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The Effects in Performance and Emissions of DI Diesel Engine Using Biodiesel (PPME)-Blends as Fuel

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Abstract – **In the present work biodiesel derived from non edible oil with diesel was used to study the performance of DI Diesel engine at 200 bar injection pressure and 1500rpm. Experiments were carried out with pogamia pinnata oil methyl ester (POME) and diesel blends in different proportions to reduce tail pipe emissions. Comparative study is conducted using diesel, bio-diesel and with various blends of biodiesel. POME is used (diesel, 20, 40, 60, 80, 100) with various percentages by volume for all loads (0, 3, 6, 9 and 12kg load). The performance of the engine is compared with neat diesel in respect of brake thermal efficiency, BSFC and exhaust emissions.**

Keywords: **Pogamia methyl ester, POME, Biodiesel, Performance, Exhaust emissions.**

I. Introduction

The petroleum fuel reserves are fast depleting due to excessive usage. Besides combating the limited availability of crude oil, researchers are also dealing with other associated serious problems with petroleum fuel such as increase in pollutant emissions. [1]. In recent times, biodiesel has received significant attention both as a possible renewable alternative fuel and as an also an additive to the existing petroleum-based fuels [2]. Vegetable oils have good ignition quality because they have very long molecular chains and are not branched. Poor volatility could be responsible for their low cetane numbers. The heating value of vegetable oils is lower due to higher oxygen content, but viscosity and carbon residue are higher than diesel due to their larger chemical structure and molecular mass [3]. The flash point of these oils is much higher than that of diesel, indicating much safer to store than diesel oil. Vegetable oils are about 10% denser than diesel and cold point is higher, indicating problems of thickening or even freezing at low ambient temperatures. It is evident that vegetable oils are much less volatile than diesel, makes slow in evaporation when injected into the engine [4]. Vegetable oils have cetane numbers of about 35 to 50 depending on their composition, which is very close to diesel value [5].

Transesterification is one of the methods in which viscosity could be reduced and the fuel could be adopted for use in diesel engine. The process involves reacting vegetable oils with alcohols such as methanol or ethanol in the presence of a catalyst (usually sodium hydroxide) at about 65°C to give the ester and the by-product glycerin. This esterified vegetable oil is popularly known as biodiesel which is commercially [6]. Development of treatment devices has also mitigated the emission problem to a large extent while allowing the combustion process to be optimized for maximum fuel efficiency [7]. Experimental investigation on replacement of diesel with Pongamia Pinnata Methyl Ester (PPME) and came to a conclusion that diesel with PPME (40%) could possibly replace diesel for diesel engine applications for getting better performance, less emission, energy economy and environmental protection [8]. Preheated Palm Oil Methyl Esters (POME) in the diesel engine above room temperature has in turn improved the brake power output and engine performance in terms of emissions [9]. Experiments with biodiesel blends in a single cylinder, four stroke diesel engines and found out that specific fuel consumption values of the methyl esters were less than that of the raw vegetable oils and high specific fuel consumption in vegetable oils is due to lower energy content [10].

The recent investigations on diesel engine with biodiesel-diesel and canola oil-diesel blends and found out that pure and used canola biodiesel-diesel blends showed similar performance, emission and fuel properties. The CO and HC emissions are less than neat diesel in biodiesel-diesel blends [11]. The experimental analysis with biofuel as alternative fuel for compression ignition engines and found out that adding small amount of diesel with biofuel shows performance similar to that of neat biofuel and there is also reduction in NOx emission [12].

II. Experimentation

The experimental setup shown in Fig. 1 consists of single cylinder, four stroke, diesel engine connected to eddy current type dynamometer for loading. The setup has panel box consisting of air box, fuel tank, fuel measuring unit and engine indicator. The performance analysis was carried out using esterified pongamia oil–diesel blend fuel at a rated speed of 1500 rpm. For every test specific fuel consumption, exhaust gas temperature and emissions such as carbon monoxide (CO), hydrocarbon (HC), nitrogen oxides (NOx), carbon dioxide (CO_2) are measured. From the measured values brake thermal efficiency and specific fuel consumption at all loads are calculated from the measured data. The obtained and calculated data are shown in the form of graphs for comparison with diesel readings.

