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Comparative Wear Analysis in a DI Diesel Engine Using Diesel and Biodiesel

V.Manieniyan[1], R.Senthilkumar[2] and S.Sivaprakasam[3]

[1]*Assistant Professor in Mechanical Engineering, Directorate of Distance Education, Engineering wing, Annamalai University,*
[2] *Assistant professor in Mechanical Engineering, Department of Mechanical Engineering, Annamalai University,*
[3]*Associate professor in Mechanical Engineering, Department of Mechanical Engineering, Annamalai University, Annamalainagar, 608 002, Tamil Nadu, India. Email:*

Abstract-The functioning of engine parts is much influenced by the presence of wear. It is not an easy task to do an accurate evaluation of wear in oil analysis for engine condition monitoring. Though guidelines are provided by the Original Equipment Manufacturers, lubricant suppliers and oil analysis laboratories for wear metal concentrations, it suites only for interpreting oil analysis data. Other functions like oil consumption, fresh oil additions and particular features such as engine age, type of service, environmental conditions which influence the concentration of wear debris and contaminants in an oil sample are not taken into account. The experiment was carried to measure the wear from the lubricating oil by running the engine for 75 hours with a predetermined engine loading cycle. The lubricating oil of the engine was analyzed for metal addition after every 25 hour interval. After a series of experimental work done with biodiesel blend and diesel, it is found that presences of wear metals are lesser in biodiesel.

Keywords: Biodiesel, Emission, Lubricating oil, Wear,

I. INTRODUCTION

Vegetable oil is a promising alternative to petro diesel fuel because it has several advantages. It is renewable, environmental friendly and can produce easily in rural areas, where there is an acute need for modern forms of energy [1]. The use of biodiesel in diesel engines does not require any hardware modification [2]. The performance of engine parts degrades mainly due to the sliding contact between the metallic components of the engine, which results in wear and in turn generation of minute metal particles. The need for wear measurement arises in order to reduce the negative effect on the functioning of engine parts. Piston, piston rings, cylinder liner, bearings, crankshaft, cam, tappet, and valves are the major components subjected to wear in diesel engine [3-5]. By washing away the lubricated diesel engine system using lubricating oil the wear particle remain in suspension in the lubricating oil. The wear measurement in terms of wear rate, source of wear metals, and engine conditions are predicted by analyzing and examining the variation in the concentration of the metallic particle in the lubricating oil after certain running duration [6].

The engine is operated using different fuels at different loads. The fuels used for engine operation are diesel and biodiesel, so that the effect of fuels on the life of engine hardware could be compared. Lubricating oil is used to wash away the wear particle which picks up the wear debris of various metals [7]. Two different types of evaluation can be done on the wear particles present in the oil. The quantitative evaluation of wear particles present in oil gives the magnitude of engine component deterioration. The qualitative evaluation is to find the wearing component. These two evaluations give sufficient information about the deteriorated components and the incipient failure of the machine. The various contaminant metals present in lube oil might have various possible sources in the engines [3].

Table 1 lists the typical sources of metallic elements in wear debris of the lubricating oil.

Metals	***Components***
Iron	*Block Corrosion, Pistons, Cylinders and Cylinder Walls, Shafts, Cams, Valves, Valve Guides, Springs, Rods, Gear Sets.*
Copper	*Main and Rod Bearings, Bushings, and Backings, Some Cylinder Inserts, Some Engine Gear Sets*
Tin	*Tubing Solder Joints,*
Lead	*Bearings, Sealing Compounds, Leaded Gasoline.*
Chromium	*With Iron, Shafts, Cams, Rods, Springs, Valve, Valve Guides.*
Nickel	*With Iron, Shafts, Cams, Rods, Springs, Valve, Valve Guides.*
Titanium	*With Iron, Shafts, Cams, Rods, Springs, Valve, Valve Guides, Without iron turbo charger*
Antimony	*With high lead: main bearing,*
Zinc	*With high copper: severe bushing wear, With high lead: serve main bearing wear, possible gear set wear, Alone: sealing compound*
Aluminum	*Pistons, block corrosion sealing compound*
Silver	*EMD bearing*

1.1 Testing Equipments

The testing equipment used is Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES), is one of the most common techniques for elemental analysis. Its high specificity, multi-element capability and good detection limits result in the use of the technique in a large variety of applications. All kinds of dissolved samples can be analyzed, varying from solutions containing high salt concentrations to diluted acids. The schematic of an ICP-AES is shown in Fig.1. In the ICP-AES a plasma source is used dissociate the sample into its constituent atoms or ions, exciting them to a higher energy level. They return to their ground state by emitting photons of a characteristic wavelength depending on the element present. This light is recorded by an optical spectrometer which separates this light in the characteristic wavelengths. When calibrated against standards the technique provides a quantitative analysis of the original sample.

