Performance of Lubricant from Vegetable Oils by using Four Ball Testing Machine

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Abstract— Lubricants play a key role in lubrication of components of internal combustion engine and enhancing the working life of engine. Load carrying capacity of lubricating oil is important parameter for their application. In this paper, Four-Ball testing method is used to measure wear scar diameter of two different bio lubricant oil. Tests were carried out according to the standard test methods with the tribological properties of the formulated oil were evaluated by four ball tester. The rotating ball was rotated at a speed of 1,200 rpm at 75°C for one hour. The wear scar of the fixed ball was measured using an optical microscope of 0.01 mm accuracy. The balls were cleaned by acetone and heptanes before each run. The coefficient of friction was evaluated as per ASTM D 4172 B. The rotating ball was rotated at a speed of 1200 rpm with a load of 400N at 75°C. The wear test was conducted as per ASTM D4172B with a rotating speed of 1,200 rpm and a load of 400 N at 75°C, so we recognize to final sample oil to conformed from results.

Keywords: Four Ball Testing Machine, Ball Bearing, Test Parameter, Cottonseed Oil, Palm Oil, 20W40 Engine Oil

I. INTRODUCTION

A lubricant is a substance, usually organic, introduced to reduce friction between surface in mutual contact, which ultimately reduces the heat generated when the surfaces move. It may also have the function of transmitting forces, transporting foreign particles, or heating or cooling the surfaces. Lubricants are the materials (generally liquids, but may be solids or semi-solids) used to lubricate machinery parts to reduce friction and increase their lifetimes. Lubricants have a significant role in tribological, and are formulated from a range of base fluids and chemical additives. Depending on the nature of the base oil, which is the main component of lubricants, they might be categorized as mineral oil.

A. Properties of Lubricants
   - A high boiling point and low freezing point (in order to say liquid within a wide range of temperature)
   - A high viscosity index
   - Thermal stability
   - Hydraulic stability
   - Demulsibility
   - Corrosion prevention
   - A high resistance to oxidation

B. Bio Lubricants

Bio-lubricants are derived from vegetable oils and other renewable sources. They usually are triglyceride esters (fats). Obtained from plants and animals. For lubricant base oil use, the vegetable derived materials are preferred. Common ones include high oleic canola oil, castor oil, palm oil, sunflower seed oil and rapeseed oil from vegetable, and tall oil from tree sources. Many vegetable oils are often hydrolyzed to yield the acids which are subsequently combined selectively to form specialist synthetic esters. Other naturally derived lubricants include lanolin (wool grease, a natural water repellent). Vegetable oils, a renewable resource, are finding their way into lubricants for industrial and transportation applications. Waste disposal is also of less concern for vegetable oil-based products because of their environment-friendly and nontoxic nature. Oleo chemical esters is a class of products that improve the thermal and cold-flow instability of the neat vegetable oils and fulfill the basic requirements as lubricant base stocks.

C. Four Ball Tribometer

Four ball testing machine is widely used for evaluation of the tribological properties of lubricant oil such as wear preventive characteristic, extreme pressure and shear stability. The apparatus can be used to measure coefficient of friction, anti-wear and load carrying capacity of lubricating oils under standard operating conditions. This machine consists of four balls, three at the bottom which are clamped together and one on top. The bottom three balls are clamped together in a ball pot containing the lubricating oil under test and pressed against the test ball. The top ball is made to rotate at the desired speed while the bottom three balls are pressed against it. In general these devices embody rubbing test specimens operating under variable measurable loads. The test machines differ as to speeds, geometry of test specimens, load ranges, temperature ranges and test materials. The lubricating oils are selected considering the various operations condition like temperature rise, working load, normal working temperature; Extreme conditions etc. The wear scar diameter for the tested oils with the help of image acquisition system. The image acquisition and magnification are done with the help of windu com 2014 software.

In this paper we find out or Evaluate Tribological properties i.e. of load carrying capacity and weld point or various oils or lubricants used for various purposes. It’s necessary to form a lubricating fluid film of low shear strength, then it is possible to decide the film breaking strength in other words load carrying capacity of oil can be calculated.

II. LITERATURE SURVEY

1) A.D. Dongare et al.(2012) As per the American Society of Testing Materials (ASTM-D-2783), the standard test method for measurement of Extreme Pressure properties of lubricating oils by using Four Ball Extreme Pressure Oil Testing Machine plays an important role in oil industry while selecting such oils as a lubricating media for testing various types of lubricating oils. Lubricating oils are needed to reduce frictional losses as well as to...
support working load and avoid metal to metal contact between the components working together for obtaining desired functions in machines. This four ball machine is utilized for finding the load carrying capacity and weld point of different types of lubricants/Oils fluids. Extreme Pressure properties like-Load Wear Index, Weld Point, Non load are the basis of differentiation of Lubricating oils having low, medium and high level of extreme pressure properties. In this paper, we find out or Evaluate Tribological properties i.e. of load carrying capacity and weld point or various oils or lubricants used for various purposes. It’s necessary to form a lubricating fluid film of low shear strength, then it is possible to decide the film breaking strength in other words load carrying capacity of oil can be calculated.

