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PERFORMANCE ANALYSIS OF C I ENGINE FUELLED WITH DIESEL - BIODIESEL (METHYL/ETHYL ESTERS) BLEND OF NON-EDIBLE OIL

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ABSTRACT

High viscosity, poor volatility and heavy chemical structure of vegetable oil are the main constraints to replace diesel fuel. This paper investigates the scope of utilizing biodiesel produced with ethanol and methanol as alcohols in the process of making biodiesel. Experiments were conducted on diesel engine with B20 of methyl and ethyl esters of Pongamia oil (POME20, POEE20), methyl and ethyl esters of Mahua oil (MOME20, MOEE20) and standard diesel fuel separately. The performance and emission characteristic results were compared with diesel fuel. Results indicate that from all the experiments 20% Pongamia oil methyl ester produces 13.2% less power at 3.22% more specific fuel consumption than diesel fuel at maximum load. From the emission results the observation is that slight reduction of hydrocarbon, carbon monoxide and smoke emissions with moderate increase in carbon dioxide emission.

Keywords:
Diesel engine, Performance, Biodiesel, Emissions, Methyl ester, Ethyl ester.

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1. INTRODUCTION

Fast depletion of petroleum fuel resources, increasing demand and stringent regulations of environment pollution made researchers to search for new suitable future alternative fuels for diesel engines. Biodiesels made from renewable oils can be used in diesel engines to replace diesel fuel. These fuels have properties similar to diesel oils and reduced emissions from a cleaner burn due to their higher Oxygen content. [1, 2]. Alternative fuels are easily available, renewable and environment friendly. One of the promising alternative fuels considered for diesel engine is biodiesel. Particularly non-edible oils can be used to make biodiesel to replace feature fuel requirement for diesel engines [3].

Biodiesel also offer the advantage of being able to readily use in existing diesel engines without any modifications of the engine [4]. Even though biodiesel has many advantages, its usage is restricted to the maximum of 20%, this is due to gum deposits on the cylinder surface for long run [5, 6]. Use of biodiesel as fuel in the existing engines the observation is decrease in power, drop in thermal efficiency, increase in specific fuel consumption and higher emissions [7, 8]. In order to overcome these problems the modifications in engine operating parameters suggested that are varying the compression ratio and injection pressure, use of multiple injections and oil preheating.[9-12]. Experimental tests have been carried out, to evaluate the performance and exhaust emissions of Methyl ester/Ethyl ester blended with diesel fuel on the engine.

2. MATERIALS AND METHODS

Transesterification process is used to make biodiesel from ***pongamia*** oil. Filtered oil is heated at 105^0C temperature to remove all the water content. Methanol of 99% pure, 120 ml per liter of oil is added and stirred for ten minutes. Two milliliter of 98% pure sulfuric acid is added for each liter of oil, heated and stirred for one hour at 60^0C in a closed conical beaker in acid treatment. The mixture is allowed to settle for four hours and glycerin is removed from methyl/ethyl ester.

Methanol of 200ml (20% by volume) with 6.5 grams of 97% pure NaOH (Sodium Hydroxide) is thoroughly mixed until it forms a clear solution called "***Sodium Methoxide***". This *solution* is added to oil at 60^0C temperature by stirring at 500 to 600 rpm in a closed container. The solution turns into brown silky in colour after completion of reaction as shown in figure 1. After settlement of the mixture, glycerin is separated from biodiesel in the base treatment. The formed methyl ester is bubble washed with distilled water for about half an hour to remove soaps and un-reacted alcohol. Washing is repeated till the methyl ester separated with clear water [13, 14]. Collected methyl ester is heated to remove water and formed biodiesel is used to make blend fuel (POME20) with diesel. By using similar procedure of making biodiesel as shown in figure 2, other blend fuels (MOME20, POEE20 and MOEE20) were also prepared for experimental work.

