A Review on Study of Tribological Parameters of Used Engine Oil

Anchal Singh[1], R.K. Mondloi[2]

[1] *Research Scholar, Mechanical Engineering, M.A.N.I.T, Bhopal, M.P. India*
[2] *Associate Professor, Mechanical Engineering, M.A.N.I.T, Bhopal, M.P. India*

Abstract: *Lubricants play an important role in I.C. Engine and enhancing the life of components of internal combustion engine. Lubricating oil helps to reduce frictional losses between two surfaces having relative motion with each other. Lubricating oils are used to reduce friction and wear by imposing a film between rubbing surfaces. The paper will review existing literature from outside the work conducted by the authors and will substantiate some of the important aspects of tribological properties i.e. of load carrying capacity and weld point of various oils or lubricants used for various purposes. The key part of the paper will be to review Properties like-Load wear Index and Weld Point are the basis of differentiation of Lubricating oils having low, medium and high level of extreme pressure properties.*

Keywords: Tribology, Lubrication, engine oil, Wear

1. INTRODUCTION

Lubricating oils mainly consists of two materials namely the base oil and additive. Many different types of additives are blended with the base oil depends on specific duty or requirement. Used lubricating oils must be replaced on regular time interval in all operating equipment because they contaminated from dirt, water, salt, metals, incomplete products of combustion and other materials.

The main functions of lubricating oil are to reduce friction, wear, temperature, corrosion, contamination and shocks. And fresh and used engine oils are differ in chemical & physical composition from fresh/virgin oils.

The four ball extreme pressure oil testing machine is used to investigate the anti-wear and extreme pressure properties of lubricating oils at various parameter such as operating speed, temperature, load, base oil and material of balls. This machine plays an important role in oil industries and in R&D for testing various types of lubricating oils and grease.

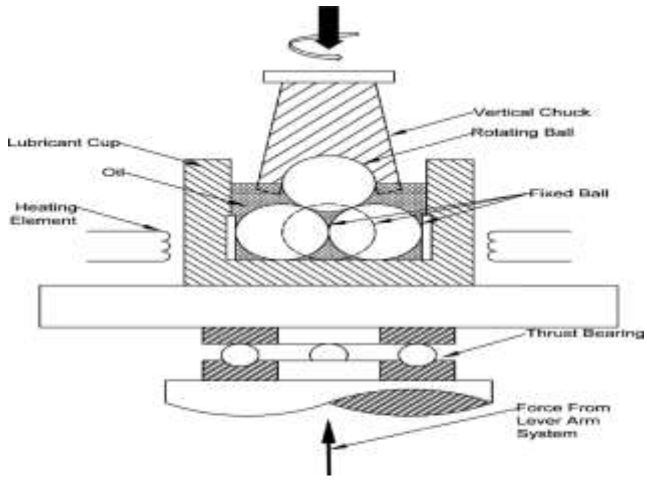

Fig. 1 Schematic diagram of four ball tester

II. LITERATURE REVIEW

Dongare et al. [1] Investigate tribological properties (i.e. load carrying capacity and weld point of various oil or lubricant used for various purpose) by using four ball extreme pressure oil testing machine. In this test chromium alloy steel ball of 12.7mm are used. In this paper various lubricants tested i.e. SAE-20, SAE-30, SAE-40, SAE-50, SAE-60, SAE-90, SAE-12 and SAE140 for finding their load carrying capacity and weld loads under various loads and others parameters for time duration 10 seconds. . The rotating speed of ball was 1700 rpm. The loads are applied in steps series like 6, 8, 10, 13, 16, 20, 24, 32 40, 50, 63, 80, 100, 126, 160, 200, 250, 315, 400, 500, 620 and 800kgsf. And if welding does not occurs at 800 kgf, then the lubricants having a weld point of +800kgf. It is observed that if pressure or applied load increases the minimum scar diameter, weld load and temperature also increases.

Gautam et al. [2] Investigate the anti-wear and extreme pressure properties of fresh and used SAE 15W40 and SAE 20W50 grade engine lubricating oil of different working time cycle. Tests were carried out according to the standards test methods for measurement of wear preventive properties and extreme pressure properties of lubricating fluids, using an ASTM D4172 and ASTM D2783. The test performed on Ducom four ball tester TR-30L atmospheric pressure at 392KN load and 75ºC temperature with speed 1250 rpm. The sample for diesel and petrol unused (D and P) and used (D1, D2, P1 and P2) lubricating engine oil has been taken. Diesel engine oil sample D1 shows less wear scar diameter and shallow grooves as compare to sample D2. These finding shows state of anti-friction and anti-wear properties of diesel sample D2 have been depleted firstly as compare to diesel sample D1. Hence, it may be concluded that component of diesel engine D2 have maximum wear out. On the other hand in petrol engine, anti-wear and anti-friction property of sample P2 has been depleted maximum and before the sample P1.

