Experimental Analysis of Wear and Friction Performance of Pongamia oil Bio-lubricant with ZDDP Additive

Gurudatt H.M, Dr.T. Nagaraju*
***Professor and Head**
Department of Mechanical Engineering, P.E.S College of Engineering, Mandya, India

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ABSTRACT

Pongamia bio lubricant was synthesized by introducing Zinc-Dialkyl-Dithiophosphate (ZDDP) into commercialized Pongamia oil. Introducing ZDDP into Pongamia oil results in decrease in wear and friction. The newly developed bio lubricant oil was tested with Pin on Disc wear and friction testing machine, while Pongamia oil with 2 wt% ZDDP showed least wear and co-efficient of friction and decreasing trend of both wear and COF was observed upto 2wt% of ZDDP and both wear and COF increases with increase in ZDDP above 2wt% of ZDDP.

Keywords: *Pongamia, ZDDP, Wear, Co-efficient of Friction (COF), Bio-lubricant.*

1. INTRODUCTION

Vegetable oils are being considered for their suitability as industrial lubricant. One of the main problems of vegetable oils is their poor performance when working at high temperature and pressure[[1]. They may oxidize and undergo changes to their chemical and physical composition. In the worst cases, the oxygen bond in vegetable oils can lead to metal oxidation and weaken the structure of the metal [1]. In this paper, the performance of synthesized pongamia vegetable oil as a lubricant was tested using a Pin on Disc wear and friction test rig, The normal load used for this test was 15N. The results showed that synthesized pongamia vegetable oils have a low co-efficient of friction for Pongamia oil blended with 2wt% of ZDDP. Also, the wear produced by synthesized vegetable oil is lower for Pongamia oil blended with 2wt% of ZDDP than those produced by 0wt% pongamia oil. It can be concluded that pongamia vegetable oil blended with 2wt% of ZDDP is a effective bio-lubricant.

2. METHODOLOGY

2.1 Blending

A magnetic stirrer is used for blending. Magnetic stir bars are radial-flow mixers that induce solid body rotation in the fluid being mixed. The cylindrical stir is used for mixing. The vessel used for laboratory mixing is conical flasks.

2.1.1 Blending Procedure

1. The conical flask is cleaned using acetone for removal of dust and dirt.

2. The conical flask is placed on the magnetic stirrer.
3. Required amount of pongamia oil is weighed and poured to the conical flask.
4. The cylindrical magnet has been suspended in the oil.
5. The temperature knob has been adjusted to maintain the temperature.
6. The RPM knob has been adjusted to set the stirrer speed to required level.
7. Then the required amount of methyl ester is weighed and added to the pongamia oil in the flask and the stirring is carried out until the components get blended.

2.2 Pin on Disc Wear and Friction Test Rig

Table 2.1:- Technical Specification of Pin on Disc Test Rig

Rotational Speed	Up to 2000 rpm
Track Diameter	40mm – 118 mm
Load Range	Up to 200 N
Disc Size	Diameter 120 mm * Thickness 8mm
Pin Size	Diameter 6mm * Length 30mm
Wear or Displacement	Up to 2000 Microns
Frictional Force	Up to 200 N

A pin on disc tribometer consists of a stationary "pin" under an applied load in contact with a rotating disc. The lubricant has been introduced to rotating disc on which the pin stays stationary. The pin can have any shape to simulate a specific contact, but spherical tips are often used to simplify the contact geometry. Coefficient of friction is determined by the ratio of the frictional force to the loading force on the pin. The pin on disc test has proved useful in providing a simple wear and friction test for low friction coatings such as diamond-like carbon coatings on valve train components in internal combustion engines. In these experiments, the user typically has the ability to control and measure the applied normal load, unidirectional speed or oscillation frequency, and environmental parameters such as temperature, pressure, type of gas (vacuum, air, nitrogen, refrigerant, etc.) and presence of a lubricant. Both the normal and friction forces are measured with transducers. The pin holder is attached to a fixture that is allowed to deflect slightly; the transducer measures this deflection and converts it to a force. Performance is generally characterized by friction coefficient and wear rates (wear per unit time) determined my mass or volume loss with the aid of a wear meter.

