Experimental Investigation Of Tribological Properties Of Lubricating Oil For Biodiesel Fuelled Single Cylinder Diesel Engine.

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Abstract

Bio diesel is an alternate fuel that can be produced from renewable feed stock such as edible and non-edible, vegetable oils, wasted frying oils and animal fats. It is oxygenated Sulphur free, non- toxic, bio –degradable and renewable fuel. Various properties of bio-diesel and diesel fuel are found to be comparable according to the past research. The increased use of biodiesel fuels has raised concerns over the fuel's impact on engine performance and hardware (engine) compatibility. Since the fuel interacts directly with the lubricating oil through fuel dilution and may impact its lubricating properties.

The purpose of this study is to check the inherent effect of bio-diesel usage on lubricity properties of the lubricating oil. In this test a comparative study of various properties and effect of mineral diesel and biodiesel (transesterified jatropha oil) on the lubricating oil will be made. The wear of the engine components will be studied to see and compare the effects of two fuels. Tests will be conducted for the measurement of kinematic viscosity, flash point, fire point. Based on the results obtained a conclusion can be drawn as to which of the two will be having better effect on lubrication oil performance.

Keywords : lubricating oil, bio-diesel, lubricity, properties.

Introduction

Systematic efforts have been made to utilize vegetable oils as fuels in the engines. Vegetable oils have approximately 90 percent heat content of petroleum diesel and their combustion related properties are somewhat similar to petroleum diesel. However several properties of oil such as high viscosity, high molecular weight, and low volatility, etc. cause poor fuel atomization leading to incomplete combustion resulting in severe engine deposits, injector coking, piston ring sticking and lubricating oil degradation, etc. Most of these problems are a consequence of high viscosity, low volatility and polyunsaturated character of vegetable oils. Thus it has to be converted to more engine friendly fuel called Biodiesel (vegetable oil ester). Among the various fuel modification techniques available like pyrolysis, blending, micro-emulsion and transesterification, transesterification is the most effective and widely used technique for formulating properties of vegetable oil.

Biodiesel is produced via the transesterification of vegetable oils and animal fats with an alcohol in the presence of a catalyst. In the transesterification process triacyl glycerides, of which most fats and oils are composed, are reacted with either ethanol or methanol mono alkyl esters (biodiesel) and glycerol, a by product. The resulting fuel is either termed a methyl ester or ethyl ester, depending on the alcohol used in the reaction, methanol or ethanol, respectively. The most common catalysts used in the transesterification reaction are sodium and potassium hydroxide. Following the reaction, residual glycerin, catalyst, alcohols, and free fatty acids must be removed from the finished fuel.

It directly mixes with the engine lubricant through fuel dilution, and indirectly through the formation of combustion products (soot) and gasses which may become entrained or dissolved in the oil. Fuel dilution occurs when liquid fuel impinges on the cylinder walls, mixes with the lubricant, and slowly accumulates in the oil sump. The rate of fuel dilution in the lubricant is determined by a number of factors including fuel properties, injection parameters, and combustion strategies. Generally accepted maximum fuel dilution limits are 5% wt. in heavy-duty diesel engines. The effect of fuel on lubricating oil degradation is very important as it affects the fuel economy, emissions as well as engine durability. In an engine, the cost of the lubricating oil alone is approximately 6-7% of overall operating costs.

Accumulation of insoluble deposits on the engine parts cause poor lubrication and increased engine wear. When diesel engines are operated at high temperature, the viscosity of the engine oil can increase due to oil oxidation and nitration, evaporation of the lighter fractions of the base-stock, and accumulation of soot in the lubricating oil. Detergent additives provide alkalinity reserve to neutralize acidic by-products of combustion. They react with oxidation enhancing products to reduce the formation of insoluble and provide some measure of corrosion protection. Total Base Number (TBN) provides a measure of the remaining alkalinity of protective elements i.e. additives specially for neutralizing acid. Higher the base number greater is the neutralizing capacity of the additive.

Agarwal performed 512 hours endurance test on two single cylinder constant speed diesel engines for 20% linseed oil biodiesel and diesel respectively as fuel and conducted various tribological studies on the lubricating oil samples drawn at regular intervals from the both the engines. Lower wear in case of biodiesel fuel and better condition of lubricating oil hence longer life of lubricating oil for biodiesel operated engine was reported. A lot of literature is available on the performance and emission characteristics of biodiesel fuelled engines but only a few studies regarding lubricating oil tribology were found in the literature. The behaviour of biodiesel on wear of engine components and lubricating oil contamination is also to be analyzed critically before adopting it as fuel for diesel engines on a large scale.

