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Performance, Combustion and Emission Analysis on A Diesel Engine Fueled with Methyl Ester of Neem and Madhua Oil

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Abstract: One hundred years ago, Rudolf Diesel tested vegetable oil as fuel for his engine. In 1930s and 1940s vegetable oils were used as diesel fuels, but only in emergency situations. Alternative fuels for diesel engines are becoming increasingly important due to diminishing petroleum reserves and the environmental consequences of exhaust gases from petroleum fueled engines. Experimental tests have been carried out to evaluate the performance, emission and combustion characteristics of a diesel engine when fuelled with two different biodiesel (Neem oil MEON, Madhua oil MEOM) and its blends of 20%, 40%, 60%, 80% and 100% of biodiesel with ordinary diesel fuel separately. Tests on ordinary diesel fuel have also been carried out for comparison purposes. The experimental results show that the engine brake thermal efficiency and fuel consumption are comparable to diesel when fueled with two different biodiesel and its blends. The emission of nitrogen oxides (NOx) from biodiesel and its blends are lower than that of pure diesel fuel.
Keywords- Biodiesel, Combustion, Emission, Performance, Neem oil, Madhua oil.

1. Introduction

India being predominantly agricultural country requires major attention for the fulfillment of energy demands of a farmer. Irrigation is the bottleneck of Indian agriculture, it has to be developed on a large scale, but at the same time diesel fuel consumption must be kept to a minimum level because of the price of diesel and its scarcity. The increased use of diesel in agriculture and transportation sectors has resulted in diesel crisis. Finding an alternative fuel for diesel fuel is critically important for our nation's economy and security. Biodiesel is a diesel fuel blending component made from vegetable oil, waste cooking oil, or animal fat by reaction with methanol to form methyl esters [1]. Biodiesel blends are used to reduce petroleum consumption as well as greenhouse gas and pollutant emissions, and to comply with mandates for the use of alternative fuels. Biodiesel fuel, an alternative diesel fuel, is an environmentally clean and renewable energy source. It is well known that biodiesel can be mixed with diesel fuel when applied in a diesel engine because of different physical properties, such as higher viscosity, cetane number, and lower heating values compared with conventional diesel fuel. Consequently, biodiesel fuel can be operated in a compression ignition engine with little or no modifications [3].

In spite of these many studies on biodiesel fuel properties and their effect on combustion and emissions, most studies are focused on engine performance rather than on spray and atomization characteristics. The fuel properties and flow characteristics of biodiesel are different from those of conventional diesel fuel as indicated in previous studies. These different fuel properties of biodiesel, such as higher viscosity and surface tension, may also influence the fuel atomization characteristics when applied in a diesel engine. In the case of a direct injection diesel engine, the injection characteristics in the combustion chamber through the fuel spray nozzle determine the combustion performance and thermal efficiency of the engine [2]. Transesterification is probably the most effective and widely used technique for formulating suitable fuel for CI engines from biodiesel in order to avoid these problems.

2. Experimental Procedure

The experiment was carried out in DI diesel engine using diesel with biodiesel mixture. The engine specification is 10 Hp, 1500 rpm, Twin cylinder, 4-stroke, water cooled, over head value, vertical diesel engine (Table 1). The schematic of the experimental setup is shown in fig 1. The engine was always run at its rated speed. The governor of the engine was used to control the engine speed. Experimental tests have been carried out to evaluate the performance, emission and combustion characteristics of a diesel engine when fueled with two different biodiesel (Neem oil MEON , Madhua oil MEOM) and its blends of 20%, 40%, 60%, 80% and 100% of biodiesel with ordinary diesel fuel separately. It is coupled with a swing field electrical dynamometer. AVL 444 Di-gas analyzer was used to measure the oxides of nitrogen. AVL 437 smoke meter was used to measure the density of exhaust gas. AVL combustion analyzer was used to analyze the combustion characteristics.

