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Experimental Investigation on DI Diesel Engine Using Vegetable Oils as a Bio Additive

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ABSTRACT

Due to the fast depletion of fossil fuels and worsening environmental pollution related to fossil fuel usage in recent years, vegetable oils have come across as a good potential feedstock for producing diesel substitutes. Since vegetable oils have cetane numbers close to that of diesel fuel, they can be used in existing compression ignition engines with little or no modifications. In this investigation the performance, emission and combustion characteristics of single cylinder, four stroke, water cooled Diesel engine using bio additive blend with Diesel of 1.0 ml, 1.5ml, 2.0 ml, 2.5ml and 3.0 ml and standard Diesel fuel separately. It was found that there was a reduction in NOx emission for Bio additive (Bio Mileager- (BM)) and its Diesel blends along with a marginal decrease in HC and CO emissions. Brake thermal efficiency was higher for bio additive blends.

Keywords:—*Diesel Engine, Bio Additive, Vegetable oil, Emission Control, Performance Improvement.*

I. INTRODUCTION

Vegetable oil offers many benefits, including sustainability, reduction of green house gas emissions, regional development, and improvement in agriculture. The chemical composition of vegetable oil helps in reducing the emission of unwanted components when they are burned. Several techniques like retarded fuel injection timing, recycled exhaust gas and after treatment devices are employed for reducing nitric oxide emissions from an engine. It is observed that these techniques while reducing nitric oxide from the exhaust of an unmodified engine suffers from one or more disadvantages because of the inherent trade-off with respect to particulate matter or cost. Any post treatment strategy requires certain additional arrangements for their implementation. From effective and simplicity stand point, the approaches on fuel modifications to reduce nitric oxide emissions remain attractive. The principle requirement of fuels for high s peed Dies el engine is good ignition quality. Poor ignition quality fuel can lead to extended delay and the results in Diesel knock. To modify the fuel quality, additives can be added in small quantity either to enhance engine performance or to reduce the emission.

II. Literature Review

Many researcher have investigated in the field for pas t years, some of the relevant study are as follows. Hess et al. [6], observed a 4.5% reduction in NO_x emissions with 20% blend of reformulated biodiesel compared to commercial biodiesel blend. The reformulated biodiesel, namely, soy methyl polyol was obtained by treating soypolyol (produced by oxidizing soybean oil resulting in an addition of hydroxyl group to double bond chain in fatty acids) with methanol.

Venkates wara et al. [7] carried out an experimental study to examine properties, performance and emissions of different blends (B10, B20, and B40) of Methyl ester of Pongamia (PME), Jatropha (JME) and Neem (NME) in comparison to pure Dies el. Results indicated that pure Diesel blends showed reasonable efficiencies, lower smoke, CO and HC. Pereira et al. [9] investigated the use of blends of 20%, 50%, 75% and 100% of soybean biodiesel in Diesel oil, testing as ingle-cylinder stationary Diesel engine. The results showed increased fuel consumption, decreased exhaust gas temperature, reduced exhaust concentrations of CO, HC, NO_x and sulphur dioxide (SO_2), and increased carbon dioxide (CO_2) emission when the biodiesel blends were used in place of Diesel oil, either to enhance engine performance or to reduce the emission.

III. Experimental Setup

The performance tests were carried on a single cylinder, four strokes and water cooled, Kirloskar TV 1 Diesel engine. The engine was directly coupled to an eddy current dynamometer. The dynamometer was interfaced to a control panel. The engine was run at a constant speed of 1500 rpm. The emissions like HC, CO, NO_x, were measured in the AVL DI gas analyzer and smoke density was measured by AVL smoke meter. The exhaust gas temperature was measured using thermo couple. Using AVL combustion analyzer the combustion parameter such as cylinder pressure, heat release and cycle to cycle variation were analyzed with Diesel as a prime component and bio additive (Bio Mileager) is mixed with Dies el in the range of 1.0 ml, 1.5ml, 2.0 ml, 2.5 ml and 3.0 ml per liter of Diesel. The engine specifications are shown in table 1.