2) Kailas M Talkit et al.(2015) Different vegetable oils viz. soybean oil, olive oil, almond oil, amla oil, castor oil, groundnut oil, cottonseed oil, coconut oil, sesame oil, sunflower oil, mustard oil were purchased from the local standard market. Different blends of vegetable oils were prepared in different proportions and lubrication properties like cloud point, pour point, flash point, fire point and % carbon residues were determined. From this study, it’s found that given lubrication properties changes with changing vegetable oil blends. This study will help the lubricant producing industry to check out most eco friendly, economical vegetable oil blends as industrial lubricant at lower as well as at higher temperatures. In the measurement of lubrication properties, test vegetable oils used in this work were soybean oil, olive oil, almond oil, amla oil, castor oil, groundnut oil, cottonseed oil, coconut oil, sesame oil, sunflower oil and mustard oil and their blends in different proportion.

3) Mohammad Hojjatoleslamy et al.(2005) Oils and fats are valuable necessary nutrients that play an important role in human life and health. Oils also affect the foods texture and that is why their rheological behaviour is important to food technologists. Viscosity is the fundamental rheological parameter that characterizes the fluid texture. The temperature is one of the most important parameters effecting on rheological behaviours (and obviously viscosity) because of chemical exchanging happens in foods after heating. In this work, soybean oil, Sunflower oil and Canola oil were analyzed by GC-MS and the fatty acid composition was identified. The rheological behaviour of the three oil types has been identified in the range of 10 to 80 °C. Measurements were done in a viscometer (model LV DVII—Brookfiild), with the UL-adaptor, spindle 00, which permits the use of only 50 ml of oil in each analysis. Temperature was controlled using a water bath (model Brookfield) with precision of 1°C. Measurements were done in different shear rates, during heating. The viscosities of vegetable oils were investigated as a function of the shear rate and also shear stress as a function of shear rate at temperatures ranging from 10 to 80 °C. The related Herschel–Bulkley Model equations of all three types of oils at the specific temperatures were identified. As a result, the Sunflower oil and soybean oil (more linoleic) had more yield stress at 10°C than Canola oil (more oleic) at the same temperature. Also, during heating, oils containing higher unsaturated fatty acids (soybean oil and Canola oil) showed Newtonian behaviour earlier than oils containing less unsaturated fatty acids (Sunflower oil). It means that a more rapid viscosity change with temperature was observed in the oils containing more double bonds due to their loosely-packed structure. So it shows the fatty acid composition affect the oils behaviour.

4) Haysan yalcin et al.(2012) In the measurement of lubrication properties, test vegetable oils used in this work were soybean oil, olive oil, almond oil, amla oil, castor oil, groundnut oil, cottonseed oil, coconut oil, sesame oil, sunflower oil and mustard oil and their blends in different proportion. During blending process soybean oil blends with other oils stirred continuously to ensure uniform mixing. In the measurement of lubrication properties, test vegetable oils used in this work were soybean oil, olive oil, almond oil, amla oil, castor oil, groundnut oil, cottonseed oil, coconut oil, sesame oil, sunflower oil and mustard oil and their blends in different proportion. During blending process soybean oil blends with other oils stirred continuously to ensure uniform mixing. In the measurement of lubrication properties, test vegetable oils used in this work were soybean oil, olive oil, almond oil, amla oil, castor oil, groundnut oil, cottonseed oil, coconut oil, sesame oil, sunflower oil and mustard oil and their blends in different proportion. During blending process soybean oil blends with other oils stirred continuously to ensure uniform mixing.

5) Lemuel M. Diamante and Tianying Lan.(2014) A study was carried out to determine the effect of higher shear rates (64.5 to 4835 s−1) on the absolute viscosities of different vegetable oils at different temperatures (26 to 90°C). The absolute viscosities of the different vegetable oils were determined using a Lamy Viscometer RM100, a rotating viscometer with coaxial cylinder. The torque of each sample at different temperatures was recorded at different shear rates. Based on the rheograms (plot of mean shear stress against shear rate), all of the vegetable oils studied were found to be Newtonian fluids. Rice bran oil was the most viscous (0.0398 Pa·s at 38°C) while walnut oil was the least viscous (0.0296 Pa·s at 38°C) among the oils studied. The higher shear range used did not significantly affect the absolute viscosities of the vegetable oils at the different temperatures. The absolute viscosities of the vegetable oils decreased with increasing temperature and can be fitted with an Arrhenius type relationship. The activation energies for the different vegetable oils ranged from 21 to 30 kJ/mole. The peanut and safflower oils had the highest and lowest activation energies, respectively. This means that greater energy was needed to effect a viscosity change in the peanut oil.