Experimental Description

Transesterified Jatropha biodiesel was used for required blend preparation. The blends were referred ass Bxx where xx refers the percentage of ester in that blend.

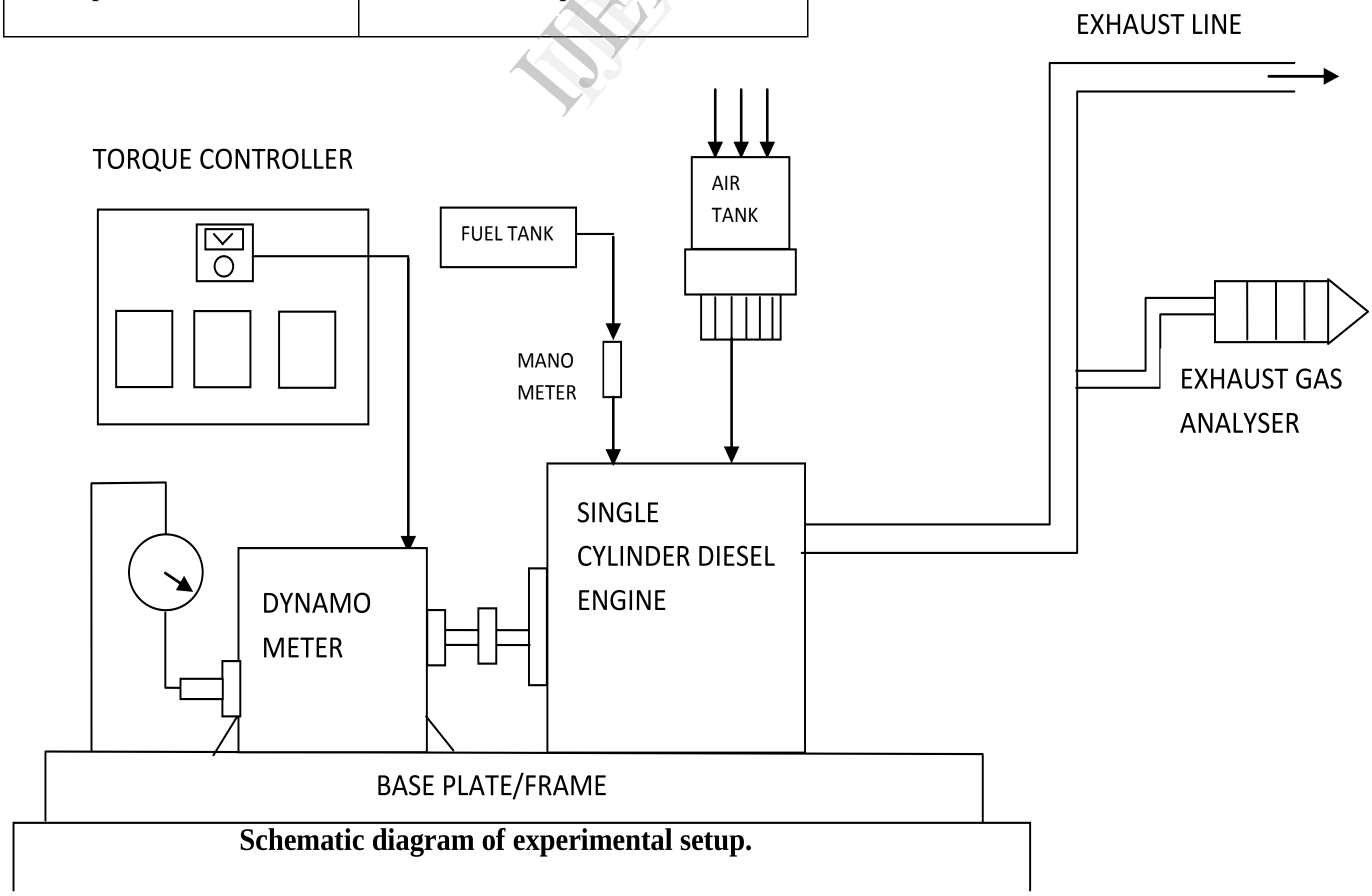
Table 1 : Properties of Fuels

Property	ASTM Method	Jatopha	Petroleum diesel
Specific gravity @30*C		0.917	0.839
Viscosity(cst) @ 40*C	D445	5.51	3.18
Cetane no.	D613	50	51

pour point (*C)	D2500	8	-7
Flash/Fire point (*C)	D93	240/110	68/103
Calorific value (MJ/Kg)	D240	39.44	44.8

Table 2 : Specification of the engine.