Ghouti et al. [3] To determine the difference between virgin and recycled engine oil. Recycled oils have high level of water and sediment than virgin oils. The samples were evaluated on basis of physical and chemical properties, wear metals and Infrared spectra to determine any significant variations. ASTM chemical methods such as the determination of kinematic viscosity and pour point are carried out. The spectra of mono- and multigrade engine oil samples were observed and the spectra of all the samples show dissimilarity with virgin oil. FTIR spectra of different engine oil samples shows considerable differences exist in the band 1716 per cm. At last concluded that the recycling process used for purification of the sample oils are inadequate in dealing with Pb, Fe and Si. However, the use of more advanced methods to remove pollutants from waste oils involves higher preparation cost.

Syahrullail et al. [4] has investigated the performance of refined, bleached and deodorized (RBD) palm oil by using pin-on-disc tester. The pin was help on rotating disc at normal load 10N. The tests performed by using a direct flow of RBD palm olein on a plain disk at speed of 0.4 m/sec and 4m/sec. Both frictional surfaces material was stainless steel. The lubricated frictional and sliding wear tests were using a conventional pin-on-disk machine. The principle of sliding consisted of a cantilever loaded pin pressed against a horizontal rotating disk in a lubricant oil bath. All tests were carried out at normal ambient condition (34 ± 2 °C). In this experiment, different sliding speeds predicted to affect the friction and wear characteristics were considered. The finished surface of the wear sample and disk were measured before and after the experiment. Before starting the experiment, the disk and pin surfaces were cleaned properly with acetone to confirm that there were no additional particles or dust on these surfaces. Three tests were performed for each parameter and condition. It was found that the wear obtained with the samples lubricated with the palm olein were generally lower than those with the hydraulic oil. The final wear values obtained by the pin lubricated with the palm olein were around 22.12μm for speed 0.4m/s and 411.92μm for speed 4 m/s. The results show that the wear obtained by using the RBD palm olein was noticeably lower than that of the hydraulic oil. In addition, the coefficient of friction and wear scar diameter of the sample lubricated with RBD palm olein was lower at low speeds, but almost same as hydraulic oil at high speeds.

Masjuki et al. [5] has investigated the tribological performance of palm oil methyl ester with the help of four ball extreme pressure oil testing machine. The ball material was EN31 steel and of 12.7mm diameter. Before starting a series of tests, four new balls for each test were cleaned using spirit alcohol or acetone and dried. The lubricants used for each test were diesel engine oil of SAE-10 and SAE-30 grades. The effects of different percentages of palm oil methyl ester (POME) on the wear scar diameter for different loads when blended or mixed with different categories of commercial oils were evaluated. It is clear that the WSD increases gradually with an increase in wear load. These oils were contaminated with 3%, 5%, 7% and 10% by volume of palm oil methyl ester (POME). The test run was carried out at load range from 51.2 kg to 64 kg and at 1500 rev per min with test duration of 1 min. The wear scar diameter (WSD) was measured using microscope. It was concluded that for other % of contamination, the WSD observed is slightly higher when compared with 5% POME contamination. The maximum wear occurred when pure lubricant was used, particularly at load beyond 57.6 kg, indicating lubrication failure at high load.

Syahrullail et al. [6] has evaluated the performance of vegetable oil as Lubricant in Extreme Pressure Condition by using a four ball testing machine. The test lubricants were commercial stamping oil, commercial hydraulic oil, jatropha oil, RBD palm olein and palm fatty acid distillate. The normal load was 126 kg. The top bearing rotates against three stationary ball bearings at 1770±60 rpm under variable load condition. The temperature of the lubricants was 27ºC±8ºC for duration of 10secs. The results showed that vegetable oils have a high friction coefficient compared to mineral oil. Also, the wear scar diameter produced by vegetable oil is slightly lower than those produced by mineral oil. Hence, it can be concluded that vegetable oils have potential as lubricants.

