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Friction is not a devil

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Investigation on tribological properties of carbon nanotubes as natural oil-based lubricant additive

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KEYWORDS

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ABSTRACT

Carbon nanotubes (CNT) are expected to be a good candidate among other nanoparticles for the lubricant additives due to their roller-like shape, extremely small particle size and unique mechanical properties. This work investigates the prospects of carbon nanotubes as additive for natural oil-based lubricant. The experiment is conducted to obtain the friction and wear characteristics by using four-ball tester set-up. The natural oil-based lubricants involved in this study are refined glycerin, crude glycerol and oleic methyl ester with 1wt% of CNT as additive. Based on the result for COF, the effect of 1wt% CNT as additive is less for oleic methyl ester. In term of the effect of CNT on wear properties, the reduction of wear scar diameter only occurred for crude glycerol.

1. Introduction

Global environmental awareness encouraged the replacement of mineral lubricant with renewable, sustainability, high biodegradability and eco-friendly lubricant [1]. As a matter of fact, environment friendly lubricants are declared to represent the developing trend of the lubricant industry in the future [2]. Palm oil based lubricant constitute as one of the natural oil-based lubricant has the potential to replace the mineral lubricant as alternative lubricant for industrial processes [3].

Previous works [4-6] has investigated the potential of nanoparticles as additive in lubricants studies. Among a variety of nanoparticles, carbon nanotubes (CNT) are expected to be a good candidate for the lubricant additives, considering their roller-like shape and remarkable mechanical properties [2]. The tribological properties of carbon nanotubes as additive to liquid lubricants were studied by a few research groups, but few studies have been made on CNT as natural oil-based lubricant additives [2].

The performance of lubricants is mainly depending on the friction and wear characteristic [1]. This work investigates the prospects of natural oil-based lubricant for automotive applications in contrast to the available conventional lubricant. The lubricant that is selected for this work includes refined glycerin (RG), crude glycerol (CG) and oleic methyl-ester (OME). The effects of carbon nanotubes as an additive for each lubricant were also being tested.

2. Experimental Procedure

Friction and wear test were carried out by using four-ball tester apparatus. This machine works by using four balls, three balls at the bottom and one ball at the top. The three-bottom balls are held firmly in a ball pot including the lubricant being examined and pressed against the top ball [3]. The top ball is designed to rotate at the desired speed while the bottom three balls are pushed against it [3]. The surfaces of the components were cleaned with acetone before conducting each test [2]. From this work, friction and wear evaluation was performed at 40 kg loading with the speed of 1200 rpm for 60 minutes at lubricant temperature of 75°C.

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The tests are divided into 2 main parts. The first part of the tests was conducted without mixing the lubricants with the additive. The second part of the tests was conducted by adding the 1wt% amount of CNT which are from the industrial grade multiwalled CNT. This CNT have extremely small particle size with average diameter of 10-30 nm. The mixing process was carried out by using a homogenizer. Both tests were conducted based ASTM D-4172 B standard [7].

3. Results and discussion

3.1 Coefficient of Friction

Figure 1 shows the results for coefficient of friction (COF) against time based on the tests using the four-ball tester. Referring to Figure 1, it is shown that there is a rapid increment of COF at the beginning of the test. The phenomena occur at the beginning of experiment is called running-in period. When the rolling or sliding process start, the ball bearing movement and the speed increment of sliding induced the sample lubricants become hydrodynamic lubricant. This will result an increment in film thickness and raise lubricant viscosity which reduce the COF until its reach steady state after the Running-In period [8].

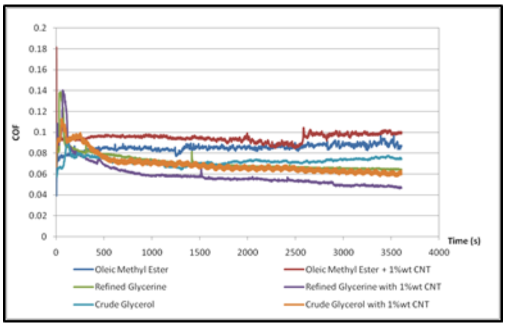

Figure 1: Coefficient of friction against time.

3.2 Wear Scar Diameter

The diameter of wear scar is measured by using circle method in SEM system. This method is conducted by locating an adjustable circular diameter where the wear scar should be fitted in the area of the circle. Based on the overall result as shown in Table 1, the effect of CNT as additive is prominent for CG. This is in contrast with RG and OME, as the wear scar diameter is larger compare to the sample without the additive.

Table 1: Average wear scar diameter for different lubricant in unit μm.

Sample	Crude Glycerol	Refined Glycerin	Oleic Methyl Ester
1.0 wt% additive	159.49	145.5	173.53
Without additive	181.58	139.59	162.51

3. Conclusion

Based on the result for COF, it can be concluded that CNT has a strong molecular structure and small particle size which can assist in reducing the friction between two contacting surface. However, the effect is less for OME sample. In term of the effect of CNT on wear properties, the reduction of wear scar diameter only occurred for CG sample. However, CNT is giving less effect for RG and OME as the wear scar diameter from the mixing is larger than the sample without the additive.

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