A flat Aluminum pin was used and directly touched the disc surface at the beginning of the experiment. The pin samples were designed to be 6mm in diameter and 27mm in length. After the completion of the each test, the disc was cleaned with the acetone. A load of 20N was applied on the pin at the contact zone of the pin and disc and a constant flow of the test lubricant is directed towards the contact zone of pin and disc. The disc is rotated at 2000 rpm for duration of 30 minutes. For every 5 minutes the Wear and frictional force are noted down. The observations are recorded in the data acquisition system. Further the tests are repeated for different bio lubricant percentage samples.

3. RESULTS AND DISCUSSION

3.1 Wear Test

Figure 1(a) shows the curves of pin wear as a function of wt% of ZDDP for various Pongamia oil blends with ZDDP additive. The values of linear pin wear under 1000 rpm and 15 N loads for each pin vary from 30 to 190 microns for the samples considered. It was observed that the value of wear decreases as the wt% of ZDDP increases up to 2wt% of ZDDP beyond which the wear increases with increase in wt% of ZDDP and 2wt% of ZDDP gives least wear.

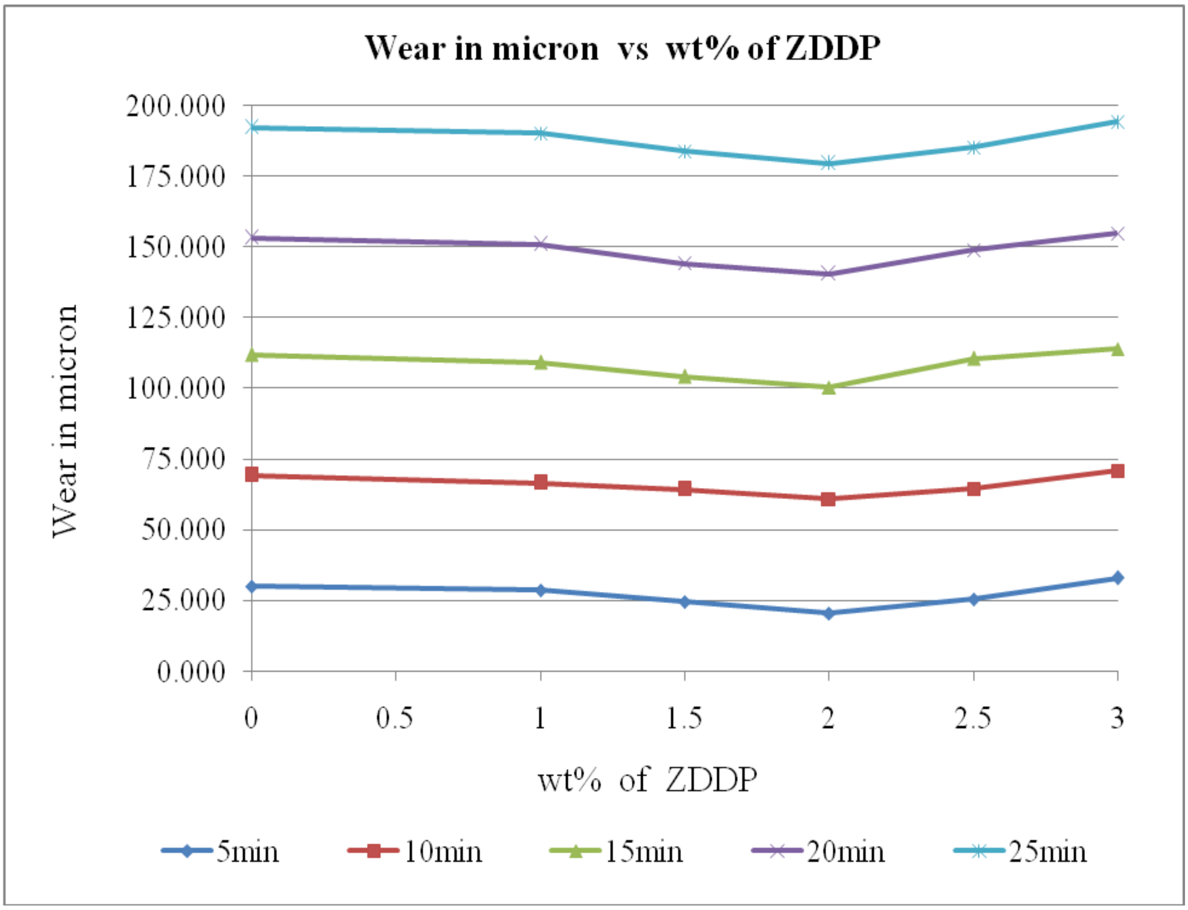

Fig 1(a): Variation of Wear v/s wt% of ZDDP

Figure 1(b) shows the curves of pin wear as a function of sliding distance for various Pongamia oil blends with ZDDP additive. It was observed that the higher wear occurred in all the samples at the end of the experiment. From the graph we