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# Performance and emission characteristics of diesel engine fuelled with mahua biodiesel blend (20MOME)

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## Abstract

This study investigates the effect of biodiesel namely 20MOME (80%diesel+20%mahua oil methyl ester) on a kirloskar, single cylinder, direct injection diesel engine. Performance and emission characteristics like break thermal efficiency, exhaust gas temperature; Carbon monoxide (CO), unburned hydrocarbon (UBHC) and oxides of nitrogen (NOx) emissions were determined for 20MOME and compared with diesel fuel. The results showed that the engine performance under biodiesel blends were similar to that of neat diesel fuel with nearly the same brake thermal efficiency, and slightly higher fue1 consumption. The carbon monoxide and hydrocarbon emissions decreased significantly compared to neat diesel fuel whereas the oxides of nitrogen increased.

***Keywords**:* Biodiesel; Mahua oil; Kirloskar; Olive oil; Exhaust gas temperature; Break thermal efficiency.

***Abbreviations***: DI-Direct injection; EGT- Exhaust gas temperature; MOME-Crude Mahua oil and Mahua Biodeisel; CO-Carbon monoxide; UBHC-Unburned hydrocarbon; NOx-Oxides of nitrogen.

## Introduction

The world energy demand is increasing rapidly because of increase in population and industrialization (Ali Keskin *et al*., 2010). Today, the majority of energy needs are supplied through fossil fuels. However due to increase in petroleum price and environment pollution, the researchers have been looking for renewable energy sources (Phan and Phan, 2008; Dizge *et al*., 2009). Biodiesel is one of the alternative fuels for diesel which comes under renewable energy sources.

Lapuerta et al have investigated the use of waste cooking oil esters as alternative fuel in a naturally aspirated diesel engine and been reported that the smoke emission was lower than that of diesel. The NOx emissions were marginally higher than diesel and the soot formed at the point of impingement of ester was lower than diesel. Dorado et al tested the use of methyl ester of olive oil as fuel in a direct injection (DI) diesel engine and reported that the combustion efficiency and engine performance were found to be the same as that of diesel. Also, there were reduction in emissions namely, CO, $CO_2$, NOx and sulphur dioxide as 59%, 8.6%, 32% and 57% respectively. Further, it has been reported that the smoke emission was low. Deepanraj *et al*. (2011a, 2011b) investigated the palm oil biodiesel blends with diesel in a single cylinder direct injection diesel engine and found that the acceptable thermal efficiencies were obtained and the specific fuel consumption and exhaust gas temperatures were higher than the diesel. Godiganur *et al*. ran a diesel engine fuelled with methyl ester of mahua oil/diesel blends. They found that vegetable oils have to undergo the process of *trans*-esterification to be usable in diesel engines.

*Table 1.* Properties of fuels

| Properties | Diesel | Mahua oil | MOME |
|---|---|---|---|
| Density (kg/m$^3$) | 840 | 924 | 915 |
| Specific gravity | 0.84 | 0.924 | 0.915 |
| Kinematic viscosity at 40°C (cSt) | 3.72 | 37.3 | 5.8 |
| Acid value (mg KOH/ gm) | 0.20 | 29 | 0.57 |
| Calorific value (kJ/kg) | 42800 | 37614 | 39400 |
| Flash point (°C) | 62 | 238 | 129 |
| Fire point (°C) | 75 | 246 | 141 |

In this study, mahua oil is chosen as a potential alternative for the use of fuel in diesel engines. The viscosity of the crude mahua oil is reduced by preparing biodiesel using *trans*-esterification process. This lowers the viscosity and ensures smooth flow of fuel in the fuel system (Demirbas *et al*., 2002; Vivek *et al*., 2004; Meher *et al*., 2006). The properties of diesel, crude mahua oil and mahua biodiesel (MOME) are shown in Table 1.

## Experimental setup

Experiments were conducted in a Kirloskar, four stroke, single cylinder, water cooled, direct injection diesel engine coupled with eddy current dynamometer. The specification of the engine used for test is given in Table 2 and the experimental setup is shown in Fig.1.

