Proceedings of Malaysian International Tribology Conference 2015, pp. 213-214, November 2015

Addition of ZDDP in corn oil as lubricant physical property improver

N.R. Mat Nuri[1], Q.N. Suffian[1], M.F.H.M. Saroji[1], M.A. Azhari[1,2,*]
[1)] Faculty of Engineering Technology, Universiti Teknikal Malaysia Melaka,
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[2)] Centre for Advanced Research on Energy, Universiti Teknikal Malaysia Melaka,
Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.

[*]Corresponding e-mail: azwar@utem.edu.my

Keywords: Corn oil; ZDDP; bio-lubricant

ABSTRACT – Newly developed lubricant was produced by introducing Zinc Dialkyldithiophosphate (ZDDP) into commercialized corn oil. ZDDP added acted as a physical property improver which lowers the kinematic viscosity and reduces coefficient of friction. The newly developed oil was tested with a kinematic viscometer while characterized using a pin on disc tribometer. Corn oil with 2 wt% ZDDP and 5 wt% ZDDP showed a decreasing trend of coefficient of friction with increment of applied load on the pin on disc test. Corn oil with 2 wt% ZDDP showed a desirable kinematic viscosity value of 36.3 cSt.

1. INTRODUCTION

Demand for environmentally friendly lubricants are increasing because of the high concern for environmental protection. Vegetable oils are being explored as a source of environmentally acceptable lubricant as they have exposed their anti-wear and fatigue resistance properties rather than mineral oils, as well as improved deterioration load carrying capacity [1]. Plant oil lubricants also obtain most of the properties required for lubricants such as high viscosity indices because of their high molecular weights, low volatility and good lubricity because their ester bonds enable the oil molecules to stick to metal surfaces through physical bonding and offer better boundary lubricity compared to nonpolar petroleum-based mineral oil [2].

However, oxidation stability of vegetable oil is one of the problems in formulating bio-lubricants using vegetable oils [3]. The high content of unsaturated fatty acids in vegetable oils produces the oil less cooperative in stabilizing the oxidation. The modification of the vegetable oil or addition of antioxidant additives could help in stabilizing the oxidation process [4]. The degradation of lubricant oil can be decreased by the addition of ZDDP into the base parent oil as the effective antiwear and antioxidant additive [5].

2. METHODOLOGY

In this study, 0 wt%, 2 wt% and 5 wt% of ZDDP was added into commercialized corn oil to study the lubricity effect of the oil. The prepared samples were then immersed in a 50ºC water bath for 20 minutes to ensure that ZDDP is properly dissolved into the parent base oil.

After sample preparation, the samples were then tested for kinematic viscosity at 40ºC using a Kittiwake Heated Viscometer and characterized using a pin-on disc tribometer with 4 different loads applied.

3. RESULTS AND DISCUSSION

3.1 Effect on Kinematic Viscosity

The prepared samples were tested using heated viscometer at 40ºC. Table 1 shows the kinematic viscosity of three different concentrations of oil tested using heated viscometer.

From Table 1, it is evident that the value of kinematic viscosity at 40ºC reduces to 36.3cSt when the oil was added with 2 wt% ZDDP while increases to 37.9 cSt when added with 5 wt% ZDDP. With the addition of 2wt% ZDDP the newly developed oil has been found to create a boundary film which forms on the metal surfaces contacting. The film formed by ZDDP acts as a friction reducer showing that ZDDP additive in the right amount is beneficial [6]. At higher concentration the excess ZDDP adversely effect on the boundary film formation. Zinc forms a film on the metal surface. With the increase of weight percentage of the oil, more film is formed on metal. This condition may be contributed to the increase of the viscosity due to the excess of the metal present in the oil. [7]. This resulted in significant increment of kinematic viscosity of oil with addition of 5 wt% ZDDP.

Table 1 Kinematic viscosity of corn oil with 0 wt%, 2 wt% and 5 wt% ZDDP.