Manufacturer	Kirloskar ltd, India
Model	AV1
Type of Engine	4-stroke, natural aspirated, water cooled diesel engine
Number of cylinders	One
Combustion system	Direct injection
Bore/stroke	80/110 mm
Displacement Volume	662.00 cc
Rated power	3.7 kw at 1500 rpm



Schematic diagram of experimental setup.

The experimental test was conducted for period of 30 hours for each biodiesel blend and diesel. In the first phase engine was run with diesel (B00) and in the second phase, the engine was run with B20 blend. Sample was taken after 15 hours. The lubricating oil samples were collected from both the engines and various properties were tested. A number of factors affect lubricating oil performance : oil thickening/thinning, depletion of wear protection additives, and deposit control additives, sludge formation, etc. The following tests were conducted on the lubricating oil samples to asses the comparative condition of engine oil drawn from petroleum diesel and biodiesel fuelled engines : Kinematic viscosity, Flash point, Fire point.

Results and discussion

The fuel handling system was found to operate normally on both the fuel .i.e. petroleum diesel and B20 blend. The measured results of the tests conducted on lubricating oil samples are discussed below.

Kinematic Viscosity

Change in viscosity is undesirable because it affects the lubricating efficiency of the lubricant, The viscosity of lubricating oil may increase or decrease with usage depending on the factors affecting the viscosity. There are two main factors which are responsible for the viscosity change in opposite direction. Formation of resinous products because of oil oxidation, depletion of anti-wear additives, evaporation of lighter fractions and contamination by insoluble tend to increase the viscosity while fuel dilution and moisture addition tend to reduce viscosity. Inadequate lubricating oil viscosity affects the lubricating oil film thickness and load bearing capacity leading to excessive wear of mating parts and bearings. Viscosity modifiers are added to the lubricant formulations to make them effective at high temperatures. The viscosity of lubricating oil samples collected at regular interval from the two experiments were measured at 40*C and 80*C as shown in figures1 - 2.

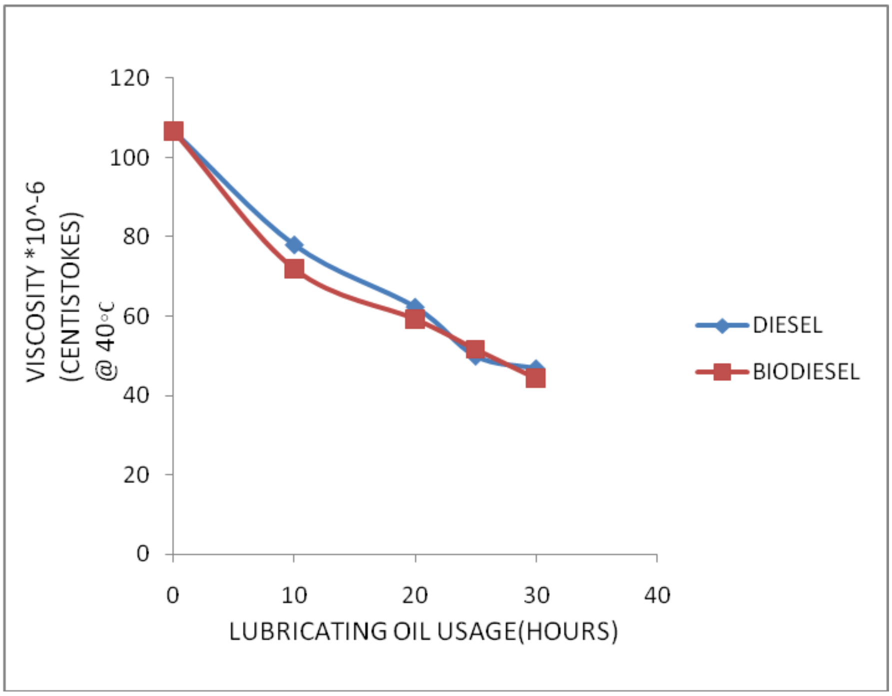


Figure 1: Variation in lubricating oil Kinematic viscosity with usage.