Table 1. Engine specification

Make	:	Simpsons S 217
Type	:	Vertical inline diesel engine, 4 stroke, Twin cylinder
Displacement	:	1670 cc
Bore × Stroke	:	91.4 mm × 127 mm
Compression ratio	:	18.5:1
Fuel	:	Diesel engine
Rated brake power	:	7.46 kW
Ignition system	:	Compression Ignition

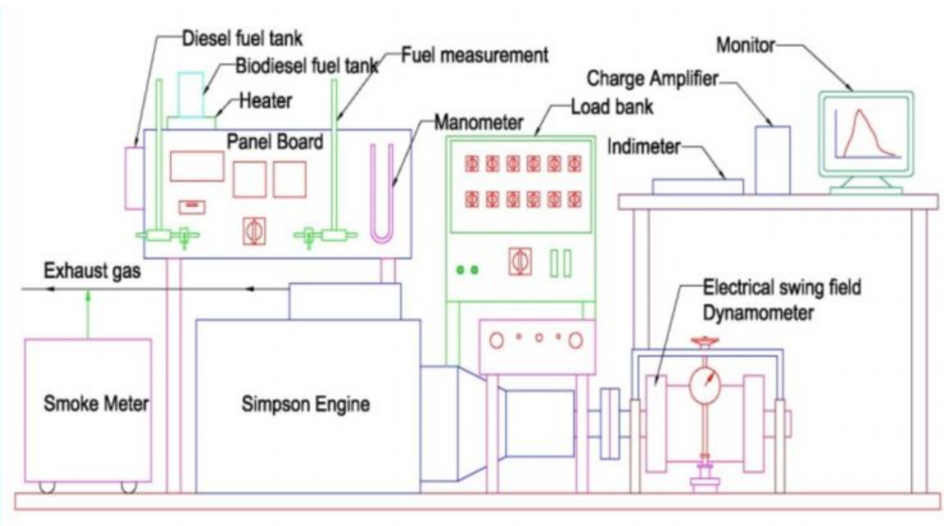

Fig 1. Test Engine

Table 2. Fuel properties

Test Property	Diesel	Biodiesel	
		MEON	MEOM
Density at 15° C kg/m^3	826.8	887.5	879.6
Kinematic Viscosity at 40°C	3.68	5.05	4.53
Flash Point (PMCC) °C, (min)	90	168	126

Gross Colorific value k.cal/kg	10896	10220	10540
Pour point °C	4.5	3	4
Cetane Number (min)	53	53	56
Acidity as mg of KOH/gm	0.30	0.27	0.15

3. Results and Discussions

Experimental investigation shows that the best blends MEON 40% and MEOM 40% were obtained at injection timing 24° bTDC based on the performance and emission characteristics. The results of experimental investigation carried out to compare optimal blends with diesel.

1.1 Fuel consumption and Brake thermal efficiency

The fig.2 shows the comparison of fuel consumption and Brake power. It is clear from the graph that as the load increase the fuel consumption also increases. The fuel consumption is minimum in diesel compared to other fuel at full load condition. Fuel consumption at maximum brake power is the lowest (2.07 kg/hr) for B40 blend of MEON. The viscosity of this blend is lower than the B40 blend of MEON. This may be due to combination effect of low heating value and low density.

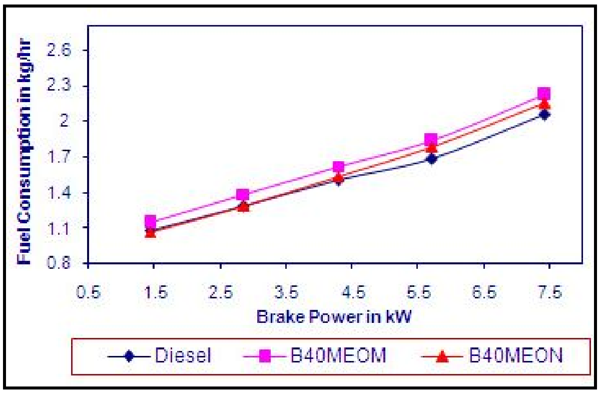

Fig.2 Fuel Consumption Vs Brake power

1.2 Brake thermal efficiency

The fig 3 shows the brake thermal efficiency with respect to brake power. the main difference between methyl ester blends and diesel fuel is in calorific value and cetane number. Combustion with esters and their blends is better compared to diesel due to increased fuel oxygen. Viscosity, density, droplet size are the other factors influencing combustion. At maximum brake power, the B40 blend of MEON has the maximum brake thermal efficiency of 28.33%, coinciding with that of diesel fuel [6].