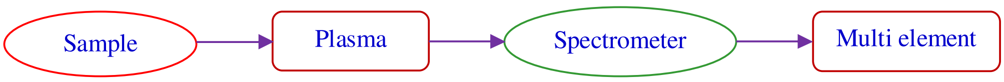

Fig 1 Schematic of an ICP-AES

1.2 Sample preparation for lubricating oil

The ASTM method 5185 is an ICP-AES method for the determination of additive elements, wear metals and contaminants in used oils as well as the determination of selected elements in base oils. All samples, standards, and controls are diluted with kerosene/xylene (80/20) prior to measurement. 9.9 ml kerosene/xylene (80/20) is added to 1 gram sample, standard, and control and then vortex mixed. Co, added to the kerosene/xylene solvent, is used as an internal standard to correct for non-spectral interferences affecting all the analysts. Approximately 100 ppm Co is used to provide a minimum of 100,000 counts.

II. Experimental setup

A Vertical, water cooled, single cylinder and four stroke engine is used for the study with the details of engine specification given in Table 2. The engine is coupled to an eddy current dynamometer for loading (Fig 2). The property of mahua oil is given in Table 3. The wear measurement is done using diesel and the B20 biodiesel blend. For measuring the wear, the engine subjected to test for 75 hours using diesel as fuel at varying load at constant speed. A lubricating oil sample is taken for every 25 hours. Similar process is carried out for the B20 biodiesel. Wear analysis is done for the lubricating oil sample using ICP–AES. The measured wear value of biodiesel is compared with diesel.

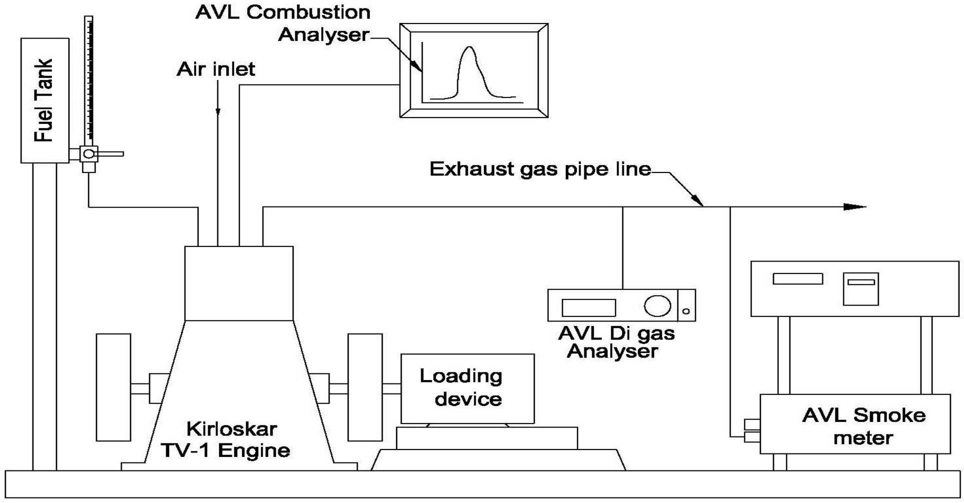

Fig 2. Experiential Setup

Table 2. Specifications of the Test Engine

Type	*Vertical inline diesel engine ,4 stroke, water cooled*
No of cylinder	*Single cylinder*
Bore × Stroke	*87.5 mm × 110 mm*
Compression ratio	*17.5:1*
Brake power	*5.2 Kw*
Speed	*1500 rpm*
Dynamometer	*Eddy current*
Ignition timing	*23° bTDC (rated)*

Table 3. Properties of biodiesel (Mahua)

Test Property	***Biodiesel (Mahuwa) B20***
Density at 15°C kg/m³	*879.6*
Kinematic Viscosity at 40°C	*4.53*
Flash Point (PMCC) °C, (min)	*126*
Gross Colorific value k.cal/kg	*10540*
Pour point °C	*4*
Cetane Number (min)	*56*

III. Results and discussion

The lubricating oil is analyzed, the amount of wear is influenced by the amount of metallic debris such as cobalt (Co), copper (Cu), iron (Fe), magnesium (Mg), lead (Pb) and Zinc (Zn), present in lube oil samples.

3.1 Cobalt

Fig 3 shows the concentration of cobalt in biodiesel and diesel. The figure clearly illustrates that, the concentration of cobalt is lower for biodiesel blends compared with diesel with respect to hours of lube oil usage. The source of cobalt is from the bearings.

3.2 Copper

Fig 4 shows the concentration of copper in biodiesel and diesel fuelled engine with respect to hours of lube oil usage. The figure clearly illustrates that concentration of copper is lower in biodiesel fuelled engine when compared with the diesel, which clearly indicates lesser wear in biodiesel fuelled system when compared with diesel engine.

3.3 Iron

The sources of iron are from wear of the cylinder liner, piston, rings, valves, valve guides, gears, shafts, bearing, rust, and crankshaft. Fig 5 shows the concentration of iron in biodiesel and diesel with respect to hours of lube oil usage. The concentration of iron is lesser in biodiesel when compared with the diesel. So the wear is lesser in biodiesel fuelled system when compared with diesel engine.