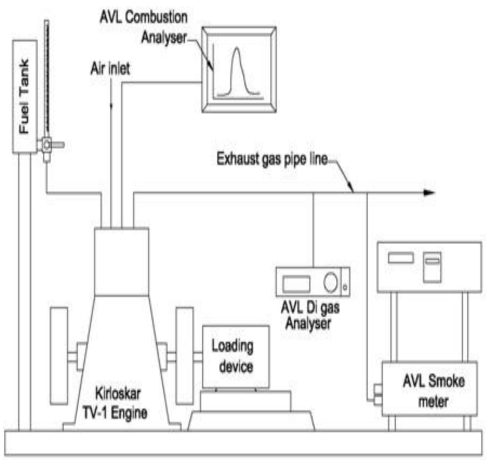

Figure 1: Experimental Setup

Table 1: Engine Specifications

Type	Vertical inline Diesel engine, Four 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 System	Compression Ignition
Ignition timing	23° bTDC (rated)
Injection pressure	220 kgf/cm^2

IV. Results and Discussion

4.1. Performance Characteristics

The results for the variation in the specific fuel consumption with increasing brake power on the engine for the various blends of bio additive and Diesel is presented in Figure 2 from this figure it is seen that the specific fuel consumption increases with increase in bio additive blend. This is mainly due to the combined effects lower value of the relative fuel density and viscosity, and higher heating value of the blends . The specific fuel consumption for Dies el is 0.26777 kg/kW -hr at maximum load while the corresponding figures for various blends (1.0 ml, 1.5ml, 2.0 ml, 2.5ml, and 3.0 ml) of bio additive are 0.26321, 0.25621, 0.25757, 0.2562, and 0.261 kg/kW -hr respectively.

Figure 3 shows the brake thermal efficiency againt brake power, it is seen that when load increases brake thermal efficiency also increases. The higher efficiency is obtained with 1.5 ml at maximum load with 28.88 %. This is due to the better spray characteristics of bio Mileager blends in the combustion chamber, which leads to effective utilization of air resulting in complete combustion of fuel.

4.2. Emission Characteristics

Figure 4 shows the variation of smoke density with brake power. It can be observed that smoke density increases with increase in brake power. Maximum emission occurs at maximum load. For 3.0 ml blend of bio additive at maximum load is 57.5 HSU. For Dies el is 78.1 HSU at the maximum brake power of the engine. It can be seen that 3.0 ml Bio Mileager blend effectively reduces the smoke density. The oxygen enrichment provided by the bio additive leads to smoke reduction. It is also noted that at 3KW brake power there was a peaking of smoke density on the trends; this can be attributed to the stoichiometric ratio of air fuel mixture hence more smoke density.

Figure 5 shows the comparison of the NO_x concentration being emitted from the engine exhaust using neat Diesel and Bio Mileager blends. The NO_x concentration increases when the load increases. It is seen that for all blends the NO_x emission was lower than Diesel. It is due to conversion of elemental nitrogen to NO under the condition of high gas temperature which can be easily combined with oxygen to create nitrogen oxides (NO_x) at higher blends. It is observed that NO_x emission for 1.0 ml is about 416 ppm and Dies el 715 ppm at maximum brake power.

Figure 6 shows the comparison of HC using Diesel and bio mileager blends. All Bio mileager blends reduces the HC emission when compared to Dies el. The bio additives reduce the surface tens ion and make the cohesive bonding between the molecules stronger. This leads to better combustion when compared to Diesel. The 1.0 ml of bio mil eager blend reduces HC by 20 ppm.

Figure 7 shows the comparison of CO using Diesel and bio mileager blends. It is seen that when the load is increased CO increases. CO decreases for all bio mileager blends when compared to Diesel. The CO emission for 1.0 ml, bio mileager blend is the lowest when compared with Dies el and other blends. This behavior can be explained by the fact that at lower output, the engine gets the lean mixture, and at a higher output, richer mixture is supplied to the engine that results in incomplete combustion and, therefore, a higher percent of CO.

Figure 8 shows the comparison of engine exhaust gas temperature using Diesel and bio-mileager blends. It is clear that when load increases the exhaust gas temperature is also increased. It is found that the exhaust gas temperature decreases in all Bio Mileager blends when compared with Diesel.

4.3. Combustion Characteristics

The comparison of cylinder pressure with crank angle is as shown in figure 9. The Bio Mileager blends have highest pressure compared to Diesel. As the Dies el quantity in the blends increase the amount of fuel taking part in the uncontrolled combustion period of the mixture reduces, which result in a higher pressure rise. The cylinder pressure depends upon the burned fuel fraction during the premixed burning phase. For 3.0 ml bio additive blend it shows a maximum value of 70.647 bar pressure.