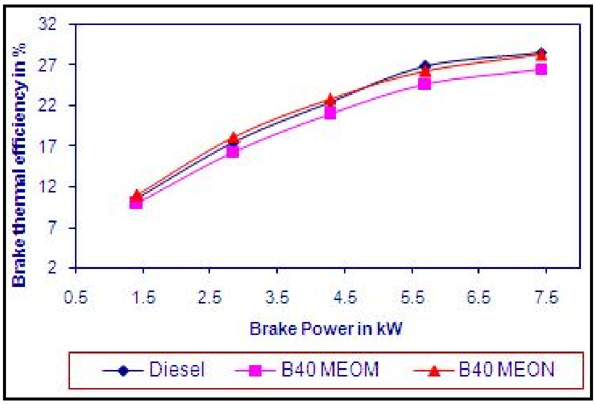

Fig 3. Brake thermal efficiency Vs Brake power

1.3 Exhaust Gas Temperature

The fig 4 shows the exhaust gas temperature with respect to brake power. It is observed that the exhaust gas temperature increase with load increment. More fuel is burnt at higher load. The Exhaust gas temperature is slightly higher with B40 MEOM compared to other fuels.

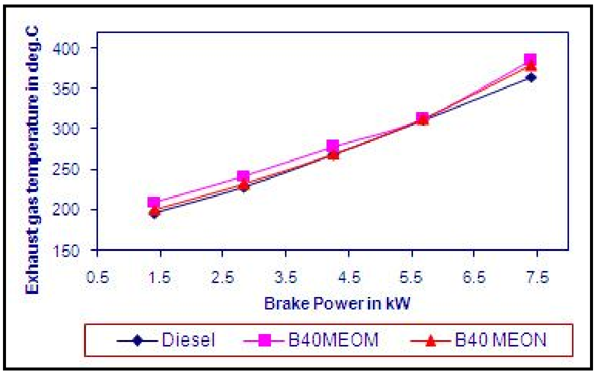

Fig 4. Exhaust gas temperature Vs Brake power

1.4 Smoke Density

Here in this Fig 5, we observe variation in the density of smoke with increasing load. Amongst the blends, Smoke density is observed to be at it highest when 100% Bio-diesel or B100 blend is used as fuel in the DI Diesel Engine. Sole Diesel Fuel displays the highest value in Smoke Density with nearly 33.7 HSU at full load. The least observed value is for the blend B40 MEON at 13 HSU for full load condition.

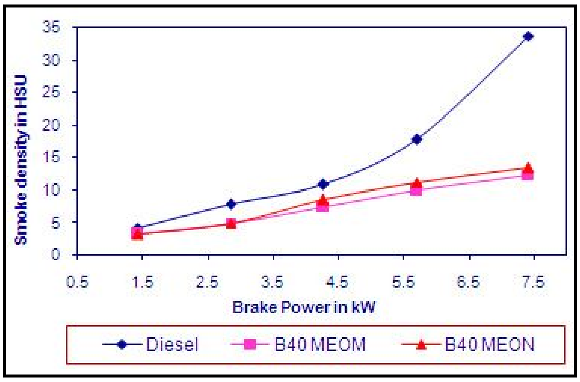

Fig 5. Smoke density Vs Brake power

1.5 Oxides of nitrogen

Fig 6 shows the variation of NOx with brake power. The B40 MEOM oil yielded lower NOx emission compare to all other fuels. Generally NOx is closely related to the rate of heat release during engine operation. Consequently, the NOx emissions of bio-diesel are higher than that of diesel regardless of injection timing, because the heat release rate of bio-diesel is higher. It can be also seen that NOx is increased as the injection timing is advanced due to rapid combustion of fuel [7].

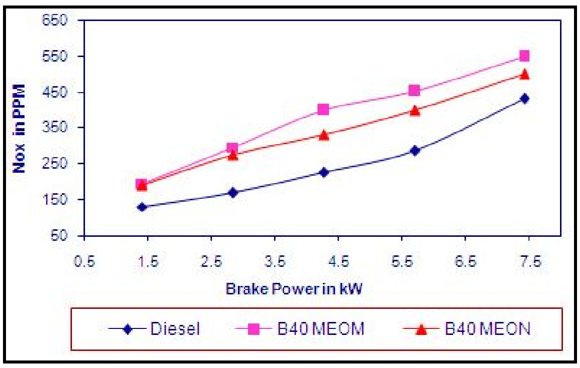

Fig 6. Oxides of nitrogen Vs Brake power

1.6 Cylinder pressure

The comparison of cylinder pressure with crank angle is as shown in fig.7. The value with B40 blend of MEOM is highest compared to other fuel. As the diesel quantity in the blends increases the amount of fuel taking part in the blends increases the amount of fuel taking part in the uncontrolled combustion stage of the mixture reduces, which result in a higher pressure rise. The cylinder pressure depends upon burned fuel fraction during the premixed burning phase.

