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Experimental Study of Castor Oil Based Lubricant for Automotive Applications

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ABSTRACT
Vegetable oils due to their better natural propertiescan be used as an alternative to reduce the dependency on the conventional lubricants. With the depletion of conventional resources at faster pace, need of hour is to approach the safer alternatives for ensuring the availability of such resources for longer periods with lesser harm to the mankind and sorroundings.This workevaluates the prospects of Castor oil based lubricant for automotive applications in contrast to the available commercial servo gear oil. Experimentation has been performed on four ball tester set up.Material used is carbon steel balls. Refined castor and mahua oils are blended in fixed ratios and subjected to friction and wear tests. Experimentation reveals that castor mahua oil blend possess immense potential in contrast to servo gear oil due to good wear reducing traits apart from environmental benefits.
Key words: Castor Oil, Mahua Oil, Servo Gear Oil, Blending, Viscosity, Four Ball Tester

I. INTRODUCTION

Lubricant is a fluid intersposed between the interacting surfaces to smoothen out the motion without harming the tribosystem involved. Literature reveals their use almost to the birth of human civilization in ancient era dating back to 1400 B.C. earlier the lubrication with animal fat (tallow) was applied to reduce the friction on chariot wheel axles. Developments steadily made in roads for transportation and machinery thereafter during the middle ages (450 –1450)AD. The value of lubricants in reducing friction and wear got recognition during industrial revolution phase (1750-1850)AD. Transition from the natural products to conventional mineral based lubricants took place during the birth of petroleum industry, 1859.Earlier petro based lubricants lacked the intactness as inherited by the animal/ vegetable oils. With the rising demands of automobiles and other transportation aids ensuring better industrialisation research and developments took at faster pace after 1920's. Modern conventional lubricants are formulated from a range of premium base fluids and advanced additive chemistry heavily loaded with synthetics and chemicals for providing best performance. The base fluids has several functions but primarily it is the lubricant providing a fluid layer separating moving surfaces or removing heat and wear particles while keeping friction at minimum. Many of the properties of the lubricant are enhanced or created by addition of special chemical additives to base fluids. It is these combinations which has been proving a threat to the environment and the living being[1-3]. Due to the population explosion worldwide, limited crude resources are being extracted at excessive rates causing their faster depletion. Poor biodegradibilities, elevatedcrude oil prices , unsafe disposal techniques, absence of lubricant usage norms globally threatening environment has unconditionally drew its attention towards the alternatives.Vegetable oils are chemically triglycerides of long chain unsaturated free fatty acidsattached at hydroxy groups via ester linkage. Deviations in thephysiochemical structure and properties are guided by theses blocks [4-6]. Higher oiliness, better ignition temperature properties, environmentally safe optionsgives them upper hand on the conventional one inspite of fewer drawbacks which could be compensated for proper modifications. Of the innumerable plant species very few have been explored and need further investigations for lubricant applications [7-10]. Castor and Mahua are the varieties which are non edible, compatible varieties and possess immense potential in overriding the frictional effects encountered during the interaction. Castor (Ricinuscommunis L.)grows well in arid and semi arid zone and its annual production accounts to around 8 lac tonnes per annum. Mahua (MadhucaIndica L.) belongs to Sapotaceae family flourishes under dry tropical and sub-tropical over greater parts of our country with 2 lac tonnes per annum of yield. Both of them have better rural economy prospects and have diversified range of utilities ranging from cosmetics, paints to medicines etc. The quantum of work in context to these varieties has been done to the limited levels for automotive applications [11-15]. The present investigation is an attempt to look in to the prospects of castor based lubricant blended with mahua against the conventional servo gear oil for automotive applications.

II. EXPERIMENTATION

2.1 Sample Preparation and Test specimen

In this work refined castor oil and mahua oil have been investigated, where castor is used as the base oil and mahua as the blending agent. The conventional lubricant used as reference in this work is servo gear (HP90) oil. Blends of castor and mahua oil samples with five different ratios have been prepared varying from 10%-50% by volume. Total seven samples have been analysed. Test specimen used are spherical balls 12.7mm diameter. Ball material is carbon steel with carbon % (0.20-0.35).

2.2 Experimental Set Up

Experimentation has been performed on the four ball tester as per ASTM (D 4172) standards as shown in **Fig.1.** This set up uses four balls, three at the bottom and one on top. All the balls are dried washed with acetone to maintain the surfaces free from impurities.The bottom three balls are held firmly in a ball pot containing the lubricant under test and pressed against the top 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 the evaluating the wear scar formed on the balls and coefficient of friction observed for the respective combination after the test.

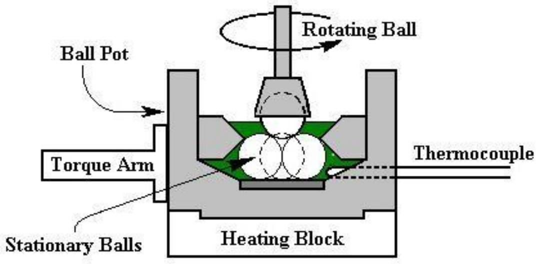

Fig.1 Schematic Diagram of Four Ball Tester

2.3 Experimental Procedure

A load of 40kg (392 N) was applied at the contact zone of balls with test lubricant placed in the ball pot. The top most ball fixed in the collet attached to the spindle of the tester is made to rotate at the speed of 1200 RPM for one hour with temperature maintained at 75^{0}c. Coefficient of friction (μ) is measured with the help of above set up for the particular settings. The observations are recorded in the data acquisition system which are further analyzed. Wear scar is measured by the microscope of 0.01 mm accuracy. This procedure is followed for all the other test samples. The lubricant test oil samples are Servo gear oil, Castor oil, blend 1, blend 2, blend 3, blend 4 and blend 5 as shown in **Table 1**.

