Study on Effects of Triphenyl Phosphate as a potential Additive for Lubricating Oil

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Abstract— Lubricating oils play a vital role in our modern automotive, aviation and power generation industries. These oils are formulated by blending a special purpose base oils with suitable additives to enhance the base oil properties suitable for particular application. The main aim of this research is to study the effect of additives on turbine base oil. The main focus of this study is to evaluate the oils obtained from mixture of base oil and additives for its physic-chemical properties. The values so obtained were compared with commercially available turbine oil in market. The values of the properties of additive blended with base oil depends upon the base oil and the concentration of the additive used.

***Key words*:** turbine base oil, Lubricating Oil Chauhan, Effects Of Triphenyl Phosphate.

I. INTRODUCTION

Lubricant is a substance introduced between two sufaces in motion to reduce the friction between them. A lubricant forms a layer which allows for two touching surfaces to be separated and "smoothed" thus lessening the friction between them.

On a global scale always there is a scope for development of better lubricants in order to meet the standards set by the manufacturers. In the most common cases when a load is applied the fluid tends to resist the motion as pressure is generated due to friction between two moving parts. This study of friction, lubrication and wear is called tribology. Model additives like organic esters of phosphates and phosphonates also prove to be good antiwear additives [1]. Zinc dialkyl dithiophosphates although it is a most inevitable additive as it imparts better wear resistance property to the lubricant it contains sulfur which may cause rusting of iron parts. As an alternative phosphorothionates are used which has similar properties as that of ZnDTP [2]. Tricresyl phosphates, [3] phosphate esters and thio phosphate esters prove to be good anti wear additives [4]. Polytetraflouroethylene powder is also used for imparting extreme load carrying properties to the lubricant. It has been observed that for high concentration of PTFE the scars are very less for higher welding loads [5]. Base polarity of an oil also influences the tribological performance of ZDDPs. When ZDDP is added to a base oil without polarity, the adsorption rate is enhanced leading to better accessibility to steel surfaces, than when ZDDP is added to polar oil. Addition of ZDDP to base oil without polarity results in the formation of denser ZDDP-derived reaction layers and better lubrication to the steel surfaces .So a good lubricant should exhibit good load carrying capacity and should operate without mild wear [6].

Viscosity Index is one of the major property of a lube oil. This VI can be defined as a property of lube oil which indicates the changes in viscosity with respect to temperature. This also indicates how stable a oil can be at varying temperatures and under normal working conditions. The viscosity of the finest oils do not vary with the varying temperatures during normal working conditions. The oil to show consistent performance within the normal conditions. There are number of viscosity improvers available which try to enhance the viscosity index of the base oils. Co polymers of sunflower oil with methyl methacrylate and decyl arcylate can be used as a viscosity improver for lube oils. It has been proved that this additive enhances the VI [7]. A additive package contains special types of polymers, which in small proportions remarkably improves oils rheological properties such as viscosity and viscosity index. However when oil is in use due to break down of molecules there is decrease in friction and wear. The addition of additives improve the flow properties by reducing the viscosity [8]. The contribution of additives for longer sustainability of commercial lube oil would be better compared to base oils without additives[9].Turbine fuel when blended with spindle oil show better results for parameters like viscosity density, aniline point [10]. Corrosion and rusting of copper, steel and iron machinery parts should be avoided in a long run. Anti corrosive agents are added to avoid rusting and corroding of the steel and iron parts. Foaming tendency of a lubricating oil is a serious problem is systems such as high speed gear transmissions, turbines etc. If an oil has foaming tendency then the lubrication becomes discontinuous, there will be loss of lubricant due to overflow, which may lead to mechanical damage and decrease the life time of the product and higher maintenance cost. So various anti foaming agents are added to the base oil to reduce this foaming tendency[11]. Oxidation is a chemical reaction of oxygen with oil. The life of lube oils will be reduced due to oxidation as oxidation leads to formation of varnish or sludge on the machine parts. In order to avoid this oxidation of oil during working conditions antioxidants are added [12]. Pour point of a fluid or oil is the temperature at which the oil loses its flow properties and tends to become semi solid. In order to improve the pour point and to meet the criteria set by the industries pour point depressants are added. PPD reduces the size of wax crystals by depositing or adsorbing on the wax crystal network [13].

II. EXPERIMENTAL PART

Here three different types of base oils from three different groups are taken which are blended with Tri phenyl phosphate additive in different concentrations. The additive concentration are added in volume % (2,4,6,8,10) to the base oils and physical parameters are studied for the three base oils and base oils formulated with additive using standards ASTM test methods.

III. RESULTS AND DISCCUSION

A. Evaluation of Viscosity Index

The Viscosity Index of the base oils and the formulated oils were evaluated according to (ASTM D 2270). The kinematic viscosity at 40◦C and 100◦C were determined and viscosity index was calculated from the below formula.

$$V = 100\frac{(L-U)}{(L-H)}$$

where V indicates the viscosity index, U the kinematic viscosity at 40 °C (104 °F), and L & H are various values based on the kinematic viscosity at 100 °C (212 °F) available in ASTM D 2270.