Figure 10 shows the heat release rate with crank angle. It is inferred that heat release rate increases with the load,

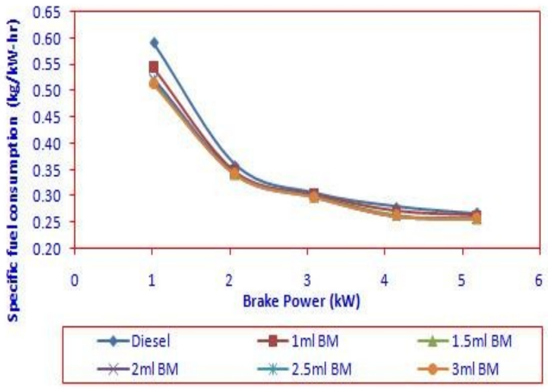

Figure 2: Specific Fuel Consumption Vs Brake Power

3.0 ml bio additive blend has a higher heat release rate when compared with other blends. At full load condition the rate of heat release for the Bio Mileager blend shows short delay period. However the periods of premixed combustion of the all bio additives shows no difference.

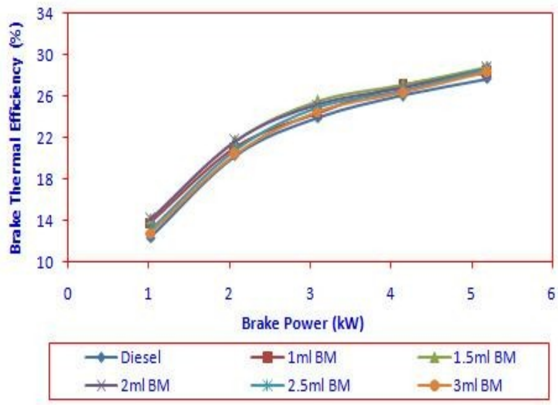

Figure 3: Brake thermal Efficiency Vs brake power

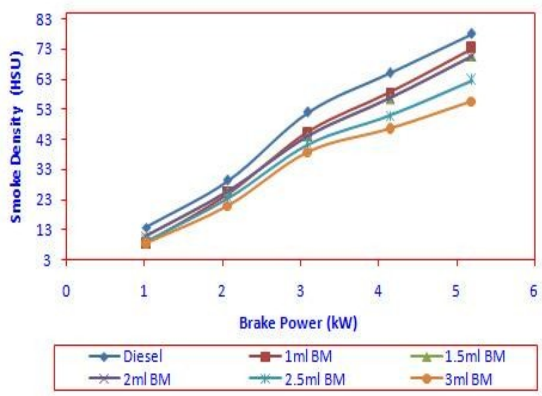

Figure 4: Smoke Density Vs Brake Power

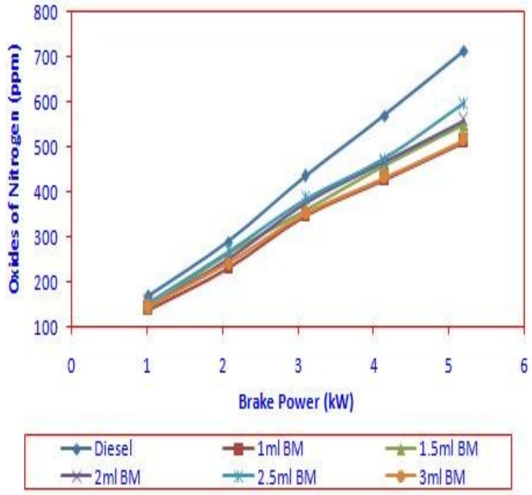

Figure 5: Oxides of Nitrogen Vs Brake Power

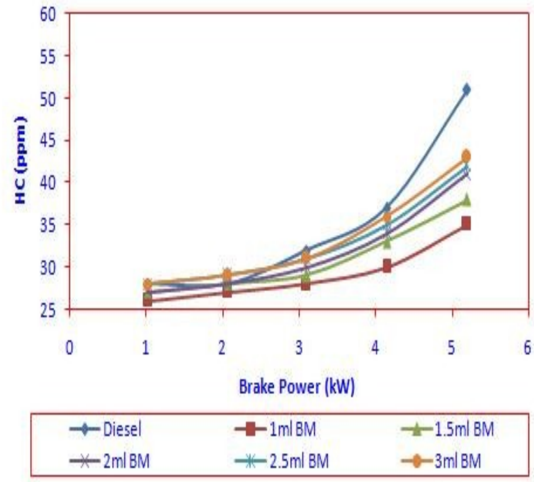

Figure 6: HC Vs Brake Power

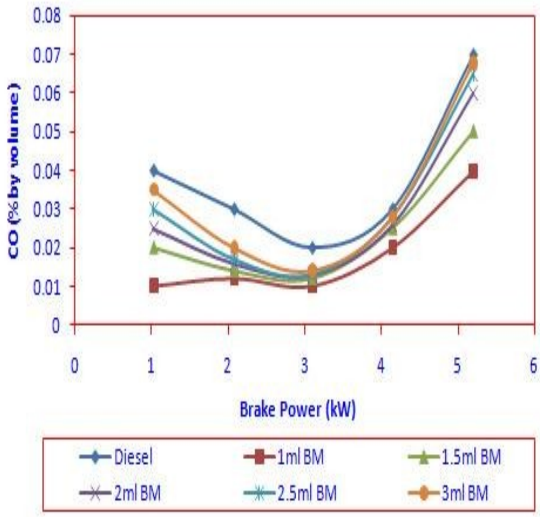

Figure 7: CO Vs Brake Power

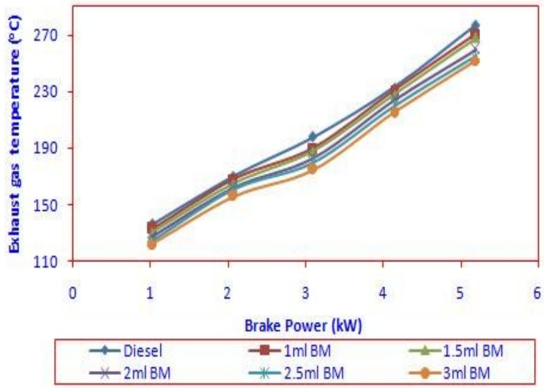

Figure 8: Exhaust gas temperature Vs Brake Power

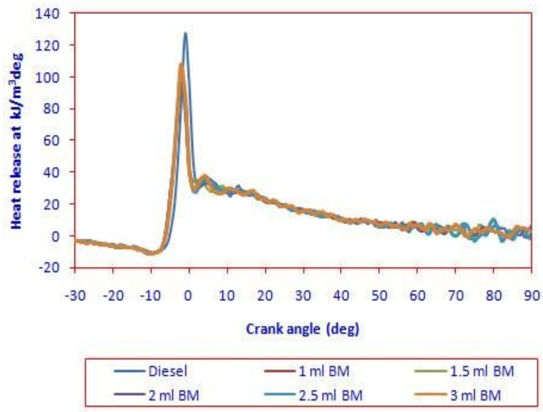

Figure 9: Heat Release Rate Vs Crank Angle

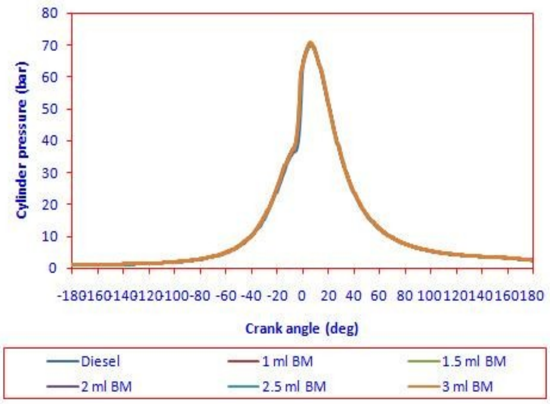

Figure 10: Cylinder pressure Vs Crank Angle

V. INFERENCE

From this experimental investigation, we inferred that the specific fuel consumption decreases with increase in bio additive blends, minimum specific fuel consumption is obtained in 1.5 ml bio additive blend. (0.25621). Brake thermal efficiency closer for all bio additive blends with Dies el. Highest efficiency is obtained with 1.5 ml. (28.72%). The exhaust gas temperature increased in bio additive blend compared with Diesel. (100%). The 3.0 ml bio additive added to Dies el fuel effectively reduces the smoke density. (23.6 HSU). NOx gets reduced for bio additive all blends, when compared with Dies el. (1.0 ml, 203ppm). All Bio additive blends reduce the HC emission when compared to Diesel. Blending 1.0 ml of bio additive with Diesel reduces 16 ppm. CO is decreases for all bio additives concentration with compared Diesel. 1.0 ml, bio additive blend is minimum CO when compared with Dies el other blends. It is inferred that heat release rate increases with the load, 3.0 ml bio additive blend has higher heat release rate when compared with other blends. Maximum cylinder pressure for bio additive all blends is marginally increased when compared with Diesel and other blends (3.0 ml).

VI. CONCLUSIONS

There have been extensive search for biodiesel feeds tock all over the World. In this paper the suitability of bio additive blend with diesel has been analyzed and it has been observed that there was a reduction in NO_x emission for Bio additive (Bio Mileager- (BM)) and its Diesel blends along with a marginal decrease in HC and CO emissions. And also Brake thermal efficiency was higher for bio additive blends.

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