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Preliminary study of friction and wear on natural oil-based lubricants

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ABSTRACT – Nowadays, natural oil-based is much desired for its application as a lubricant in metal forming processes, a renewable resource and has high biodegradability compared to mineral oil. Other good characteristics include sustainability and eco-friendly. Therefore, it is important to study their tribological properties and perhaps can provide other alternative to replace mineral oils as lubricant. This paper presents the preliminary study for natural oil-based lubricant which in this case are refined glycerine, oleic methyl ester and crude glycerol. The study concentrated on friction and wears tests and was carried out using a four-ball tester.

1. INTRODUCTION

Lubricants have an important role in world industrial and economic development, mainly by reducing friction and wear in mechanical contacts. Future lubricants have to be more environmentally adapted, have a higher level of performance, and lower total life cycle cost (LCC) than presently used lubricants.

In the last 25 years, there has been an increasing interest in the use of biodegradable products. This has been driven by environmental problems that have heightened the need to limit pollution from lubricants and hydraulic fluids based on mineral oils [1-4]. Natural oil-based are potential substitutes for petroleum-based oils; not only they are environmentally friendly, renewable and less toxic, but also they have excellent lubricating properties such as high viscosity index, high lubricity and low volatility[5]. For these reasons, natural oil-based lubricants are being actively demanded form any green industrial activities.

The advantages of natural oil-based lubricant are sustainability and eco-friendly. It is important to study their tribological properties in order to replace mineral oils as lubricant. Friction tests were performed by using a four-ball tester in order to study the tribological properties of natural oil-based lubricant which in this case is refined glycerin.

2. METHODOLOGY

This experiment used a four-ball tester which is an instrument for friction and wear measurement. This instrument uses four balls; three at the bottom and one on the top. The upper ball is held in a collet at the lower end of a vertical spindle that is driven by the motor. The bottom three balls are held firmly in a ball pot containing the test lubricant and pressed against the upper rotating ball. The test conditions are listed in Table 1.

Table 1 Test conditions.

Speed 1000 rpm Load 50 kg	
Test	**Temperature (C^0)**
1	27
2	80
3	100

All parts in the four-ball (upper and lower balls and the oil cup) were thoroughly cleaned using acetone and wiped using a fresh lint-free industrial tissue. No trace of solvent should have remained once the lubricant was applied and the parts were assembled. The steel ball bearings were placed into the ball pot assembly and were tightened using a torque wrench. This was intended to prevent motion of the bottom steel balls during the experiment. The upper spinning ball was locked inside the collet and tightened into the spindle. The test lubricant was applied into the ball pot assembly. The test lubricants for this work include refined glycerine (RG), oleic methyl ester (OME) and crude glycerol (CG).

Apart from that, the oil levels should be filled all the voids in the test cup assembly. The oil cup and the ball bearings were fitted in specific holder, and mounted on the non-friction disc in the four-ball machine and shock loading was avoided by slowly applying the test load. After that, the selected lubricant was heated up to the desired temperature. When the set temperature was reached, we started the drive motor, which had been set to drive the top ball at the desired speed. After duration of 30 minutes, the heater was turned off and the oil cup assembly was removed from the machine. The test oil in the oil cup was then drained off and the wear scar area was wiped using tissue. The wear scar on the bottom balls was measured using a special microscope base that had been designed for the purpose.

3. RESULT AND DISCUSSION

After the experiment, the wear scar diameter (WSD) on the three ball-bearings, which were fitted into the oil cup, was observed and measured using a CCD microscope as shown in Figure 1. The average values of the wear scar diameter were taken. At the normal load of 50 kg, RBD PS gave the smallest value of WSD compared with the value given by the PMO under the same experimental conditions.

For experimental conditions with 50 kg normal loads, the worn surface on the ball-bearing lubricated with both RBD PS and PMO showed almost similar wear patterns with parallel grooves. Some of the grooves were deep while others were shallow. This finding shows that the dominant wear mechanism was abrasive wear [6]. The grooves resulted from stiff particles, such as wear debris of the oxide layer, or ragged adhesion. The particles contaminated the lubricant and damaged the ball-bearing surface.

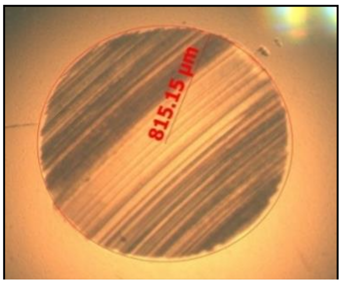

Figure 1 Sample of measured wear scar diameter.

Friction tests were carried out using a four-ball tester. The friction torques, calculated from the friction measured from the load cell in the four-ball tester. The steady-state condition of the friction torque as shown in Figure 2 indicates that the lubricant layer between ball-bearings was stable and no severe breakdown of lubricant film occurred. However, for high normal loads, especially for 50 kg, there was an increment of friction torque throughout the process, due to the lubricant film breakdown. This resulted in an increase in the metal-to-metal contact, while creating high friction throughout the motion.

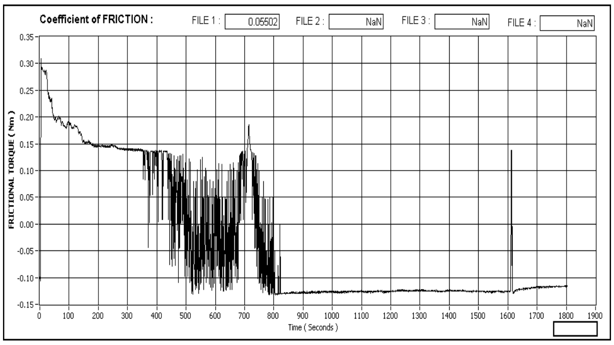

Figure 2 Friction coefficient plot.

Figure 3 shows the effect of temperature on COF for each lubricant. As indicated in the Figure, the COF values are decreased with the increment of temperature. This is due to the change in the lubricant properties, such as viscosity and the chains for oxidation [7]. Refined glycerine has the highest COF at 27°C, followed by oleic methyl ester and crude glycerol.

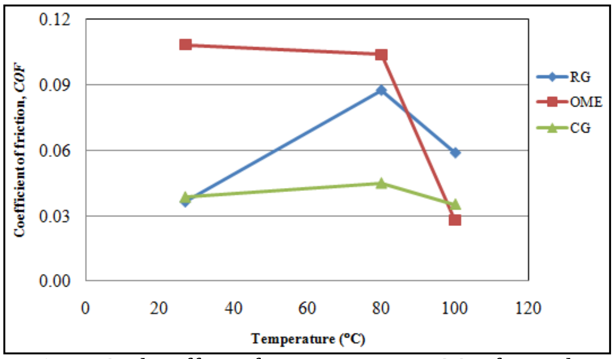

Figure 3 The effect of temperature on COF for each lubricant.

4. CONCLUSION

The tribological evaluations of natural oil-based lubricants were conducted using a four-ball tester. The temperature of the lubricating oil has significant influence on the wear mechanism. From the observation on the surface topography of the worn surface, the rough surface (deep valley of asperities) that formed helped to create an oil reservoir of the lubricant, and prevented metal-to-metal contact. Further tests with different load conditions will be conducted in future investigation.

5. REFERENCES

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