An investigation of hard-on-soft contact: For reducing friction in hemispherical cup

D.M. Razak[1,2,*], S. Syahrullail[1], M.A. Nurul[1,2], N. Nuraliza[1], Y. Azli[3]

[1)] Faculty of Mechanical Engineering, Universiti Teknologi Malaysia,
81310 UTM Skudai, Johor, Malaysia.
[2)] Jabatan Pengajian Politeknik, KPTM present 2, 62100 W.P, Putrajaya Malaysia
[3)] Faculty of Biosciences and Medical Engineering, Universiti Teknologi Malaysia,
81310 UTM Skudai, Johor, Malaysia.

[*]Corresponding e-mail: razakat@gmail.com

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ABSTRACT – Sliding motion for hard on soft (HOS) implant material application causes sliding impact failure. This research was conducted using different cup surfaces. Different amount pits fused on the hemispherical cup have shown the potential for improving the tribology of HoS sliding contact. Four-ball machine has been used as screening machine to evaluate the friction. The results showed that modified hemispherical cup with pits and lubricated with palm oil had a significant to reduce frictional rate. This new surface improvement will prolong the life span of soft implant material due to lubrication activities in HoS contact sliding.

1. INTRODUCTION

Surface modification on soft metal is one of the approaches for avoiding direct contact soft material on metal contact from rubbing surfaces. One of the applications was used in hip replacement or Total Hip Arthroplasty (THA). Severe damaged of normal human hip need a replacement the ball or cup joint with a prosthetic implant [1-2].

The hemispherical cup was made of acrylonitrile butadiene styrene (ABS), which in thermoplastic technology has a broad range of performance characteristics. This experiment was set up with a hemispherical cup model shaped by used deposition modeling. Previous study showed that a rapid prototyping is able to fabricate ABS as medical devices [3].

The focus of this paper is to compare the effect of modified and skinned surfaces on a hemispherical cup made of ABS against metal ball bearing. For this purpose, pit which also known as dimples, micro-tanks, holes, or cavities as surface modification were presented in a model hemispherical hip cup. Also, the effect of palm oil based as a lubricant as mediator between hard-on-soft contacts sliding was discussed.

2. MATERIAL

Three types hemispherical cup (HC) samples, of nominal 12.8mm diameter, made of ABS with diameter 12.8mm were tested (Fig. 1). The HC was fixed to ball bearing from chrome alloy steel balls made of AISI E-52100, with a diameter of 12.7 mm.

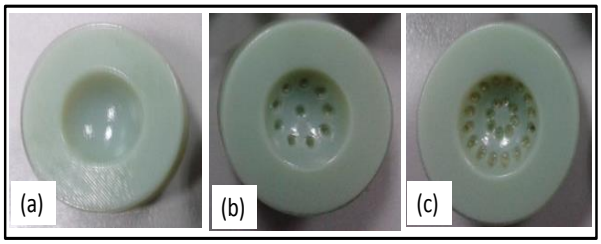

Figure 1 Represented sample a) unmodified soft hemispherical cup (flatten) a) modified inner cup with 10 pits, b) modified treated inner cup embedded with 24 pits.

2.1 Lubricants

Two types of palm-oil based (RBD Palm olein and Palm fatty acid distillate, PFAD) were used as bio-lubricants. Palm olein has good oxidative stability and is obtained from the fractionation of palm oil after crystallization. It is consist mainly of monosaturated and disaturated triglyceride, with the olein fraction are C50 (42.04%) and C52 (45.66%) and an iodine value 56. Palm Fatty Acid Distillate (PFAD) is made up of 81.7% free fatty acids with the major composition of palmitic acid and olien acid, 14.4% triglycerides, 0.8% squalene and 0.5% vitamin E. Palm oil based were supplied from Felda Iffco (Malaysia)

3. EXPERIMENTAL PROCEDURE

The modified four-ball tribometer was used to discover the friction torque of experimental lubricant oils. A steel ball and hemispherical 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, and temperature as detail (see in Table 1).

Table 1 Experimental condition on HoS using modified single ball tribotester.