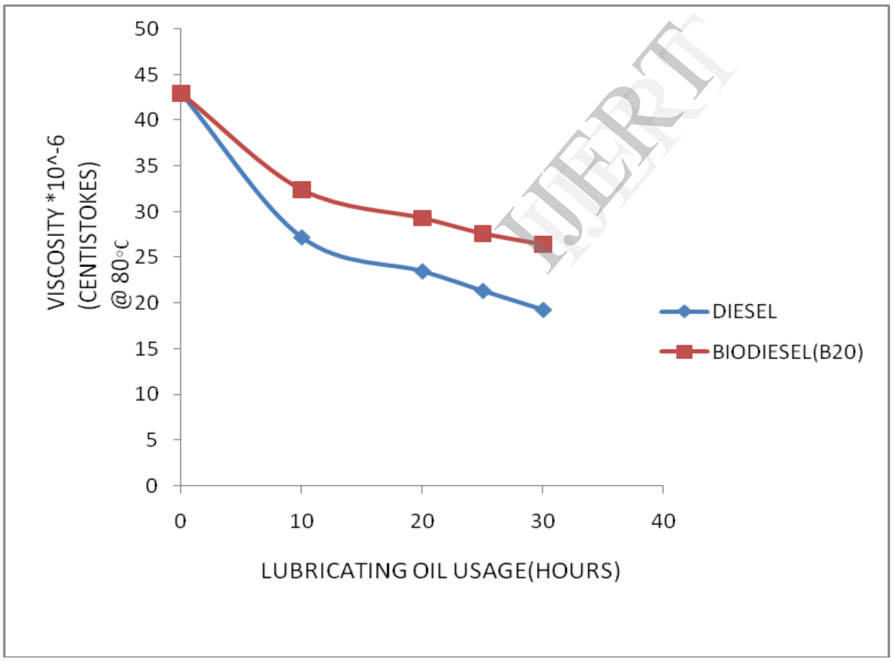


Figure 2 : Variation in lubricating oil Kinematic viscosity with usage.

Viscosity of lubricating oil increases with its usage for both sets of experiment with petroleum diesel and biodiesel. This may be possibly due to dominance of factors responsible for viscosity increase. There is however no significant difference in the viscosity of lubricating oil samples from both the engines. The viscosity decrease in case of biodiesel fuelled engine was found to be almost similar, possibly due to lower contamination/formation of resinous products and insoluble.

Viscosity at 40*C of biodiesel fuelled lubricating oil was found to be slightly lower but viscosity at 100*C was higher than diesel fuelled engine. The important observation from the figures is lower change in viscosity with temperature in case of biodiesel fuelled engine. This is due to lower depletion of viscosity index improver additives in case of biodiesel fuelled engine.

Flash Point

The flash point is that minimum temperature at which there is a sufficient concentration of evaporated fuel in the air for combustion to propagate after an ignition source has been introduced. The flash point temperature of the lubricating oil samples collected from both sets of experiment were measured with Pensky martin Test rig.
Results are shown in figure 3.

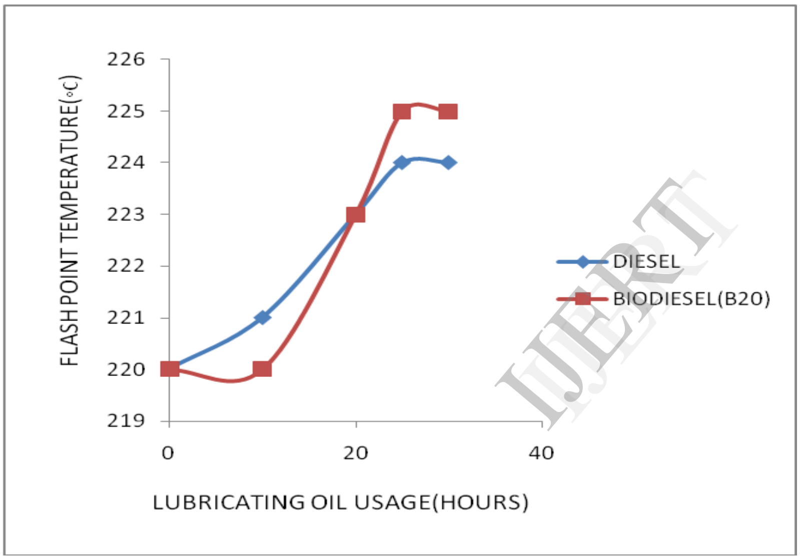


Figure 3 : Variation in lubricating oil flash point with usage.