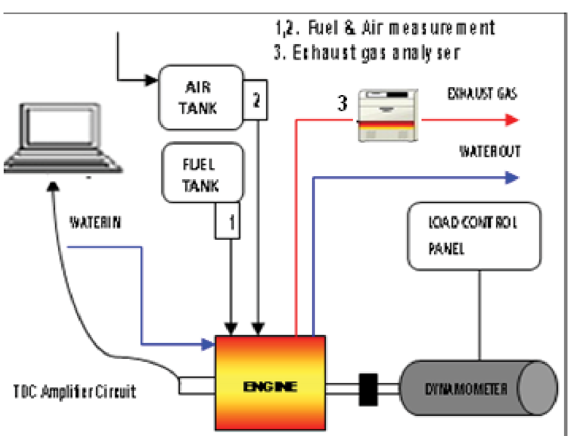

Fig. 1 Experimental Setup

III. Results and Discussion

The affect of thermal performance parameters and emissions for full load range at 200 bar are discussed below:

A. Brake Thermal Efficiency (B_{the})

From the Fig. 2 it is observed that B_{the} increases significantly with increase in load for all the blend fuels. Further B_{the} decreases with increase in blend portion due to lower C V of blend fuel. At full load B_{the} of pongamia biodiesel is lower by 7% as compared to diesel. The B_{the} values at full load, decreases gradually with increase in biodiesel quantity. At full load the B_{the} for biodiesel is lower by 8%as compared to diesel.

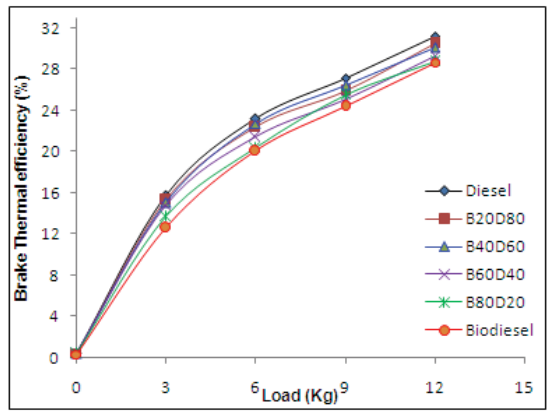

Fig. 2 Variation of B_{the} with Load

B. Brake Specific Fuel Consumption (BSFC):

The BSFC decreases significantly with increase in load for all the blend fuels. The increase in fuel consumption with load is due to mixture must be enriched beyond stochometric air fuel ratio. BSFC is higher at low loads because the engine consumes more indicated power to overcome friction. The Fig. 3 shows that BSFC increases with increase in biodiesel proportion becomes higher viscosity of blend fuel hence consumption increased. At full load BSFC of biodiesel is higher about 16% as compared to neat diesel.

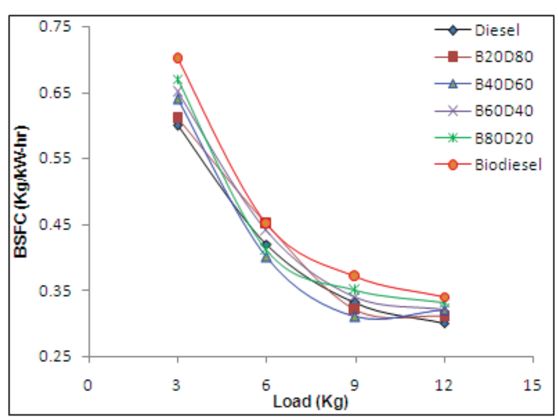

Fig. 3 Variation of BSFC with Load

C. Exhaust Gas Temperature (EGT)

The observation from Fig. 4 is that EGT increase with increase in load, this is due to higher temperature inside the cylinder, because more fuel is burnt to meet higher load demand. The decrease in EGT is not significant with increase of biodiesel in blend fuel.

