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Investigate the load carrying capacity of SAE 40 lubricating oils without using extreme pressure additives on four ball extreme pressure oil testing machine

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Abstract: Extreme pressure (EP) additives are used when components are operated under extreme pressure. This work studies the effect of base oils on the tribological performance of EP additives. The difference between the absorbability of the EP additives and that of base oils dominates the mutual compatibility and performance of the EP additive. When used, the EP additive forms a saturation layer on the rubbing surfaces. The concentration of EP additive in the saturation layer exceeds the additive concentration in the lubricants. Therefore, during operation, the protecting layer can reduce the contacting stress of rubbing surfaces by chemical and physical methods to prevent local plastic deformation from inducing serious wear. Under the harshest conditions, the immediate formation of films in a chemical reaction is important when plastic deformation of the contact region cannot be avoided. The high rate of formation of chemical films can prevent direct metal-to-metal contacts to reduce wear. A comparative account of performance of the tested compounds is presented on the basis of various tribological parameters such as initial seizure load, 2.5 s seizure delay load, weld load, mean Hertz load, flash temperature parameter, pressure wear index, friction coefficient (m) and wear scar diameter (d), etc. All the tested complexes have been found to possess significant Extreme Pressure (EP) efficiency under the experimental conditions of four ball test. In paper evaluated and investigated of tribological properties of SAE 60 lubricating oils without using extreme pressure additives.

Keywords: Lubrication, wear, Extreme pressure (EP) additives, four ball extreme pressure tester, Additives.

I. INTRODUCTION

Lubrication is the process, or technique employed to reduce wear of one or both surfaces in close proximity, and moving relative to each another, by interposing a substance called lubricant between the surfaces to carry or to help carry the load (pressure generated) between the opposing surfaces. The interposed lubricant film can be a solid (e.g. graphite, MoS_2) a solid/liquid dispersion, a liquid, a liquid-liquid dispersion (a grease) or, exceptionally a gas. Functions of lubricants are as follow.

- It reduces wear and tear of the surfaces by avoiding direct metal to metal contact between the rubbing surfaces, i.e. by introducing lubricants between the two surfaces.
- It reduces expansion of metal due to frictional heat and destruction of material.
- It acts as coolant of metal due to heat transfer media.
- It avoids unsmooth relative motion.
- It also reduces power loss in internal combustion engines.

Types of Lubrication

- Fluid–film lubrication
- Boundary lubrication

Fluid–film lubrication:

This type of lubrication is used when two surfaces of the materials rotate against each other while being completely separated. The liquid lubricants form a very thin film between the moving surfaces and thus avoid the direct metal to metal contact and reduce friction. This condition is known as fluid film lubrication. The resistance to movement of sliding moving parts is only due to the internal resistance between the particles of the lubricants moving over each other. Therefore lubricant chosen should have the minimum viscosity under working conditions and at the same time, it should remain in place and separate the surfaces. Delicate machines and light instruments like watches, clocks, guns, sewing machines, scientific instruments etc. are provided with thick fluid film lubrication.

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II. BOUNDARY LUBRICATION:

Boundary lubrication may happen slide or rotate against one another under heavy load, and such conditions there may be contact between the moving surfaces and film breaks down under these conditions, an oil is used which interact with the solid surface of the metal that will between the two sliding surfaces.

This can be possible by adsorption of lubricant molecules on the surfaces or by chemical reaction of the lubrication substances with metal surfaces.

Classification of Lubricant

- **Solid lubricants**

Solid lubricants are used for railway tract joints, chains, air compressors, open gears, heavy machines etc. the examples of solid lubricants are wax, talc, mica, molybdenum disulphide graphite etc.

- **Semi solid lubricants**

It is used where the machine parts are subjected to slow speed, heavy load & sudden jerks. The examples of semi solid lubricants are grease & Vaseline.

- **Liquid lubricants**

Liquid lubricants are used in delicate and light machines which work at high speed but under low pressure. Mineral oils, vegetable oils & animal oils are the various types of liquid lubricants.

- **Synthetic lubricants**

It can be used, where extreme temperature, chemical reactive atmosphere or some very particular operating conditions are involved & where all other lubricants fail to work effectively. e.g. polyglycols, silicones, organic amines, imines & amides.

