

# Performance Evaluation of Tribological Properties of Cotton Seed Oil for Multi-cylinder Engine

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## ABSTRACT

A lubricant is a substance that reduces friction and wear by providing a protective film between two moving surfaces. Lubricants are classified in solid, liquid and gaseous forms. Good lubricants possess the properties such as low toxicity, high viscosity index, high load carrying capacity, excellent coefficient of friction, good anti-wear capability, low emission into the environment, high ignition temperature. So tribology related problems can be minimized by proper selection of lubricant from wear consideration. Today, the depletion of reserves of crude oil, the growing prices of crude oil, and concern about protecting the environment against pollution have developed the interest towards environment-friendly lubricants. Because of these the purpose of this work is to evaluate the anti-wear performance of cotton seed oil and to check the suitability of cotton seed oil as a lubricant for multi-cylinder engine. Four ball testing machine is going to use for tribological testing tester according to ASTM standard D 4172 procedures. The wear preventive properties of cotton seed oil is obtained by measuring wear scar diameter. The present study shows the potential of cotton seed oil as an alternating lubricant.

**Keywords—** ASTM D 4172, anti-wear, Four-ball tester, cotton seed oil.

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## I. INTRODUCTION

For the effective and efficient operation of an automobile at operating conditions requires proper lubrication between the moving parts so that the parts slide smoothly over each other. To decrease energy losses, reduction of wear and friction has a key importance in engines and drive trains. In IC engines from a long time mineral oils have been used as a lubricant. However, Mineral oil is a product of the distillation of crude oil, so that it can be used until crude oil is available. Also, the disposal of mineral oils leads the problem of pollution in aquatic as well as in terrestrial ecosystems. In addition, the combustion of mineral oil lubricants have been emit traces of metals as zinc, calcium, magnesium phosphorous and iron nano-particles. Today, the depletion of reserves of crude oil, the growing prices of crude oil, and concern about protecting the environment

against pollution have developed the interest towards environment-friendly lubricants as a replacements for mineral oils in engines. In comparison with mineral oil and synthetic oils, vegetable oil based lubricants possess the properties such as low toxicity, high lubricity, high viscosity index, high load carrying capacity, excellent coefficient of friction, good anti-wear capability, low emission into the environment, high flash point. Because of polar groups in the structure of vegetable oil and presence of long fatty acid chains obtain both boundary and hydrodynamic lubrications. Many of the researchers have used vegetable oil as engine oil, but only few of the researchers have reported vegetable oil-based lubricants for automotive applications.

## II. REVIEW OF PAPERS

H.M. Mobarak et.al [1] presented the potential of vegetable oil-based bio-lubricants as an alternative lubricant. This is because of a bio-lubricants are renewable lubricants that is non-toxic, biodegradable and emits net zero greenhouse gas. In this paper the study about bio-lubricants are presented in three parts. In first part authors discussed the different sources, properties as well as advantages and disadvantages of the bio-lubricant. In the second part authors presented the potential of vegetable oil-based bio-lubricants as alternative lubricants for automobile applications. The final part discussed about the world bio-lubricant market as well as its future prospects.

Sachin M. Agrawal et.al [2] determined the influence of lubricant on wear and frictional force. For that purpose pin on disc machine is used with M2 HSS tool. Authors used the cotton seed oil for their research because of increasing crude oil prices, emphasis on the development of renewable and environmentally friendly fluids. Also, cotton seed oil is greatly available in India especially in Gujarat and Maharashtra. However, the cost of cotton seed oil is cheaper than the others. The experiments were carried out on M2 high speed steel under varying speed and load conditions over a wide range. The performance of cottonseed oil is compared with SAE 40 oil under dry and wet conditions. Analysis of results of friction and wear test is done by Analysis of Variance (ANOVA) to find the relative influence and significance of each factor. After completing the work the performance of cottonseed oil is analyzed and based on that it can be concluded that cotton seed oil can be used as a metal working fluid in industry because of it showed comparatively good result in terms of wear and coefficient of friction at various loads and speeds.