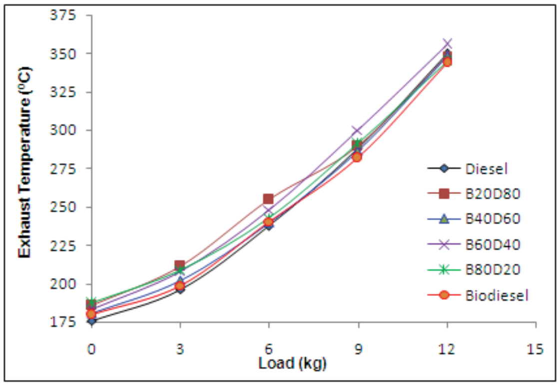

Fig. 4 Variation of EGT with Load

D. Carbon dioxide

The Fig. 5 shows that CO_2 emissions are marginally more for this biodiesel than diesel and reduces with reduction in blend portion. The reduction of CO_2 emission is because of high oxygen content in biodiesel due to this more carbon gets reaction during combustion in the cylinder results in higher CO_2 emission. The percentage increase in CO_2 emissions is about 5% for pongamia biodiesel as compared to diesel at full load of the engine.

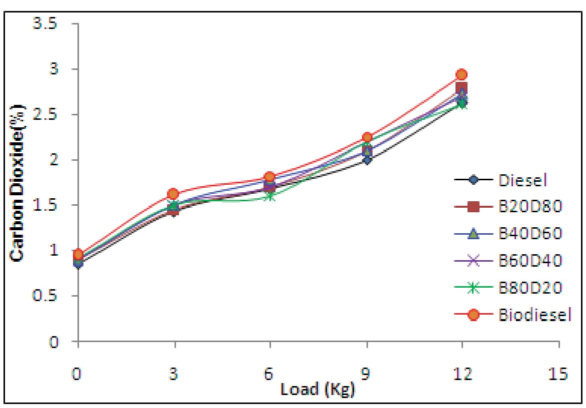

Fig. 5 Variation of CO_2 with Load

E. Hydrocarbons

The unburnt HC is generated in exhaust gas as a result of incomplete combustion of fuel. The observation from Fig. 6 is that HC emission increase by 35 to100% for all blends when loaded 0 to 12 Kg. With the increase in blend ratio up to 65% of reduction is observed in HC emissions. The HC emissions for diesel oil vary between 6 to 8 ppm and for biodiesel vary 2 to 4 ppm.

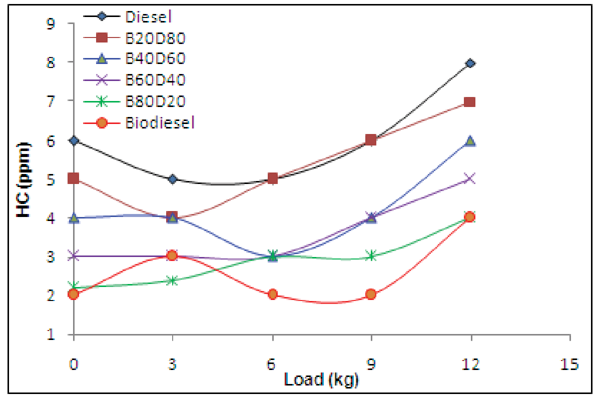

Fig. 6 Variation of HC with Load

F. Carbon Monoxide

The CO emission decrease for blend fuels are due to the oxygenated nature of biodiesel carbon gets reacted to form CO. From Fig. 7 it is found that CO emissions increase up to 170% from no load to full load condition for all the blend fuels. At full load there is 63% reduction in CO emission with biodiesel as compared to diesel.