III. ADDITIVES IN LUBRICATING OILS

Lubricants operate in the boundary between moving metal parts to prevent the contact that could lead to an increase in friction, increase in wear and eventually welding. The classic type of component used to prevent these phenomena is a boundary lubricity additive. The boundary lubricity additive typically functions by adsorbing on the metal surface to form a film that will reduce metal-to-metal contact.

This function is achieved because the boundary lubricity additive has a polar head group that can interact with the metal surface and a tail group that is compatible with the lubricant carrier (mineral oil, synthetic base stock or water). A classic example of a boundary lubricity additive is an ester which could be available as a natural product (canola oil, lard oil, tall oil fatty acid, etc.) or as a functionalized molecule (monobasic ester, diester, polyol ester, complex ester).

The lubricating oils are selected considering the various operations condition like temperature rise, working load, normal working temperature; Pressure, Extreme conditions etc.

The four ball extreme pressure tester is utilized for finding out the load carrying capacity and weld point of SAE 30 of lubricating oils without E.P. Additives; The parameters were determined as Wear-Scar Diameter (WSD), Initial Seizure Load (ISL), Just Before Weld Load (JBWL) And Weld Load (WL) etc.

Experimental Test Rig.

The Four Ball Tester is widely accepted as the industry standard for conducting WP, EP, Frictional and Fatigue Property tests on lubricants. The Ducom Four Ball Tester has the unique capability of evaluating lubricants for their Wear Preventive, Extreme Pressure, Frictional Properties and Fatigue Properties, all in one machine.

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 instrument uses four balls, three at the bottom and one on top.

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 after the test and evaluating the load at which the lubricant fails and the four balls weld together. Friction levels of the lubricant under test can also be evaluated using the TR 30 L test system.

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Fig.1. The Four Ball Extreme Pressure Oil Testing Machine.

The various Advantages of this machine are:

- The construction is quite easy to understand.
- The balls used in this testing machine are easily available and of low cost.
- The range of temperature for testing Oil is quite large 18^0C to 35^0C.
- Large variety of oils is tested by this Machine.
- As measurement of scar on the balls under microscope is very easy so by comparing from table we can easily predict the load carrying capacity of given oil.

A Vertical spindle rotates a chuck between speeds of 1200 rpm to 1800 rpm, in which metal ball of 12.7mm diameter. Were used test specimen is fitted below it three identical balls are clamped together tightly in a cup filled with lubricating oil to be tested. The cup is mounted on a thrust bearing which automatically centers the top ball held in the chuck. Thus, the load is evenly distributed over three points of contact between the top rotating ball and the underlying three stationery balls.

IV. EXPERIMENTAL PROCEDURE

First place the three test balls in the test-lubricant cup. Place the lock ring over the test balls and screw down the nut securely. Pour the lubricating fluid to be tested over the three test balls until they are covered. bring the lubricant and cup to 18 to 35°C. Press one ball into the ball chuck and mount the chuck into the chuck-holder.

Install the test-lubricant cup assembly on the test apparatus in contact with the fourth ball. Place the space between cup and thrust bearing. Placing the weight tray and sufficient weights on the horizontal arm in the correct notch for a base test load of 70 kg then release the lever arm and gently apply Start the motor and run for 10 sec.

Remove the test-lubricant cup assembly remove the chuck and discard the ball finally measure the scar diameter of test balls. Removing the the test balls then cleaning the balls with cleaning solvent and then rinse solvent .Wipe dry with a soft cloth.

Place the individual balls on a suitable holder and by means of a microscope, measure to the nearest 0.01 mm the scar diameters both parallel (horizontal) and normal (vertical) to the striations in the scar surface of one of the three test balls. Leaving the balls clamped in the cup. Pour out the lubricating fluid.

Wash the ball surfaces with cleaning solvent and then the rinse solvent. Finally Using a microscope, measure the scar diameters both parallel (horizontal) and normal (vertical) to the striations in the scar surface of one of the three test balls.

Measurements by microscope of the scar diameters on all three balls, then wear scar measurements on all three test balls must be made. Unless and until welding does not occur on the check run, repeat the test at the next higher load until welding is verified. Continue this procedure until the last non seizure load is determined. procedure until a total of ten runs below the weld point is recorded.