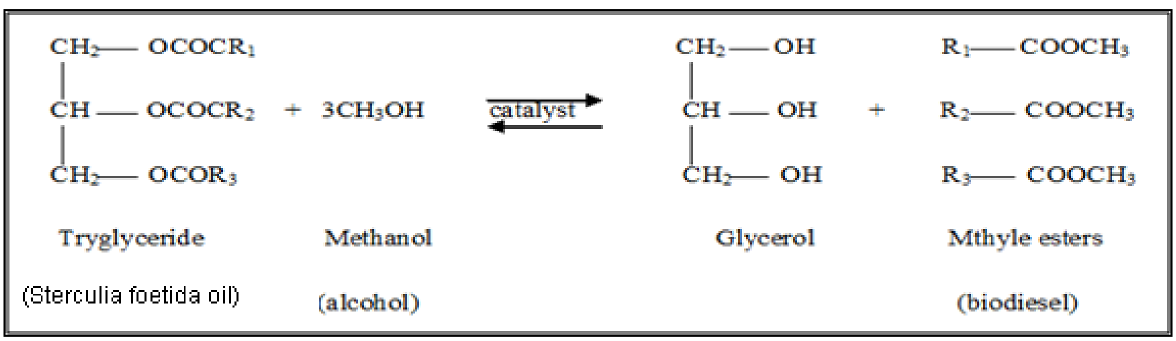

Figure 1: Reaction of Biodiesel formation

Figure 2: Biodiesel process Chart

3. EXPERIMENTATION

Four-stroke, single cylinder DI diesel engine coupled with eddy current dynamometer is used for the experimental work. Experiments were conducted by varying loads of 0, 20, 40, 60, 80 and 100% for diesel, biodiesel blends with diesel (POME20, MOME20, POBEE20 and MOEE20) at 1500 rpm constant rated speed of the engine as shown in figure 3. Fuel consumption and exhaust gas temperatures were measured by usual procedure. The parameters like brake thermal efficiency and brake specific fuel consumption are evaluated at all load conditions. The emissions characteristics were measured at steady state condition of the engine with the help of AVL make smoke meter. The exhaust gas analyzer was used to measure the carbon dioxide (CO_2), carbon monoxide (CO) and hydrocarbon emission (HC). Smoke intensity was measured with smoke meter and the results were compared with the diesel fuel.

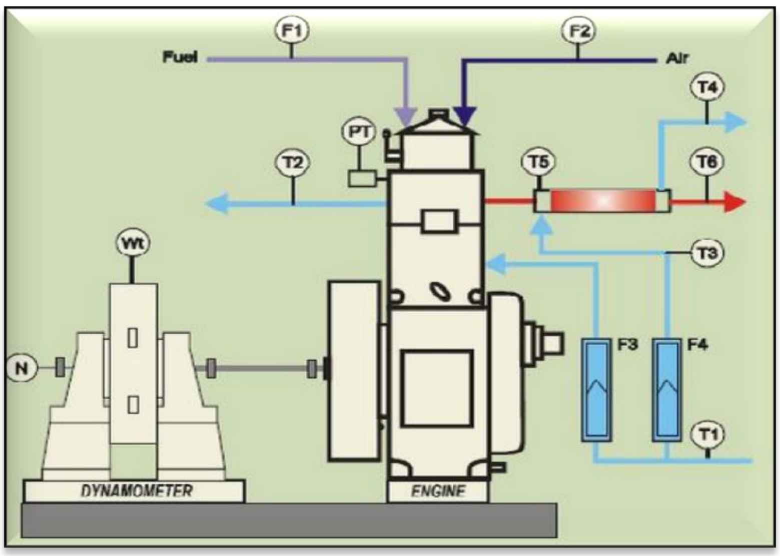

Figure 3: Experimental setup

4. RESULTS AND DISCUSSION

The performance analysis of diesel engine is analyzed with 20% of Methyl/Ethyl Esters of non-edible Oils with diesel blend and compared the results with diesel fuel.

4.1.PERFORMANCE ANALYSIS

i. Brake thermal efficiency (BTE) variation with load is shown in figure 3. BTE of all blends of esters are inferior to diesel, this is due to the lower calorific value of the non edible oil. Biodiesel of methyl esters performance is better than ethyl esters. However BTE of POME20 is higher than other blends of esters and 4.5% less than diesel fuel. This is due to low calorific value and high viscosity of biodiesel which promotes the combustion process.

ii. Brake specific fuel consumption (BSFC) variation with load is shown in figure 4. With increase in load the BSFC decreases sharply for all blends of fuel and it is higher than diesel. Biodiesels of methyl ester have lower BSFC as compared to ethyl esters. As the density of POME20 is lower than other esters and close to diesel, the trend is very close and nearly 3.22% less than diesel fuel.