Flash point was increased slightly with usage of lubricating oil. No significant difference was observed between lubricating oil samples drawn from petroleum diesel and biodiesel fuelled engine.

Fire Point

The fire point, a higher temperature than flash point is defined as the temperature at which the vapour continues to burn after being ignited. The fire point temperature of the lubricating oil samples collected from both sets of experiment were measured with Pensky martin Test rig.
Results are shown in figure 4.

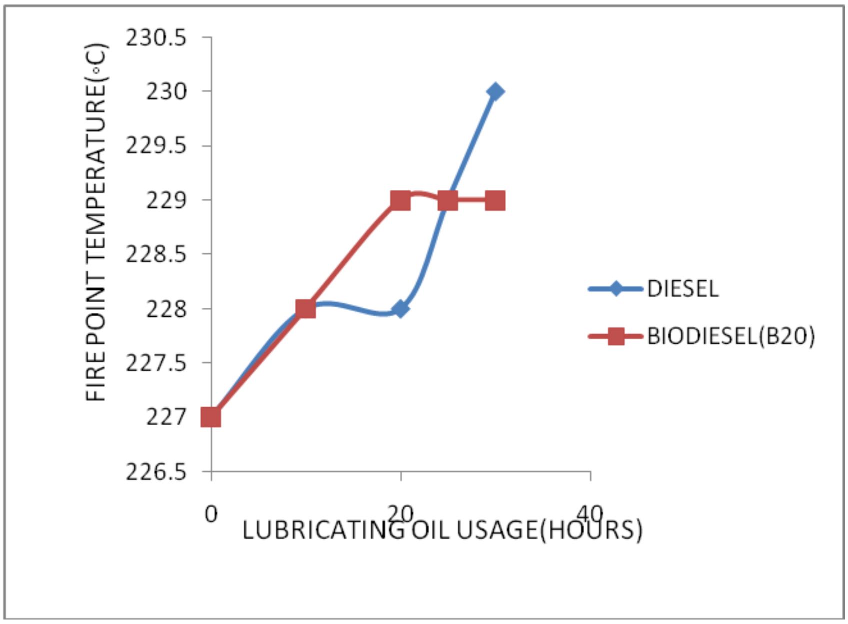


Figure 4 : Variation in lubricating oil fire point with usage.

Conclusion

Based on the experimental test and tribological investigations on the lubricating oil, it can be concluded that jatropha biodiesel can be used in combination of petroleum diesel for existing diesel engines without any significant modification in the engine.

Viscosity and flash/fire point of lubricating oil have found to have increased with usage. Lower increase is observed with biodiesel fuelled engine. Viscosity (40*C) of used lubricating oil was higher in case of diesel fuelled engine but at 100*C, it was higher for B20 fuelled engine. Lower viscosity reduction is observed with increase in temperature in case of B20 fuelled engine.

Thus it can be concluded from the results obtained from the experiments that Biodiesel can be used in combination with petroleum diesel to run diesel engine without any modifications.

Future Scope

The other Tribological properties which supports the biodiesel oil usage in diesel engine are Ash content, moisture content, density, Total base Number (TBN), Pentane and Benzene insoluble, Atomic Absorption Spectroscopy and Ferrography.

Ash content mainly indicates metallic wear debris in the lubricating oil, soot, fuel and non metallic parts of decomposition. Moisture rusts and corrodes metallic surfaces increase wear. The presence of water traces in lubricating oil indicates excessive fuel dilution, coolant leakage and short trip driving conditions. After a prolonged use. Oil gets deteriorated. It may have

- Oil soluble resinous material as a result of degradation of oil, additives or both.

- Fuel carbon or highly carbonized substances i.e. combustion related debris.

- Corrosion and wear particles originated from the engine.

- Dust particles entering from environment.

To quantify these insoluble pentane and Benzene insoluble is used.

In an engine, wear debris from various components are picked up by lubricating oil. Various metals such as Fe, Cu, Al, Ni, Zn, Mg and Pb can be analysed using Spectroscopy and Ferrography.

TBN is a measure of alkalinity, which is an indication of lubricant's ability to counter the corrosive effects due to oxidation. Higher value gives more stability to lubricating oil. Positive value of TBN indicates absence of free strong acids.

All the properties when measured are expected to show lower values for biodiesel blend except for TBN which is expected to show higher value. This supports the conclusion that biodiesel can be used in diesel engine.

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