Table 3.1: Showing variation Of viscosity and viscosity Index

% of additive added	**Kinematic Viscosity at 40◦C in Cst**	**Kinematic Viscosity at 100◦C in Cst**	**Viscosity Index**
Base Oil	9.6	2.6	90.101
2	8.93	2.45	92.8
4	7.85	2.29	93.465
6	7.93	2.23	96.31
8	7.2	2.15	97.36
10	6.65	1.99	99.46
Commercial oil	6.04	2.00	102.6

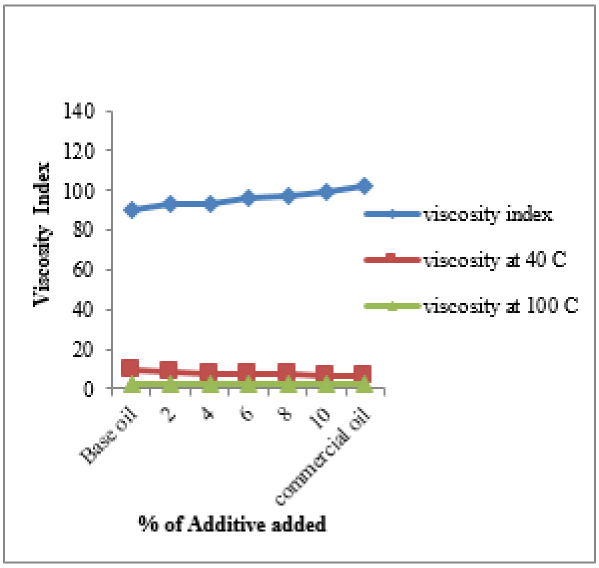

Fig. 3.1: Variation Of viscosity and viscosity index with addition of additive

B. Evaluation Of Extreme pressure

This test was carried out according to standard test method illustrated in ASTM D 4172. Here the four balls are cleaned with the help of a tissue. These balls are cleaned by using a solvent. Three balls are placed in a cup filled with the sample to be tested and are locked tightly. The fourth ball is inserted in the ball chunk and tightened. The ball cup with the sample was placed in the test machine. The timer was started and the drive motor, was set to 1200 + or - 60 rpm. After the drive motor has been on for 60 + or - 1 min, the heaters and drive motor are turned off and the ball cup and three-ball assembly were removed. The wear scars of the three lower balls and bandwidth of the fourth ball were measured

Table 3.2: Showing variation in scar diameter and bandwidth

% of additive added	**Scar diameter(mm)**	**Bandwidth(mm)**
Base Oil	3.15	1.68
2	2.16	1.98
4	2.06	1.04
6	1.97	0.98
8	1.89	0.83
10	1.64	0.64
Commercial oil	1.7	0.75

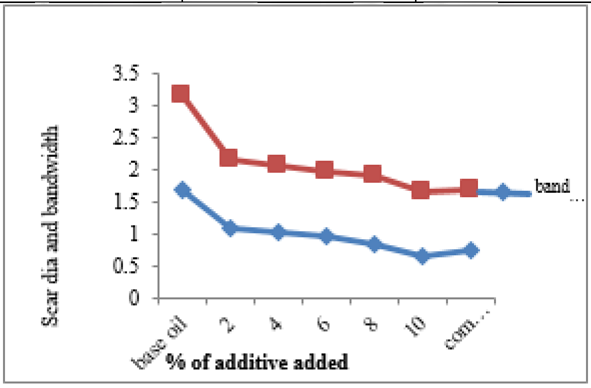

Fig. 3.2a: variation of scar dia and bandwidth with the addition of additive

Fig. 3.2b: Balls with Scar and Band Width for the fourth ball

Evaluation Of Acid Number

According to (ASTM D 664-04) into a suitable titration vessel a weighed quantity of sample was introduced to which 60 ml of TAN solution was added. The beaker was placed on the titration stand and its position was adjusted so that the electrodes are half immersed. Stirrer was started, and stirred at a rate sufficient to produce vigorous agitation without spattering and without stirring air into the solution. Titration was carried out with 0.1-mol/L alcoholic KOH solution. The titrant was added in increments, These incremental volumes varied between 0.05 and 0.5 mL.

A blank titration of 60 ml solvent is carried out for each set of samples and for every new batch of titration solvent. For automatic titration, same mode of titration as for the determination of the acidic property of the sample can be used but in smaller increments of titrant addition, 0.01 to 0.05-mL. Based on the sample blank is rechecked periodically A titration curve is obtained where a equivalence point is recognizable which give the TAN number

Table 3.3: Showing variation in total Acid number

% of Additive added	TAN mg KOH/gm of oil
Base oil	NAN
2	0.101
4	0.15
6	0.257
8	0.315
10	0.35
Commercial oil	0.25