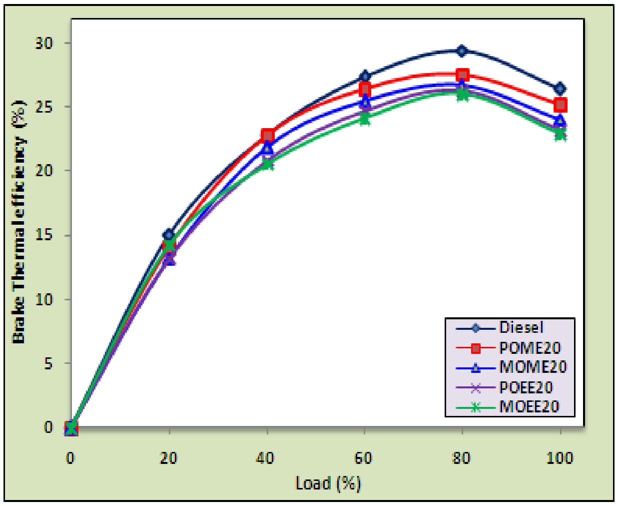

Figure 3: Thermal efficiency variation with Load

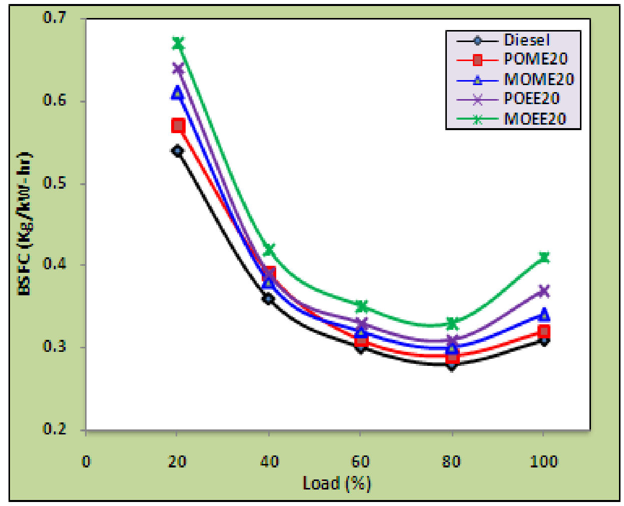

Figure 4: *BSFC* variation with Load

4.2.EMISSION ANALYSIS

i. The observation from figure 5 is that HC emission is reduced with esters compared to diesel. This is due to the presence of oxygen in the fuel. Oxygen promotes combustion processes, in turn reduces the UBHC emissions as compared to diesel. HC emission with POME is the least as compared other esters and diesel fuel.

ii. Figure 6 shows the variation carbon monoxide (CO) with load. Lower CO emissions of esters may be due to more availability of oxygen leads to complete oxidation as compared to diesel. CO produced during combustion of esters might have converted into CO_2 by taking up the extra oxygen molecule present, thus reduced CO formation. Further observed that CO is increased at full load condition; this is due to excess fuel injected inside the cylinder leads to smoke and prevents oxidation of CO to form CO_2.

iii. Carbon dioxide emission variation with Load is shown in figure 7. The CO_2 emission indicates that how efficiently fuel is burnt in the combustion chamber of a diesel engine. Since the ester-based fuel burns more efficiently than diesel, POME shows 51.3% higher CO_2 emission than diesel fuel.

iv. Figure 8 shows the variation of smoke with load. The smoke emissions are reduced, for non-edible oil methyl or ethyl esters of B20; this is due to complete combustion with excess availability of oxygen content in the biodiesel. Emission of smoke is less in ethyl esters when compared to methyl esters.