Amit Kumar Jain and Amit Suhane [3] discussed the applications of bio-lubricants in various areas because of their advantages compared to mineral oils as well as synthetic oils. It is possible to reduce the use of petroleum based lubricants and serious environmental problems both in industrial and maintenance applications by using the bio-lubricants. Bio-lubricants can be used as two-stroke engine oil, hydraulic fluids, cutting fluids, metal working fluids, gear oils, chainsaw oils, and marine lubricants in various industrial and maintenance applications. In industries, the use of bio-lubricants increases worker safety, improves the environmental conditions, increases machine life. Because of the listed advantages authors concluded that the bio-lubricants have a potential as alternative lubricant for industrial and maintenance applications.

Y.M. Shashidhara and S.R.Jayaram [4] made a review to understand the potential of vegetable oils as metal working fluids. The authors have highlighted the contributions about sixty authors on vegetable based oils as emerging environmental friendly cutting fluids. The study focused on the evolution of vegetable oils as cutting fluids particularly in manufacturing sector. Vegetable oils were found as an alternative for mineral based oils due to their environmental friendly advantages. Many of the researchers found that soyabean, sunflower and rapeseed oils have potential as metal working fluid. Finally, the review exposed that the vegetable oils have great scope to use them as metal working fluids.

N.H. Jayadas et.al [5] evaluated the tribological properties of coconut oil using a four-ball tester and a test rig

to test the wear on two stroke engines. Also, the influence of an anti-wear/extreme pressure (AW/EP) additive on the tribological performance of coconut oil was evaluated by doing experiment. To improve the tribological properties of coconut oil, an AW/EP additive ZDDP was added to coconut oil. AW/EP tests on coconut oil were conducted using DUCOM four ball test machine as per ASTM D4172-94 and ASTM D2783, respectively. To determine the optimum additive (AW/EP) concentration, the wear tests were performed at different additive concentrations. For comparison, the tests were repeated on a commercial lubricant SAE20W50. The results of four ball tester and test rig shows that coconut oil has higher wear rate than the commercial lubricants and so it cannot be recommended as 2T oil in the unmodified form. The Results also shows that anti-wear and extreme pressure properties of coconut oil were improved due to addition of suitable concentration of Zinc-Dialkyl-Dithio-Phosphate (ZDDP) AW/EP additive.

S.M. Alves et.al [6] has studied the tribological behavior of soyabean oil, sunflower oil, mineral oil, synthetic oil lubricants with nano-particles of oxides (ZnO and CuO). These oxide nano-particles used as additive for extreme pressure. High Frequency Reciprocating Rig equipment and SEM/EDS was used to study the anti-wear behavior of CuO and ZnO. A hard steel ball (570–750 HV) reciprocates on a softer steel disk (190–210 HV). The steel ball had diameter of 6.0 mm while the steel disk of 10 mm diameter of material of AISI 52100 steel. The steel ball and the steel disk were fully submerged in oil under normal load of 10 N and a 1 mm stroke length at a frequency of 20 Hz for 60 min. The lubricant temperature was kept at 50 °C. The friction coefficient was measured using piezo-electric force transducer. The results showed that with the addition of nano-particles to conventional lubricant, the tribological properties can be significantly improved. Also, lubricants developed from modified vegetable oil can replace mineral oil by improving the tribological properties and environmental characteristics.

Y.Y. Wu, W.C. Tsui, T.C. Liu [7] examined the tribological properties of API-SF engine oil and Base oil. These lubricating oils were tested with and without nano-particles additives namely CuO, TiO<sub>2</sub> and Nano-Diamond. The reciprocating sliding tribotester were used for friction and wear experiments. The friction and wear experiments were performed to evaluate the friction reduction and anti-wear abilities of these nano-particles. To present the possible mechanisms of lubrication and wear with listed nano-particle additives optical microscope (OM), energy dispersion of X-rays (EDX), transmission electron microscope (TEM) and scanning electron microscope (SEM) were used. The experimental results show that CuO nano-particles added to standard oils exhibit good anti-wear and friction reduction properties. The addition of CuO nano-particles decreased the friction coefficient by 18.4 and 5.8% in the API-SF engine oil and the Base oil respectively. Also, the worn scar depth was decreased by 16.7 and 78.8% respectively than the standard oils without CuO nano-particles.