Experimental Conditions	Load (kg)	Speed (rpm)	Samples cup (ABS)	Lubricant
40°C	40	100	Unmodified	PO/PFAD
40°C	40	100	Modified	PO/PFAD

Unmodified or modified hemispherical cup

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samples were inserted into the ball pot. The modified cup lock ring was put in to the ball pot and placed on the cup sample. The lock nut was tightened onto the cup pot and a torque wrench with a force of 68 Nm. 5 ml of test lubricant was added to the ball pot for each experiment. The cup pot assembly was placed on the antifriction disk and inside the machine, under the spindle. 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.

Fig. 2 shows the four-ball tester is used to be modified four-ball to run an experiment on the soft hemispherical cup. In other the mean frictional tests involved hard single ball bearing on the soft curvature surfaces with lubricants palm olein (PO) and palm fatty acid distillate (PFAD) for ten minutes on the samples.

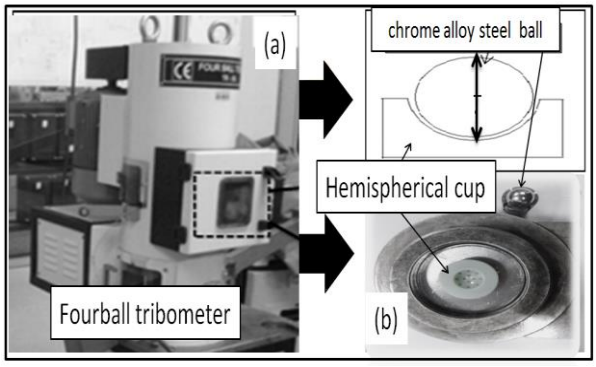

Figure 2 Test equipment a) Four ball tribometer b) Single ball (chrome alloy steel ball) and modified lock cup with ABS hemispherical cup (sample).

4. RESULTS AND DISCUSSION

The application of palm oil as a lubricant at interface soft on hard (SoH) contact is newly explored in hip tribology, and has resulted in improved lubrication. Although it is known that effectiveness of PO and PFAD were showed a significant decrease in friction when applied as the biolubricants. The unique biological properties and functions of palm oil is also a possible product for an alternative biodegradable, biocompatible and non-toxic based lubricant.

From Fig. 3 shows the averages of untreated frictional torque against palm fatty acid distillate (PFAD) and, palm olein (PO) were 0.7Nm and 1.8 Nm, respectively. The range frictional for metal cup embedded with 10 and 24 pits using PFAD at 0.022-0.007Nm and, PO at 0.031-0.013Nm was recorded.

It can be seen for each sample were test with lubricant were determined that a slight difference frictional torque recorded from the unmodified hemispherical cup compared modified surface. Previous studies showed that, pit will act to avoid rougher relative motion or sticky condition. Also, Friction coefficient decreased depending on the surface pattern, and the number of dimple such as groove [4-5].

In view of the performances of surface modification which significantly affected the friction and the lubrication on the So.

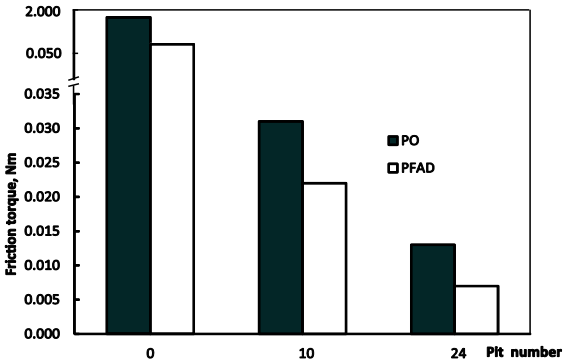

Fig. 3. A Frictional torque VS Pit using palm fatty acid distillate (PFAD) and Palm olein (PO).

It is clear that the treated curvature cup with pits in lubricated of PFAD optimizes the rate of frictional and allow for a stable of soft on hard sliding contact.

5. CONCLUSION

The results of this study revealed that the modified curvature cup with more pits in lubricated of PFAD improves the rate of friction rate. The factor of high fatty acid in PFAD oil have a potential as an alternative for biolubricants to reduce friction in HoS contact motion. Finally, Palm oil as lubricant in joint prosthetic tribology between HoS may be summarized as great lubricating oil because it possesses no additive formula and restocks specifically reducing friction.

7. ACKNOWLEDGEMENT

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