of Biosciences and Biomedical Engineering, Universiti Teknologi Malaysia, 81310,Skudai, Johor, Malaysia
[*]razakat@gmail.com

Abstract

This research investigated the tribology on the metal curvature surface in lubricated of palm olein to determine pits capability friction in hard on hard sliding contact. The study was performed using a four-ball tribotester with holder cup modified and digital microscope. The sliding friction between untreated and treated curve cup were evaluated. The experiment was conducted of constant parameters as speed; load and time under the American Society for Testing and Materials (ASTM), number D 4172. To evaluate lubricant ability all results of this research were compared to findings regarding mineral oil. For qualitative analysis worn wear on the curvature cup without applying lubricant to the sample. The results showed that, the measured friction was low significantly influenced by the treated curvature surface embedded with pits and palm olein as potential anti-friction bio-lubricant.

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Keywords: *Metal, Pit, bio-Lubricant, Friction*

1. Introduction

In biomedical engineering, the curvature cup surface was investigated as ball and socket in tribology of hip, shoulder, knee and joint prosthesis in medical implant technologies [1-4]. In other application, curvature surface that frequently used on the engine block . Studied on tribological hard hemi-curve surface have been applied in ball bearing , gear tooth in power mechanism system [5,6].

Nowadays, surface modification technology is important on hard curvature cup to reduce friction and wear which may reduce life span of metal based equipment or metal prosthesis. Surface modification on the hard metal with holes, dimples, grit is one of the approaches or machinates for avoiding direct metal – on-metal contact from

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rubbing surfaces [7,8]. Friction and wear mechanism not only destroys the sliding surfaces, but the generation of wear particles which cause cavitation and can lead to the failure of the component function.

Friction between hard on hard (HoH) sliding contact can cause a great deal of wears and tears. The in vivo test approach is one of the experimental techniques which has been proven to identify wear and friction . In this study, authors will be determined the behavior of treated hard curvature cup for improving the friction value and wear figure sliding motion. Sliding motion generates wear determined leading loosening and friction induced from the motion sliding in metal on metal [9].

Friction coefficient decreased depending on the surface pattern, and the dimple such as groove [10]. Thus, the focus of this study is to identified the behavior of pits on hard on hard (ball and curvature surface), that the treated curvature cup with pit in lubricated of palm olein optimize the rate of frictional and allow for a stable of hard on hard sliding contact. Authors also discussed the effect of palm olein and commercial mineral oil for improving the lubrication between hard on hard curvature cup contact sliding.

2. Test specimens, apparatus and procedures

2.1Electrical discharge machine die sinker (EDM DS)

In this study for a successful machining pits on the hard metal of curvature cup using CNC EDM Die sinker machine (EDM DS).

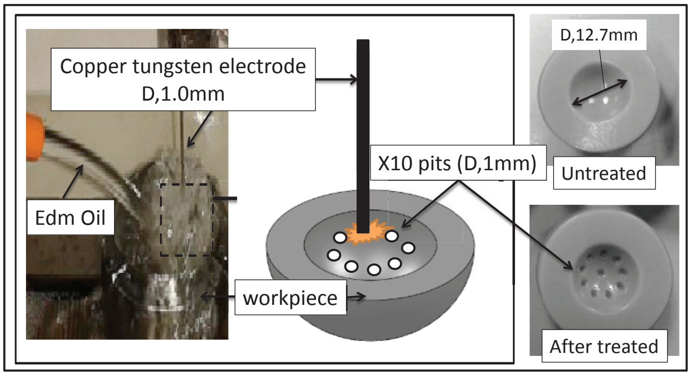

Fig 1. Experiment set up for machining micro pits of hard curvature surface.

The parameters in EDM DS are considered such as current, diameter of electrode Ø, QD_{up} (length of retraction gap distance of electrode),QD_{on}(duration of machine head pulse discharge),T_{on} (discharge on time adjustment),T_{off} (Off discharge time adjustment),V_{gap} (*voltage* during the *EDM* process). Detail of the parameter setting on this experiment is shown in Table I. An electrode radius of 0.5mm was selected for machining pits or holes of 0.5mm for radius and depth on curvature cup workpieces. Fig 1 shows the experiment set up for machining micro pits of curvature cup. The curvature cup is round in shape and curve in the center (flatten). Electrode copper tungsten rod with composition (copper25%, tungsten 75%) is used to machine ten pits on the workpiece.