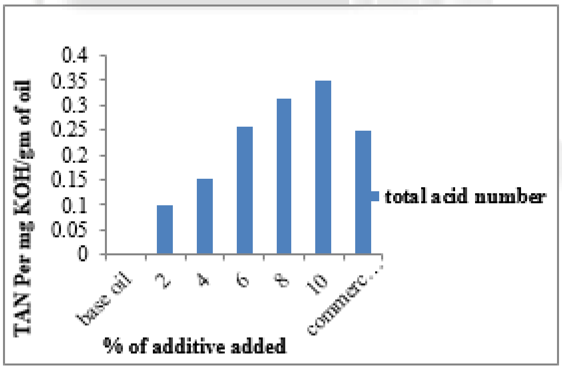

Fig 3.3: variation of TAN with addition of additive

C. Evaluation Of Pour Point

Standard Test Method for Pour Point of Petroleum Products (Automatic Pressure Pulsing Method) is an alternative to the manual test procedure. Here automatic apparatus was used and which showed pour point results in a format similar to the manual method when reporting at a 3°C. This test was conducted according to (ASTM D 97). This test method determined the pour point at a shorter period of time than manual method. Less operating time was required to run the test using this automatic method. Additionally, no external chiller bath or refrigeration unit is needed. The method was capable of determining pour point within a temperature range of -57°C to +51°C. Results reported were at 1°C or 3°C testing intervals. This test method showed better repeatability and reproducibility than manual method.

Table 3.4: Showing Variation in Pour point

% of Additive added	Pour point In Degree Celsius
Base oil	-24
2	-36
4	-43
6	-48
8	-52
10	-56
Commercial oil	-42

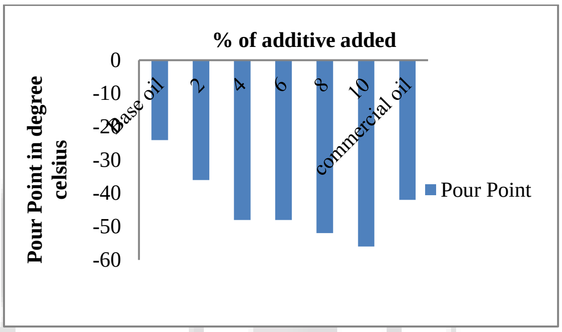

Fig 3.4: variation of pour point with addition of additive

D. Rust Prevention Characteristics

This method was carried out according to ASTM D 665-02. A 400 ml tall heat resistant glass beaker is used to put the sample. This glass beaker with sample is placed in a liquid bath capable of maintaining the test sample at a temperature of 60 C which has holes to accommodate this glass beaker. At a time 4 samples can be tested as this bath has 4 holes. A flat beaker cover made of glass is being used and was placed at suitable position on the beaker. The cover has two holes one hole for stirrer and the other for the test rod and one more hole is provided for temperature measuring device. After keeping the sample in the beaker and placing the beaker in oil bath the stirrer is placed inside the beaker. After 30 mins of waiting we add 30 ml water and place the test rod in the hole provided on the cover, the rod comes in contact with the sample. Stirring is continued for 24 hours, the specimen is removed, cleaned with organic solvent and was checked for any appearance of the rust spots.

Fig. 3.5a: rusted Fig. 3.5b: Non rusted

Iron rod Iron Rod

Table 3.5: Rust prevention property for formulated oil with additive

% of additive added	Rust Characteristics
Base Oil	Some Black Spots
2	Pass
4	Pass
6	Pass
8	Pass
10	Pass
Commercial oil	Pass

E. Copper Strip Corrosion Test

This test was conducted according to ASTM D 130. A test tube (50 ml) was filled by 30 ml of oil sample and, a polished copper strip was prepared by rubbing it by emery paper; the copper strip is slided into the test tube. Carefully the test tube was slided into the test bomb and the lid was screwed tightly. The bomb was completely immersed in a oven heated at 100°C. The contents of the test tube were protected from strong light during the test. After 3 hours the bomb was withdrawn and was immersed for a few minutes in tap water. Then the bomb was opened and was withdrawn to examine the strip.

Examination of The Strip : The contents of the test tube were emptied into a beaker of 150 mL, allowing the strip to slide in so that beaker breakage is avoided. Immediately after which the strip is taken out with stainless steel forceps and was immersed in wash solvent. The strip was taken out from the solvent and was dried with tissue paper (by blotting and not by wiping), and evidence of tarnishing or corrosion by comparison with the Copper Strip Corrosion Standard was inspected. Both the test strips and the standard strip plaque were held in such a manner that light reflected from them at an angle of approximately 45° was observed.

Figure 3.6 shows the bomb were we place the strip for testing , the chart which is used to compare the strip after the test & the copper strips used for the test.

Fig. 3.6: Copper Strip Corrosion Strips And Test Bomb

IV. CONCLUSION

- Viscosity index of the formulated oil showed better results compared to the base oil. The viscosity index for 10% additive concentration have shown good results The VI increased by 10% compared to the base oil.
- Total acid number increased as the acidic constituents increased with the addition of additive.
- Good results were seen for the parameters like copper strip and rust prevention.
- For turbine oils most important parameter is the wear property. As the turbines are subjected to heavy loads. We saw that additives decreased the scar diameter and bandwidth which indicated that additives provide lubricity to the machinery even under application of high pressure.
- This research shows that Triphenyl phosphate acts as a good antiwear additive.

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