Juozas Padgurskas et.al [8] determined the tribological effect of various mixtures of metallic nano-particles and their compounds added to mineral oil. Tribological investigations were performed on mineral oil SAE 10. To study the tribological effect, the mixtures of Fe,

Cu and Co nano-particles and their combinations were used. Converse emulsions of water in lubricant solution (CEWLS) method were used to add the nano-particles into the tested oil. The CEWLS method was used due to stable dispersion of nano-particles in mineral oil SAE 10. The tribological test was carried out on four ball tester according to the standard DIN 51350, part 3. The tests showed that each set of nano-particles significantly reduced the friction coefficient and wear up to 1.5 times. The use of Cu nano-particles effectively reduced the friction and wear in each combination of nano-particles. Surface analysis was done by SEM while chemical analysis was done by EDX. The surface analysis showed the different structures formed on the friction surface in the contact zone and over the remainder of the ball surface. The SEM micrographs and EDX chemical analysis confirm the formation of a tribo-layer. This tribo-layer was composed of the elements from the nano-particles.

The ASTM journal [9] covered the standard test method for wear preventive characteristics of lubricating fluid in sliding contact by means of the four-ball wear test machine.

In this journal they listed different terminologies related to the test as lubricant, wear. This ASTM journal gave the detailed specifications of four ball wear test machine with significance and use. This ASTM test method can be used to determine the anti-wear properties of lubricating fluids in sliding contact under the prescribed test conditions. Material of the balls, test conditions, preparation of apparatus and detailed procedure are elaborated in this journal.

The aim of this work is to evaluate the tribological properties of cotton seed oil and also to check the suitability of cotton seed oil as a lubricant for multi-cylinder engine. For this research tribological testing of lubricant is going to do on four ball testing machine and the tests are going to carry out by ASTM (ASTM D 4172) standards [9].

### III. EXPERIMENTAL PROCEDURE

#### A. Working Steps

- Carry out the literature survey carefully.
- Find out the problem statement regarding the research work.
- Find out the research gap and the objectives of the research work.
- Selection of proper engine oil for comparison.
- Test cotton seed oil on four-ball wear test machine as per ASTM standard D 4172 under prescribed condition.
- Compare the anti-wear properties of cotton seed oil with selected engine oil.
- Make a conclusion regarding wear scar diameters of worn balls from the results.

#### B. Four-Ball Wear Test Machine

The four ball wear test machine as shown in Fig. 1 is going to use for wear tests and ASTM D 4172 standard procedure is followed to find out anti-wear properties of lubricants. The Ducom four ball testers is widely used as the industry standard for conducting anti-wear, extreme pressure

and shear stability property test of lubricants. The test system is capable of carrying out a number of standards applicable to lubricant characterization and its capabilities extend beyond the scope of these standards, allowing users to perform a variety of customized tests. This machine uses 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 lubricant 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. The lubricant under test is characterized by evaluating the wear scar formed on the bottom three balls after the test.



Fig.1 Four Ball Tester

#### C. Tribological Testing

The four ball wear test machine uses four balls, three at the bottom and one on top with both of 12.7 mm [1/2-in.] diameter. The balls made up of chrome alloy steel with Rockwell C hardness 64 to 66. The top ball is pressed with a force of 147 or 392 N [15 or 40 kgf] into the cavity formed by the three clamped balls for three-point contact. The temperature of the test lubricant is controlled at 75°C [167°F] and then the top ball is rotated at 1200 rpm for 1 hr. Lubricants are compared by using the average size of the wear scar diameters measured by microscope on the worn three lower balls. The microscope is capable of measuring the scar diameters with accuracy about 0.01 mm.

### IV. EXPECTED OUTCOME

Examine the tribological properties of the cotton seed oil is main basic task of research work. I am going to make a conclusion about anti wear properties of cotton seed oil from wear scar diameters. So from the result it is expected that Cotton seed oil will has better anti-wear property than the selected engine oil.

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