Table 1- Setting condition for EDM DS neuar A50

Parameters used	***Value set***
Current	0.5 A
Diameter electrode ,Ø	0.5mm
QDup	1mm
QDon	30µs
Ton	0.50µs
Toff	4 stages=10µs
Vgap	60V

2.2 Tribo-system

In this study curvature cup is made of JIS-SKD 11 with diameter 12.8mm and fixed to ball bearing from chrome alloy steel balls made of AISI E-52100, with a diameter of 12.7 mm, extra polish (EP) grade of 25 and 64 to 66 HRC. The modified four-ball tribometer (Fig. 1) was developed to determine the friction torque of experimental lubricant oils. The microscope was used to compare the wear scar on the metal curvature surface.

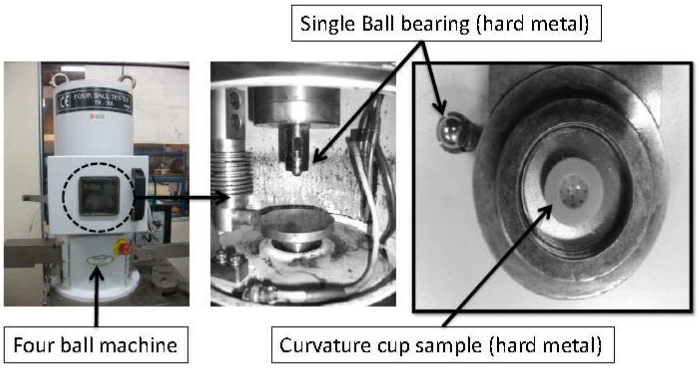

Fig. 1.Test equipment four ball tribometer with ball and metal curvature cup (HoH)

Before running the experiment, the thermocouple was connected to the ball pot. A 400N load was set to the loading arm until the digital monitoring showed the load achieved. Around 5 ml of test lubricant was added to the ball pot. The cup pot assembly was placed on the antifriction disk and inside the machine, under the spindle. A steel ball and curvature cup samples were cleaned with acetone before each experiment. This is to ensure that, no need to persist solvent effects when placed lubricants. The machine was set up with desired speed, load, temperature and time. A curvature sample was inserted into the ball pot. The cup lock ring was put in to the ball pot and placed on the cup sample and lock nut was tightened using torque wrench. One ball was inserted into the collection area to taper the end of motor spindle.

A detailed Table 2 representing an experimental condition hard on hard using modified fourball ball tribometer. These tests were carried out in different lubricant and curvature cup patterns (untreated and treated). The conditions set by the American Society for Testing and Materials (ASTM). Conditions in this research were as follows: temperature: (40), speed: (100 ± 5) rpm, and time: (60 ± 1) minutes.

Table 2. Experimental condition

Experimental Conditions	***Speed (rpm)***	***Load (kg)***	***Lubricant***	***Material hard (top)- hard (bottom) Metal-on-metal***
40°C	100rpm	40	Palm Olein/Mineral oil	Untreated (flatten)
40°C	100rpm	40	Palm Olein/Mineral oil	Treated (10 pits)
40°C	100rpm	40	None/dry	Untreated (flatten)

The test were run in dry condition and lubricated with two types of lubricant as in Table 2. Palm olein obtained from the fractionation of palm oil after crystallization .It is consist of C_{50} (42.04%) and C_{52} (45.66%) and an iodine (iodine and moisture) value 56. Palm olein was supplied from Felda Iffco (Malaysia). The data have thus suggested that all palm olein can produce less wear as compared to mineral based slopes at 400N.

3.1. The effect of Treated cup on the surface quality

In this experiment an investigation for metal on metal contact as hard on hard in dry condition lubricant, it shows a damage surface or severe surface in dry condition wear presented (in Fig.3c and Fig.3c). Moreover, the surfaces are considered in dry contact, the lubrication effect has been taken into account in the wear factor. In addition, although several wear mechanisms can affect the hard curvature during experimental in running time of sliding contact [11]. The absence of lubricants may affect quality of the surface changes to a characteristic of damage roughness. The qualitative analysis from MIA, for palm olein and mineral oil as lubricants surface appearances in well condition. However, different results were also mentioned, in the next experiment samples with lubricants were tested. Sample of cups was observed with free wear from each lubricant. Both surfaces on the sample cup (SKD 11) have no different before and after the experiment, with end up approximately adhesive surface or we accept the result is a fair surface. Predominantly for treated cup in Fig 3b and 3e is more smoother compared the untreated cup in Fig.3a and Fig.3d.