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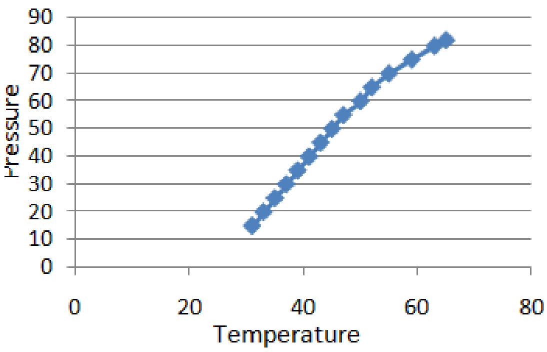
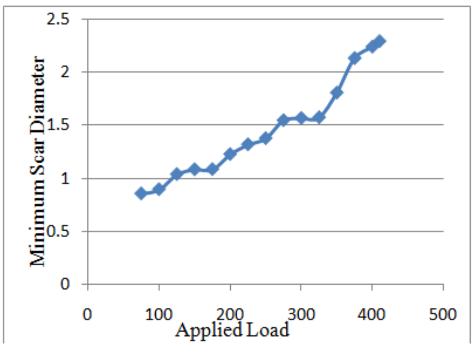
TABLE No.1 OBSERVATION TABLE OF OIL-SAE40

Sr No	Pressure (p) Kg/cm²	Applied Load (w) kg	Temp (t) ⁰c	Time (t) sec.	Minimum Scar Diameter (d) mm	Remarks Regions / Loads
1	15	75	31	10	0.8570	LNSR/L
2	20	100	33	10	0.8970	ISR/L
3	25	125	35	10	1.0395	ISR/L
4	30	150	37	10	1.0850	ISR/L
5	35	175	39	10	1.0865	ISR/L
6	40	200	41	10	1.2280	IMSR/L
7	45	225	43	10	1.3195	IMSR/L
8	50	250	45	10	1.3775	IMSR/L
9	55	275	47	10	1.5475	IMSR/L
10	60	300	50	10	1.5675	IMSR/L
11	65	325	52	10	1.5745	IMSR/L
12	70	350	55	10	1.8070	IMSR/L
13	75	375	59	10	2.1320	IMSR/L
14	80	400	63	10	2.2400	JBWR/L
15	82	410	65	10	2.2915	WR/L



Graph 1 Pressure Vs Temperature (For Oil SAE40)



Graph 2. Minimum Scar Diameter (d) mm Vs Applied Load (W) Kg

(For Oil SAE40)

Calculation of Wear Scar Diameter

The measurements are taken horizontally and vertically. These measurements are recorded in observation table. Measurements of the wear spots on each of the three lower balls taken. The mean value of these six measurements is obtained (3 vertical and 3 horizontal). The average scar diameter readings are plotted against Load Corrected load can be calculated

Corrected Load = Load x Hertz Diameter

Average Scar Diameter
(Where, Load in kg, Hertz Diameter in mm, Average Scar Diameter in mm.)

V. RESULTS

1. Testing lubricating oil SAE 30 without using Extreme Pressure Additives to find out their load carrying capacity & weld loads. Under various loads & their various parameters for time duration 10Seconds.The above Graph Graph1 and Graph 2 Shows, Minimum Scared Diameter plotted aganist Applied Load (Load in kg) is shown between for various regions up to weld point.
2. After conducting the test for SAE 30 lubricating oil, it is found that the following results for various parameters.

(i) Last Non Seizure Region.
(ii) Initial Seizure Region.
(iii) Immediate Seizure Region.
(iv) Just Before Weld Region.
(v) Weld Region.

Measurement of minimum scar diameter

$$\text{Minimum scar diameter} = \frac{\text{Average Reading}}{2} \text{ in mm.}$$

VI. CONCLUSION

Experimentation on four ball extreme pressure tester shows that in case of SAE 30 lubricating oil if Applied Load increases the Minimum Scar Diameter, Weld Load and Temperature also increases. The measurement of mean scar diameter shows that the wear of test balls in experiment. From experiment it also observed that there is proportionality between volumes of material from the fixed balls and the wear scar diameter.

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