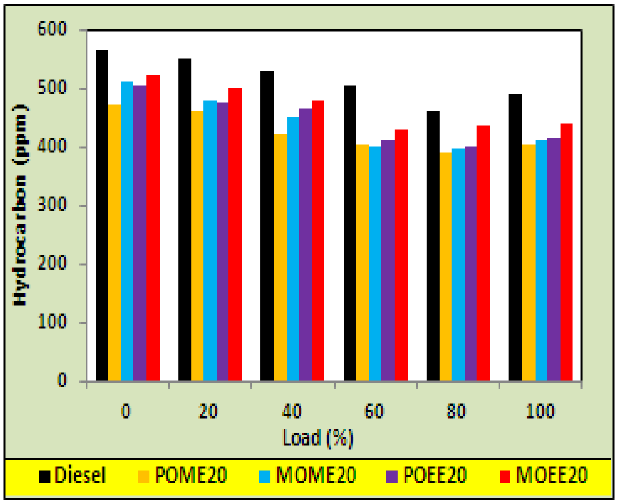

Figure 5: Hydrocarbon variation with Load

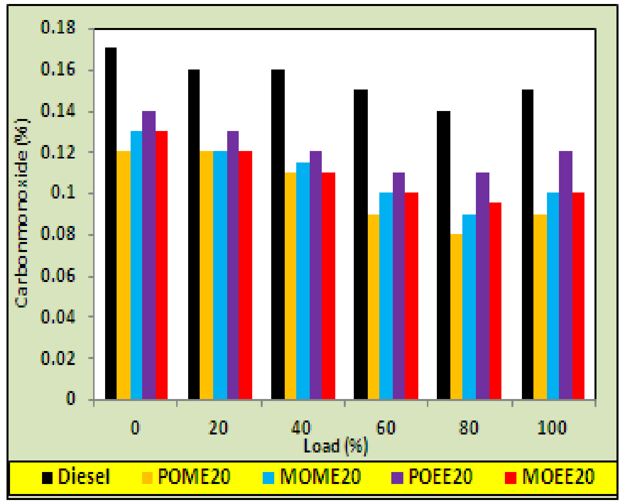

Figure 6: Carbon monoxide variation with Load

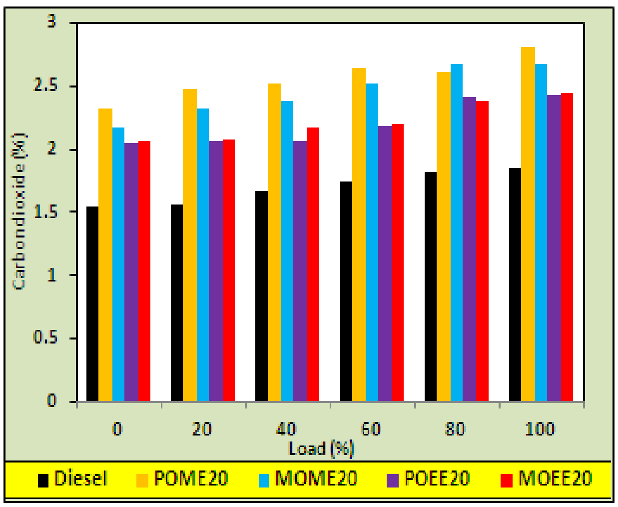

Figure 7: Carbon dioxide variation with Load

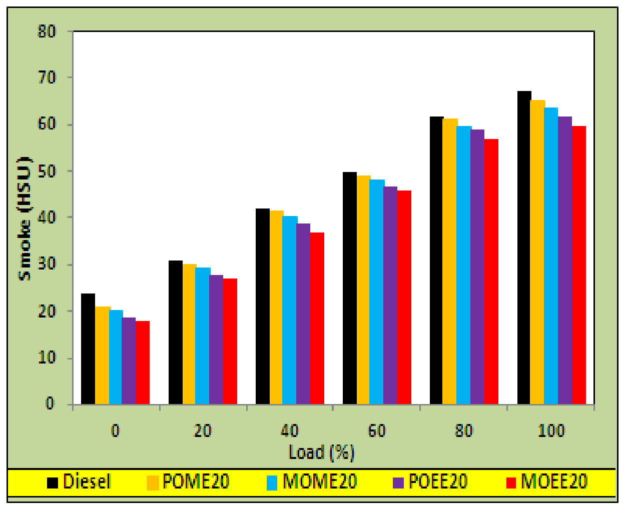

Figure 8: Smoke variation with Load

5. CONCLUSIONS

The experiments were conducted on diesel engine with B20 blend fuel of methyl and ethyl ester of Pongamia oil (POME20, POEE20), Mahua oil (MOME20, MOEE20) and the results were compared with conventional diesel fuel.

- Brake thermal efficiency of biodiesel blend was found to be slightly less than that of diesel fuel at all load conditions.
- The carbon monoxide (CO), smoke and HC emissions of engine were decreased with biodiesel blend.
- Brake thermal efficiency of Pongamia and Mahua oil methyl esters at 20% in diesel is nearly diesel fuel when compared with ethyl esters blends.
- Methyl ester of Pongamia and Mahua oil blends with diesel performing better with low *BSFC* than ethyl esters.

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