6) Tirth M. Panchal et al.(2017) Finiteness of global crude oil reserve, rising crude oil prices, and issues related to environment seems to be a reality check for the problems of emerging generations. Present article focuses on lubricating oils as well as lubricating greases developed from vegetable oil. Vegetable oil based lubricants are an attractive alternative to conventional petro based
lubricants due to number of their physical properties including renewability, biodegradability, high lubricity and high flash points. Still they have not yet replaced petro based lubricants due to their inappropriate chemical structure, which lags them behind at various odd conditions during applications. The challenges in this field are to improve certain characteristics of vegetable oils without impairing their excellent tribological and environmentally relevant properties. Chemical modification of vegetable oils overcomes the structural problems related to vegetable oil which in turn makes them fit for the application of lubricant. In this review article, we have reviewed the available literature and recently published data related to development of bio-lubricants by chemical modifications of vegetable oils. Can vegetable oils make good lubricant base stocks? Research conducted till date indicates that chemically and genetically modified vegetable oils have excellent potential to perform adequately as lubricants. Vegetable oils have been used as lubricants for machinery and transportation vehicles for a prolonged period of time before the discovery of petroleum resources.

III. METHODS AND MATERIALS

The sample oil are used one engine oil(SAE20w40) and two another sample oil are palm oil and cotton seed oil. The methods of Four ball testing machine is widely used for evaluation of the tribological properties of lubricant oil such as wear preventive characteristic, extreme pressure and shear stability. The apparatus can be used to measure coefficient of friction, anti-wear and load carrying capacity of lubricating oils under standard operating conditions. This machine consists of four balls, three at the bottom which are clamped together and one on top. The bottom three balls are clamped together in a ball pot containing the lubricating oil under test and pressed against the test ball. The coefficient of friction was evaluated as per ASTM D 4172 B. The rotating ball was rotated at a speed of 1200 rpm with a load of 400N at 75ºC. The wear test was conducted as per ASTM D4172B with a rotating speed of 1,200 rpm and a load of 40 N at 75ºC.

A. Materials

The tribological properties of the formulated oil were evaluated by four ball tester. The equipment consists of one rotating ball and three fixed balls located in a ball pot. The ball are chrome steel balls with a diameter of 12.7mm. The experiments were repeated thrice and the wear scar of the fixed ball was measured using an optical microscope of 0.01mm accuracy.

The wear scar diameter of each of the three bottom test balls was measured to determine the lubricity performance of the test lubricant. In general, the larger the wear scar diameter, the more severe the wear. The wear scar was evaluated by a computer running optical and scanning electronic microscope (high resolution) software.

B. The SEM Analysis Process

Scanning Electron Microscopy (SEM) is a test process that scans a sample with an electron beam to produce a magnified image for analysis. The method is also known as SEM analysis and SEM microscopy, and is used very effectively in microanalysis and failure analysis of solid inorganic materials. Electron microscopy is performed at high magnifications, generates high-resolution images and precisely measures very small features and objects.
IV. RESULT & DISCUSSION

The lubricant properties of sample oil were investigated with a four-ball tribotester placed in different temperatures and loads. The tests present an opportunity to discuss about the sample oil as an alternative source of lubricant oil compared to mineral oil-based lubricants.

A. Wear Scar Diameter

The results for wear scar diameters of the three bottom ball bearings were measured using a special microscope and the mean values were calculated. Figure 1 shows the mean value of the Wear Scar Diameter (WSD) for each sample oils.

From these values, we can conclude that the WSD of Palm oil, Cotton seed oil and SAE20W40 oil blended lubricant was lower than WSD of palm oil and the sample oils are 100% pure commercial lubricant.

B. Sample Oil Scar Images

1) Palm Oil

It can be concluded that the palm oil blended lubricant increases the lubricant effectiveness depending on the lower COF with lower value of Friction Torque as compared with 100% mineral lubricant. In addition, the WSD for palm oil blended lubricant shows that only Pure palm oil contamination has got lessen WSD compared to 100% mineral lubricant so it is a very good decrement of around sample oil. This means the contamination of palm oil in lubricant which have the potential to work. Therefore, the overall analysis suggests that, the palm oil has the potential in becoming a partial substitute bio-lubricant because the contamination of it did not give any negative impact on the wear phenomena and lubricating effectiveness.

REFERENCES


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