can see that as the sliding distance increases the wear increases for all the samples. Among all samples the 2wt% of ZDDP blended with pongamia oil shows least wear and 3wt% of ZDDP blended with pongamia oil shows maximum wear.

Wear was found to be decreasing with increasing concentration of the ZDDP additive up to a particular limit. Pongamia oil + 2 Wt. % ZDDP shows lower value of wear. This is due to the anti-wear property of ZDDP, which is effected by (i) mechanically protective film formation (ii) removing corrosive peroxides (iii) by digesting hard and abrasive iron oxides. Most generally the ZDDP forms a reaction film which act as mechanically protective barrier preventing the direct contact between the metal surfaces. The protective layer will act as a cushion between the metal surfaces, so this will help to reduce the stresses between the contacting surfaces. Hence it will help to reduce the wear in the specimen. The second anti-wear mechanism of ZDDP is the reaction with peroxides present in lubricants to prevent the formation of corrosive wearing at the metal surfaces. The third anti- wear mechanism is to react with iron oxides present in the base oils to form an iron phosphate which can help to reduce the wear on the metal surfaces. At higher concentration the hydrodynamic film formation is hampered, and the zinc contained in ZDDP due to its high density and heavier structure will adhere to metal surface, leading to increase in the wear of the contacting surfaces [2].