Habibullah et al. [7] has evaluated the tribological performance of Calophyllum inophyllum bio-diesel at constant speed of 1800 rpm with varying load like 40kg, 50kg, 63kg and 83kg for all tested fuels. CI biodiesels were prepared by using transesterification process and the pure biodiesel is represented as CIB100, 10% , 20%,30%, 40%, 50% biodiesel is mixed in diesel is represented as CIB10, CIB20, CIB30, CIB40, CIB50. The elemental analysis for testing fuel used multi element oil analyzer (MOA) & worn surface of ball was examined by SEM analysis. They found out that biodiesel shows better result as compare to diesel because biodiesel reduces the wear scar diameter and flash temperature parameter (FTP). The mean result shows that the pure biodiesel fuel i.e. CIB 100 shows 16% less friction coefficient and 40% less wear scar diameter than pure diesel fuel. It may be also seen that CIB20 showed the minimum worn surfaces in the blend of bio-diesel and diesel exception is only CIB100. And CIB20 shows better lubricating capability as well as capability to form lubricating film to reduce wear. The wear scar diameter for bio-diesel is approximately 41.02% lower than the diesel. Elemental analysis reprents CIB20 represents lowest amount of particle element11.5ppm and diesel fuel contains highest amount of particle element i.e. 37.5 ppm.

Haseeb et al. [8] has investigated the effect of temperature 30ºC, 45ºC, 60ºC and 75ºC on tribological properties of palm bio-diesel using four ball tester under 40 kg load applied for 60min and speed 1200 rpm For each temperature the tribological properties of petroleum diesel (B0) and three biodiesel-diesel blends like B10, B20 and B50 were investigated and compared. Result shows that the biodiesel blends B10, B20 and B50 show lower WSD as compared to diesel. At higher temperature, wear and friction increases due to fall in viscosity and because of that degradation of boundary lubrication. And wear and friction decreases with the increase in bio-diesel content in blend.

Paramvir et al. [9] has studied Influence of temperature on tribological performance of dual biofuel. New non-edible Phyllanthus emblica (aamla) seed oil was used for making biodiesel which is most capable feedstock to produce biodiesel. In this paper, effects of concentration of biodiesel in blend, temperature and load on friction and wear are investigated by using four ball tester. . There are number of bench tests conducted by the researchers i.e. high frequency reciprocating rig (HFRR), pin on disc, ball on cylinder lubricity evaluation and four ball tester etc. for the primary acquaintance about the tribological behaviour of the fuel. Biodiesel is subjected to oxidation and has affected lubricity at higher temperature and load, so the effect of oxidation was also studied. The operating loads 147–392 N and temperatures were 45–60–75 ºC respectively. The three stationary balls were fitted in steel cup by lock nut and clamping arrangement. The lock nut was tightened with the help of torque wrench with force of 68 N. The fourth ball fixed in the chuck at lower end of spindle of the electric motor. 10 ml of oil was inserted in the cup in each test. During operation of four ball wear monitor the frictional torque was recorded by data acquisition system. The scars on the balls are investigated by microscope. An analytical ferrography was done to analyses the wear debris in the used oil after each test conducted. With increase in concentration of esters in the blends lubrication seems to be better. As envisaged the trend of COF and WSD at all operating conditions, friction and wear was observed higher for diesel as compared to biodiesel.

Maleque et al. [10] has studied effects of mechanical factors like applied load and temperature on the tribological performance of 5% palm oil methyl ester. The blended lubricant was studied using a steel and cast iron pair. Wear and frictional test performed with the help of stationary steel ball and a reciprocating cast iron plate in a modified universal wear and friction testing machine. In the test conditions the contact pressure was 400 MPa, mean contact velocity was 0.34 m/s, reciprocating stroke was 80 mm, loads 100–1100 N for fixed temperature and temperature 40–140ºC for fixed load. Wear scar surfaces were investigated with the help of scanning electron microscopy to understand the wear mechanisms involved. Analysis of post bench test lubricating oils was carried out by using an ISL viscometer. TAN or TBN analyser was used to investigate the lubricating oil degradation properties. Results showed that at lower loads up to 500 N and temperatures up to 100ºC, the wear rates under 5% POME lubricant are lower whereas higher loads and temperatures produces the higher wear rates. The friction behaviour of POME as an additive in commercial lubricant shows that the prevalence of the boundary lubrication regime. The viscosity test concluded that 5% POME can improve the viscosity index properties of mineral-based lubricant up to load of 500 N. However, finally it can be seen that the dominant wear mode at higher temperature were corrosive wear and pits on the damaged surface.

III. CONCLUSIONS

Researchers carried out many experimental works on tribological analysis of different lubricating oils generally by using four ball ester or pin on disc tester. The parameters used are operating speed, temperature, load, additive, base oil and material of the ball.

1. Four ball test shows limited application to determine extreme pressure property activity of wear based fluids for metal working processes.

2. It is also concluded that if pressure or applied load increases the Minimum scar diameter temperature and weld load also increases.

3. Due to easy sample test procedure of four ball extreme pressure oil testing machine is widely used in oil industries as well as in research and development (R & D)

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