Table 1:Blending Ratio

Vol %	Blend1	Blend2	Blend3	Blend4	Blend5
Castor	90	80	70	60	50
Mahua	10	20	30	40	50

The viscosities(η) evaluated for different samples through digital viscometer are shown in**Table.2**

Table 2.Kinematic Viscosity

η cP	SGear Oil	Castor Oil	B1	B2	B3	B4	B5
27^0	240	260	230	220	190	150	140

On the basis of the experimentation, values and curves depicted in the form of table and plot shows the effect of blending on COF and wear scar.

III. RESULTS AND DISCUSSION

3.1 Coefficient of Friction (μ)

Fig.2 is the plot representing thecorrelation between coefficient of friction (μ) and the time for various oil samples. The average experimental values for the coefficient of friction parameter reported varied from 0.00625 to 0.04945 ie. in the boundary lubrication regime.Servo Gear oil and refined castor oil showed comparative higher values 0.04945 and 0.04608, respectively. The blends reported comparatively lower values as shown in the **Table 3.**The reported values arefound to be higher in the beginning and later decline to the lower values with the time. This could be due to the higher initial frictional torque during experimentation.

Resulting values from the table gives an idea about the formation of protective, stable and thick layer between the surfaces resisting material loss. The temperature conditions remained stable in the ball pot to 75^{0}c during the experimentation showing the bearing ability of the oil samples.

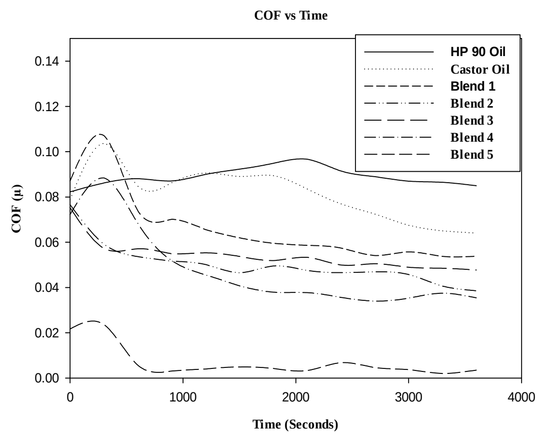

Fig.2 COF vs Time for Lubricant oil samples

Table 3:COF values

S.No.	Oil Sample	COF(μ)	Wear Scar (mm)
1	Servo Gear	0.04945	0.87
2	Castor Oil	0.04608	0.95
3	Blend 1	0.03759	0.86
4	Blend 2	0.03302	0.79
5	Blend 3	0.03025	0.74
6	Blend 4	0.02691	0.69
7	Blend 5	0.00625	0.60

3.2 Wear Scar Diameter

Wear scar diameter is the average impression mark left over the three lower static balls due to the sliding action of upper ball. Sliding interaction results in material loss from the balls. It is measured using a microscope after removing the balls from ball pot. **Table 3** gives clear picture of wear scar impression over the affected static balls. Blend 5 reported least scar damage in the denomination of 0.60 mm and refined castor reported highest ie. 0.95 mm scar impression. The probable reason for this could be the ability of blended oil sample layer to avoid metal contacts for greater portion of test span resulting in lesser material loss and hence lower wear scar damage.

3.3 Surface Profile

The surface profile of the balls analysed in the microscope revealed that the interactions between the stationery and the rotating balls showed pronounced abrasive and adhesive wear pattern under prevailed boundary lubricated regime as shown in the **fig.3.**and**fig.4.**

Fig.3. Experimental Balls in the Ball Pot

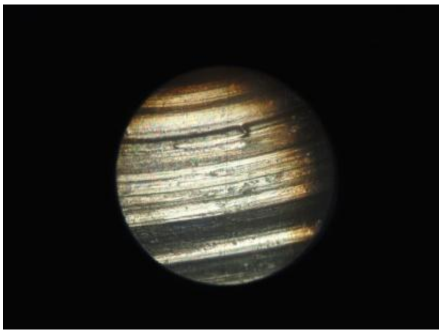

Fig.4. Wear Pattern on the Ball Surface

IV. CONCLUSIONS

Experimental observations and findings can be concluded in following points:

1. COF values are found lower and better for blend 5. Servo gear and refined castor oil gave higher values for the same.

2. Wear scar impression is reported lowest for blend 5 which is a combination of castor and mahua oil in equal concentration and highest for the refined castor oil**.**

3. Surface profile of the balls showed adhesive and abrasive wear patternsunder boundary lubricated regime.

4. Blending provided for formation of protective and stable lubricant layer which is capable of bearing temperature rise, resisting material loss. This action is observed more pronounced in blend 5.

5. Castor oil based lubricant has better prospects to servo gear oil as far as friction and wear trends are concerned. Experimental observations suggests that castor has immense potential in acting as base fluid for lubricant formulation for automotive gear applications. More elaborate work needs to be done to explore other effective blending options and applications.

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