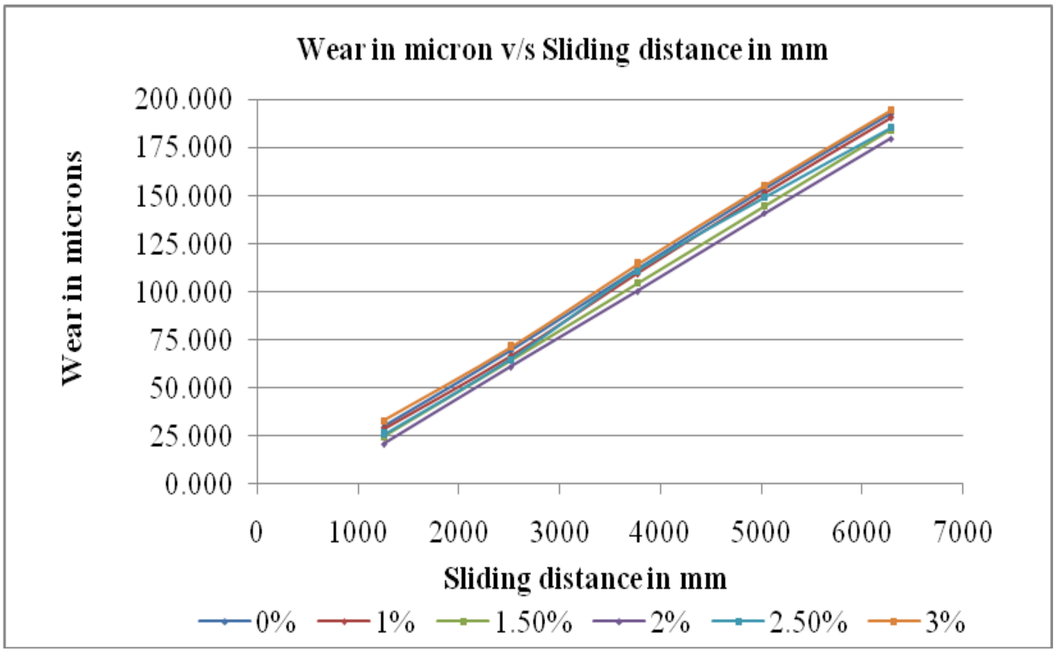

Fig 1(B): Variation of Wear V/S Sliding Distance

3.2 Friction Test

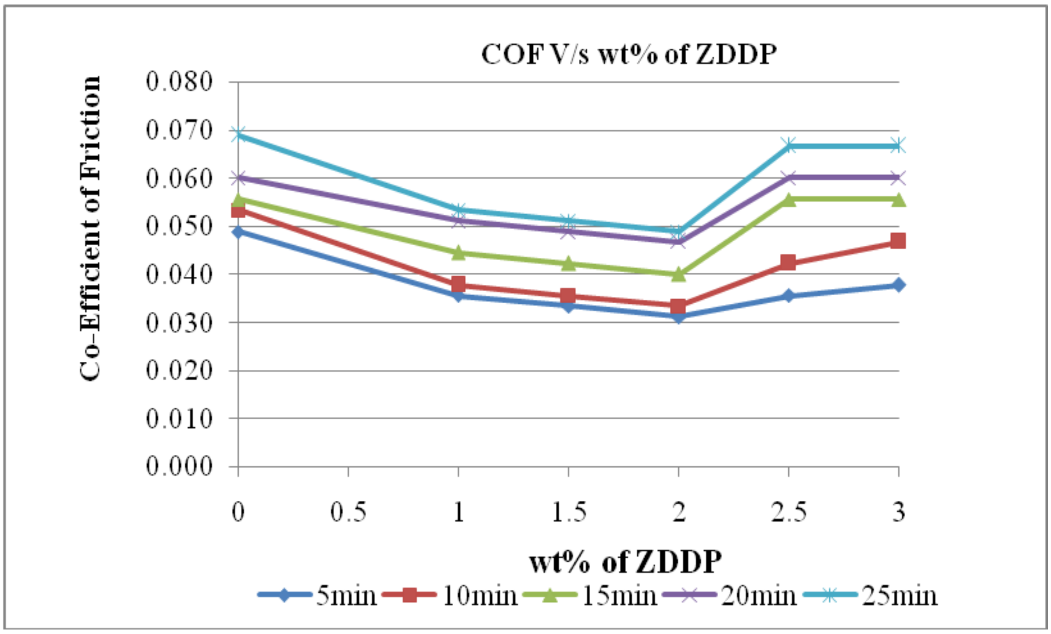

Fig 2: Variation of Co-efficient of Friction v/s wt% of ZDDP

Figure 2 shows the curves of coefficient of friction plotted against the wt% of ZDDP for various Pongamia oil based bio lubricants. From the figure it is clear that the COF reduces with increase in wt% of ZDDP up to 2%, Further increase in concentration of ZDDP results in Increase in COF and Co-efficient of friction is least for 2wt% of ZDDP blended with pongamia oil.

This is due to ZDDP forming a hydrodynamic boundary film at a particular concentration (2.0%). At this concentration frictional torque on the contacting surfaces will be reduced and the coefficient of friction at the contact surfaces will also be reduced. But at higher concentration the excess ZDDP adversely affect on the boundary film formation, due to the excess zinc adsorption on the contact surfaces leading to an increase in the frictional torque at higher concentration[2].

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4. CONCLUSION

The Pin on Disc wear and friction tests showed that Pongamia oil with 2wt% ZDDP had comparatively better coefficient friction and wear. Pongamia oil with 2wt% ZDDP showed least wear and co-efficient of friction and decreasing trend of both wear and COF was observed upto 2wt% of ZDDP and both wear and COF increases with increase in ZDDP above 2wt% of ZDDP. This will help the industry to introduce new green lubricants by evaluating different oil properties for different applications.

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