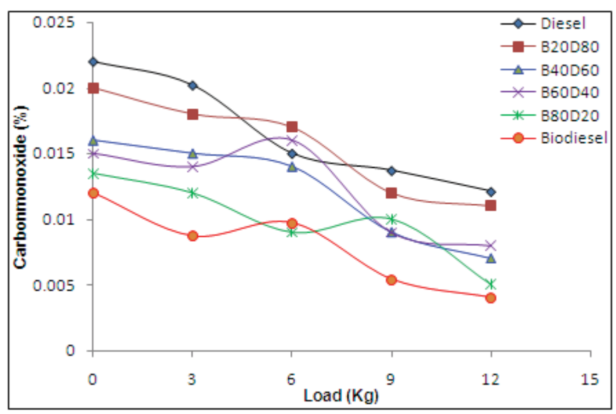

Fig. 7 Variation of CO with Load

G. NOx Emissions

From the Fig. 8 the observation is that NOx emission for biodiesel is 11%higher than that of diesel at full load of 12 Kg. It is noted that even though NOx emissions are higher for biodiesel, but not considerably high as compared to diesel.

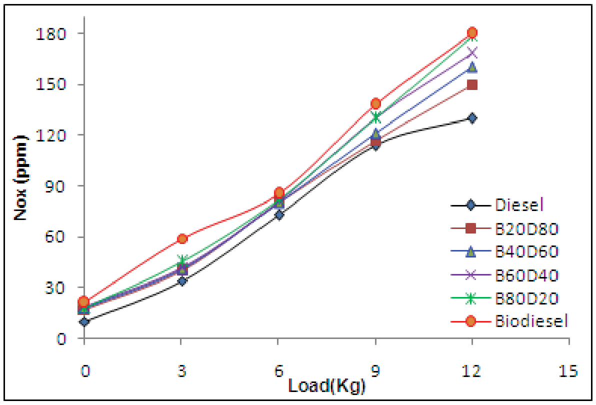

Fig. 8 Variation of NO_x with Load

H. Smoke Density

It is observed from the Fig. 9 smoke intensity decreases with increase in load because of richer mixture being burnt in the cylinder at higher loads. The increase in HSU may be due to the higher viscosity and lower volatility of pongamia biodiesel leads to improper atomization and hence in complete combustion of fuel takes place. As the load increases from 0 to 12Kg, the HSU for diesel and biodiesel increase by about 18 and 48% respectively. At maximum load the HSU for biodiesel is more by about 32%compared to diesel.

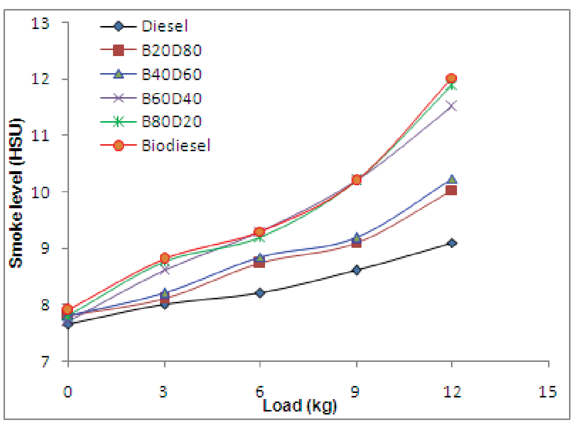

Fig. 9 Variation of HSU with Load

IV. Conclusions

The aim of the investigation was successfully carried out on VCR engine and the following conclusions were drawn:

- The Brake Thermal Efficiency at full load gradually decreases with increase in biodiesel quantity and for biodiesel is lowers by 8% as compared to diesel. The BSFC of biodiesel is higher about 16% as compared to diesel at full load. The EGT decrease is not significant with increase of biodiesel in blend fuel.
- The percentage increase in CO_2 emissions is about 5% for pongamia biodiesel as compared to diesel at full load of the engine. At full load there is 63% reduction in CO emission with biodiesel as compared to diesel. The increase in blend ratio up to 65% of HC emissions were observed with biodiesel with comparison to diesel. The HSU for biodiesel is more by about 32% and NOx emissions are higher compared to diesel.

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