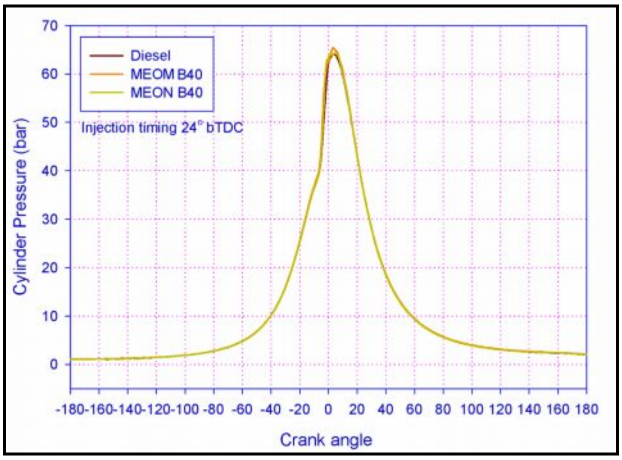

Fig 7. Cylinder pressure Vs Crank angle

1.7 Heat Release

The variation of heat release rate with crank angle as shown in fig 8. The heat release rate is higher in B40 MEOM compare to other fuel. This is because of shorter ignition delay of the blend reducing the amount of fuel injected into the cylinder resulting in the increase of heat release rate.

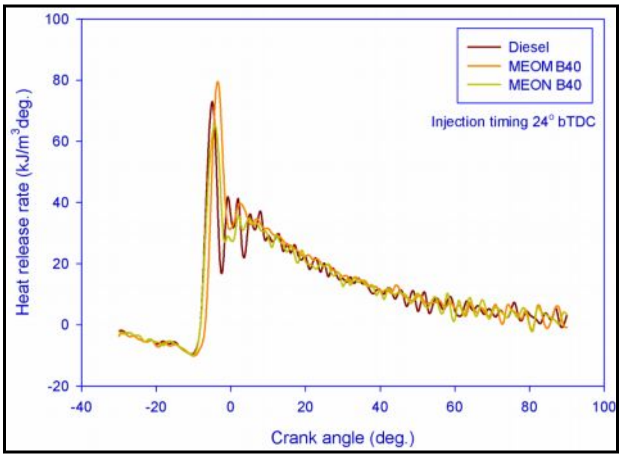

Fig 8. Heat release rate Vs Crank angle

1.8 Maximum Cylinder Pressure with Number of Cycles

The variation of peak pressure with respect to number of cycles (100) for diesel, B40 blend of MEON and B40 blend of MEOM oil is as shown in figure 9. The maximum pressure is higher for B40 MEOM compared to other fuels. While the fuel is being burnt the energy release depends on the net calorific value of the fuel. It can be seen that for certain cycles the peak pressure is higher and certain cycle it is lower. The variation in the cycles depends on the air fuel ratio. It is also observed that rich air fuel ratio and high pressure results in the higher side of the cycle and lower side having leaner air fuel ratio.

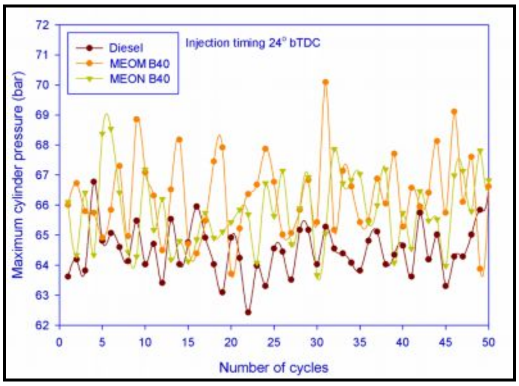

Fig 9. Cylinder pressure Vs Number of cycles

4. Conclusion

The performance, emissions and combustion characteristics of diesel engine using bio-diesel have been analyzed as follows.

- The fuel consumption increase with increase in percentage of bio-diesel blends due to lower calorific value.
- The brake thermal efficiency in B40 MEON is close to that of the diesel
- Smoke density and particulate matter is lower in bio-diesel compared to diesel at all load condition.
- NOx value is lower in B40 MEOM compare to other fuel.
- The rate of heat release of the bio-diesel driven engine is higher than the diesel fuel operated engine and B40 MEOM blend ratio shows longer combustion duration than that of the diesel engine.

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