3.4 *Magnesium*

Fig 6 shows the variation of concentration of magnesium in diesel and biodiesel with respect to hours of lube oil usage. It is evident from the figure that concentration of magnesium is lower in biodiesel fuelled systems when compared with the diesel which indicates lesser wear in biodiesel fuelled system from the sources of magnesium like wear of bearings and gear box assembling.

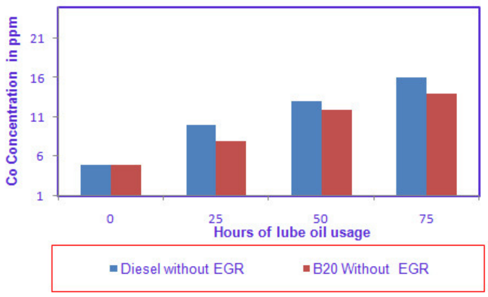

Fig 3. Cobalt Concentration Vs Hours of lube oil

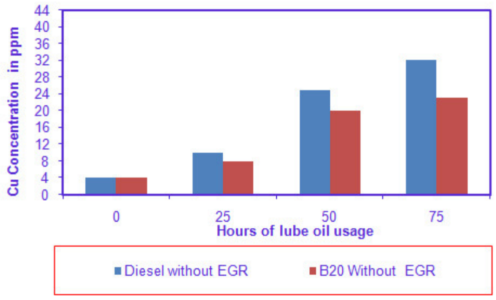

Fig 4. Copper Concentration Vs Hours of lube oil

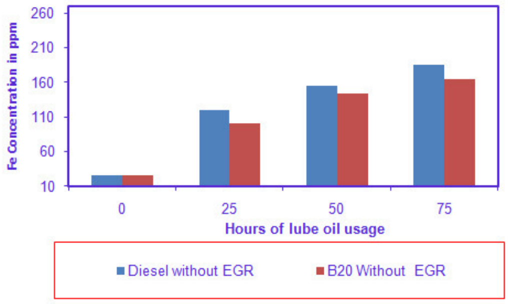

Fig 5. Iron Concentration Vs Hours of lube oil

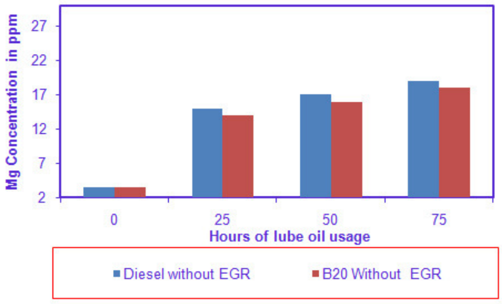

Fig 6. Magnesium Concentration Vs Hours of lube oil

3.5 Lead

The variation of concentration of lead in diesel and biodiesel with respect to hours of lube oil usage is shown in Fig 7. The concentration of lead is lower in biodiesel fuelled systems compared to diesel. This clearly indicates that wear from sources of lead like bearings, Sealing Compounds, Leaded Gasoline is lesser in biodiesel fuelled system when compared with diesel engine.

3.6 Zinc

Fig 8 shows the variation of concentration of zinc in diesel and biodiesel with respect to hours of lube oil usage. The figure clearly illustrates that concentration of zinc is lower in biodiesel fuelled systems when compared with the diesel. This clearly indicates that lesser wear in biodiesel fuelled system when compared with diesel engine. The sources of zinc are from wear of bearings, brass components, and neoprene seals.

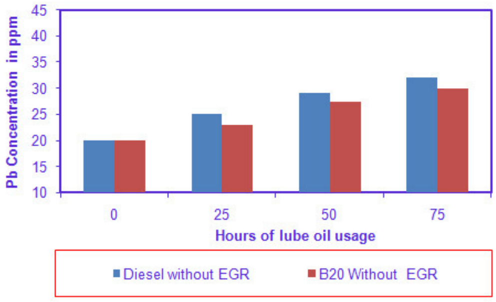

Fig 7. Lead Concentration Vs Hours of lube oil

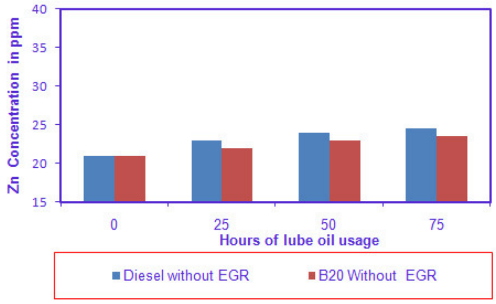

Fig 8. Zinc Concentration Vs Hours of lube oil

IV. CONCLUSION

Oil analysis by Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) studies proved to be a powerful tool to estimate not only the condition of the engines, but of other moving parts as well. The wear test conducted using diesel and bio diesel indicates that wear of engine moving parts is lesser for bio diesel. The amount wear is influenced by the amount of metallic debris such as Co, Cu, Fe, Mg, Pb, and Zn, present in lube oil samples. Each element, which is present in oil in the form of wear debris, originated from a different moving part. B20 blend is having better wear characteristics of moving parts. Based on the investigation done, it is concluded that the bio fuel is superior in wear performance to diesel. Lesser emission makes the bio diesel, eco-friendly.

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