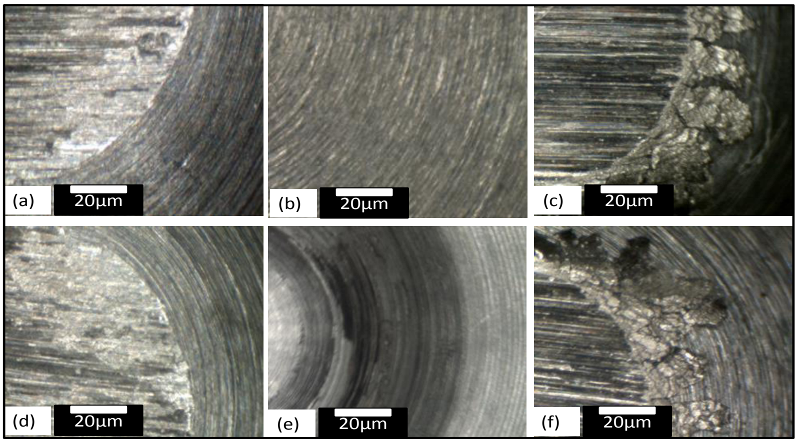

Fig. 3 Represented after experiment surface of curvature cup for 6 samples using digital microscopic Image Analysis ~ 100X (MIA). a)untreated curvature cup lubricated with mineral oil, b) treated curvature cup lubricated with mineral oil, c) untreated curvature cup in dry condition, d)untreated curvature cup lubricated with palm olein, e) treated curvature cup lubricated with palm olein, f) untreated curvature cup in dry condition

3.2. The effect of oil and pits on the sliding friction

From Fig .4 shows the averages of untreated frictional torque against palm olein and, mineral oil were 0.258 Nm and 0.273 Nm, respectively. The range frictional for hard metal cup embedded with pit using palm olein and, mineral oil at 0.224-0.264 Nm was recorded. It can be seen for each sample were test with lubricant were determined that a slight difference frictional torque recorded from the untreated compared treated surface.

In this experimental, the effect of lubrication and pits were determined mineral oil has low performances as lubrication compared to palm olein which contain fatty lauric and iodine. The sample embedded with 10 pits is more survive compared to no pit by referring the figure samples and correlate to the frictional torque. The obtained results on hard cup surface appearance will make the lifespan of metal curvature cup pro-long depend on the lubricant composition. Under the same condition as that used hard on hard, the two lubricants were tested. At the moment when mineral and palm olein lubricant applied, the frictional torque is surviving on the sliding contact (ball metal on cup metal).

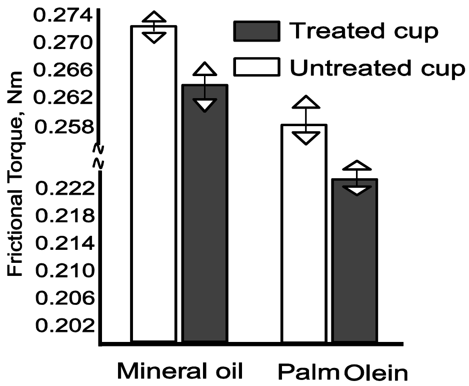

Fig.4. Frictional torque VS oil using Palm olein and Mineral oil.

Sliding pairs on the metal ball bearing hard on metal curvature cup showed that palm olein thin film of intermolecular layer in palm oil during as one factor affected reducing frictional rates [12]. The surface modified with pits correlates to frictional torque as in Fig 4. Also, palm olein showed low friction oil because low in fluid viscosities and anti-wear characteristic. Analysis of the present pits and no pit in this experiment can be seen in Fig.3 and Fig. 5 eventually worn surface depends on lubricant and pits as oil reservoir port. The present of pit will act as oil and debris reservoir which survived the surface of cup as in Fig 5.

4. Conclusion

The friction torque obtained lubricated with palm olein is better compared mineral oil. The result was compared mutually with different lubricant applied and surface with pit (treated) on the curvature cup. The results of this study revealed that the treated curvature cup with pits in lubricated of palm olein improves the rate of frictional and allow for a stable of metal on metal sliding contact. Also, the severe damage on the metal cup and reduces the friction and wear during motion with loading contact may avoided with surface in lubricated with palm olein compared to mineral oil. Finally, Palm olein used as lubricant in tribology studied on the hard on hard may be summarized as great lubricating oil because it possesses no additive formula and restocks specifically act as anti-wear and anti-friction.

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