Properties	0 wt%	2 wt%	5 wt%
Kinematic viscosity	37.3cSt	36.3cSt	37.9cSt

3.2 Effect on Coefficient of Friction

The coefficient of friction for corn oil without any addition of ZDDP is seen to be increasing with the increment of load applied using pin-on disc tribometer as shown in Figure 1. However, with the addition of 2 wt% of ZDDP in corn oil, the coefficient of friction is seen to be decrease to 0.42 when 5 N of load was applied. The trending of decrement continues with the increment of applied load. The addition of ZDDP helps to form a reaction film where this film acts as a mechanical protective barrier between the two contacting surfaces. This will help to reduce the frictional torque of the contacting surfaces with the addition of ZDDP at 2 wt%. The reduction of frictional torque will lead to a lower coefficient of friction [6]. At 5 wt% ZDDP addition, the coefficient of friction has increased to 0.51. At higher ZDDP concentration, the boundary film formation is affected. The adverse effect of the boundary layer is due to the fact of the presence of excess zinc adsorption on the contact surfaces. This leads to an increment of frictional torque of the contacting surfaces leading to an increase of coefficient of friction.

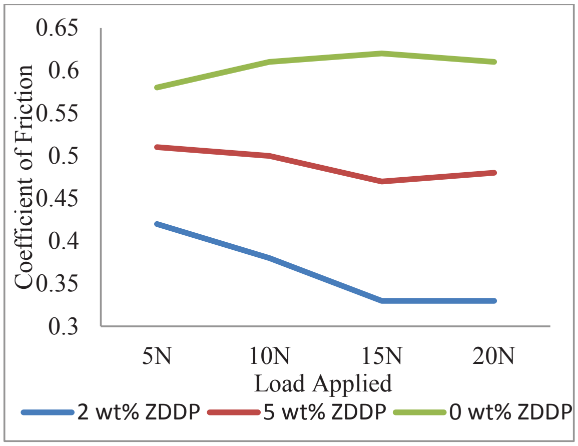

Figure 1 Coefficient of friction for corn oil with 0 wt%, 2 wt% and 5 wt% ZDDP.

4. CONCLUSION

Vegetable oil based lubricants are indeed in the limelight for substitution of mineral oil. The addition of ZDDP at 2wt% gives a desirable lower kinematic viscosity at 36.3 cSt and a lower coefficient of friction at 0.42. The newly found results would encourage further studies on green bio-lubricants.

5. ACKNOWLEDGEMENT

The author would like to acknowledge the Ministry of Science Technology and Innovation [FRGS/2013/FTK/TK06/02/3/F00166] and Universiti Teknikal Malaysia Melaka for the support and funding throughout this study.

6. REFERENCES

[1] O. A. Emmanuel, & O. J Mudiakeoghene, "The use of antioxidants in vegetable oils – A review," *African Journal of Biotechnology,* 7(25), pp. 4836-4842, 2008

[2] S. Nadia, S. Jumat, Y. Emad , & A. Mudhaffar, "Biolubricant basestocks from chemically modified plant oils: ricinoleic acid based-tetraesters", *Chemistry Central Journal,* 7(128), pp. 1-13, 2013

[3] Muhamad Azwar Azhari, Quratul Nadia Suffian, Nur Rashid Mat Nuri, "The Effect of Zinc Dialkyldithiophosphate Addition to Corn Oil in Supression of Oxidation as Enhancement for Biolubricant: A Review", *Journal of Engineering and Applied Sciences*, Vol 9, No 9, 1447 – 1449, 2014

[4] M. Masabumi, S. Hiroyasu, S. Akihito and K. Osamu, "Prevention of oxidative degradation of ZnDTP by micro capsulation and verification of its antiwearperformance", *Tribology International*. 41, 1097-1102, 2008.

[5] D. N. Canter, "*Use of Antioxidants in Automotive Lubricants", Tech Beat,* September 2008

[6] D. Mahipal, P. Krishnanunni, P. Mohammed Rafeekh & N. H. Jajadas, "Analysis of lubrication properties of zinc-dialkyl-dithio-phosphate (ZDDP)additive on Karanja oil (*Pongamia pinnatta*) as a green lubricant", IJIES, No.8, pp : 494-496, 2014

[7] I. M. Hutchings, Tribology: *Friction and wear of engineering materials*, CRC Press, 1992