*Table 2.* Specification of the test rig

| | |
|---|---|
| Engine Type | 4 stroke, single cylinder, water cooled, DI engine |
| Bore & Stroke | 87.5 & 110 mm |
| Power | 5.2 kW |
| Rated speed | 1500 rpm |
| Compression ratio | 17.5:1 |
| Loading type | Eddy Current Dynamometer |

## Results and Discussions

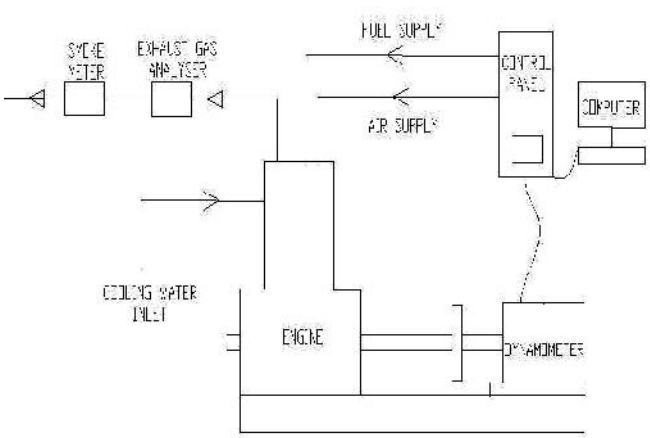


*Fig. 1.* Experimental setup

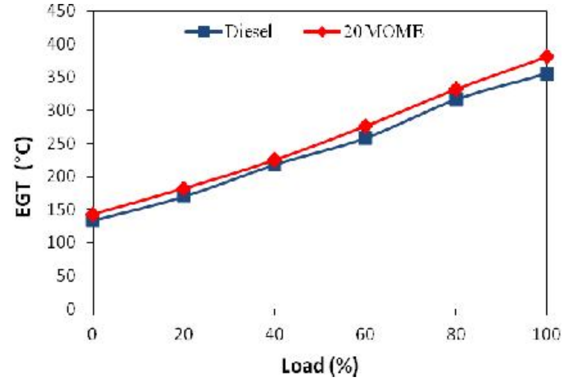


*Fig. 3.* Exhaust gas temperature $_{vs}$ load

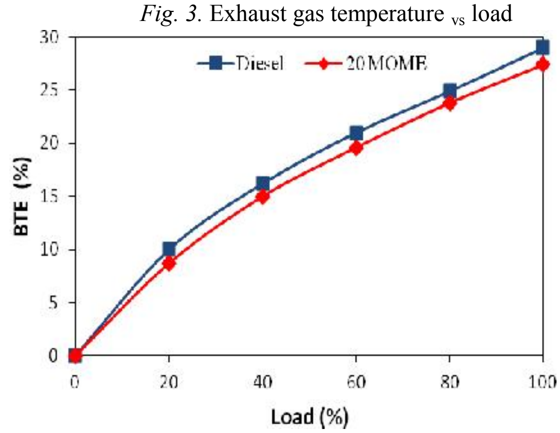


*Fig. 2.* Brake thermal efficiency $_{vs}$ load

Fig.2 shows the brake thermal efficiency variation with respect to load for diesel and 20MOME. The brake thermal efficiency increases with increase in load. At full load condition, 20MOME produce 5.5 % lower brake thermal efficiency than sole diesel. This is due to lower calorific value of the biodiesel blend than sole diesel.

Fig.3 shows the variation of exhaust gas temperature (EGT) with respect to load for diesel and 20MOME. EGT increases with increase in load. It is observed that there is a marginal increase in EGT when using PCPO and its blend as compared to diesel. At full load condition, 20MOME produce 6.8 % higher brake thermal efficiency than sole diesel. This is due to the better combustion of oxygenated fuels.

The CO emission test results for diesel and blended fuel are shown in Fig.4. It is observed that the CO emission gradually increases with increase in load. The CO emission of biodiesel blend is lower than diesel for all the load conditions due to

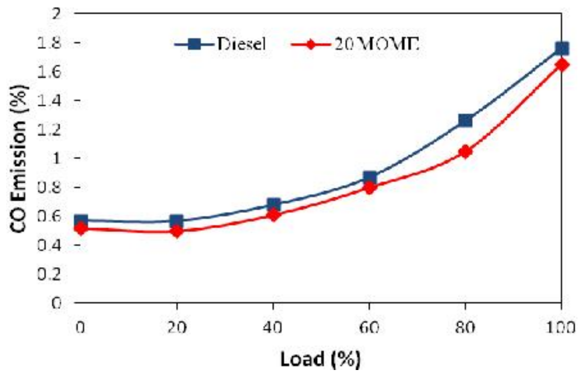


*Fig. 4*. CO emission vs. load

the availability of oxygen content which makes the combustion better. At no load condition, the 20MOME produce 8.77% lower CO emission than diesel fuel and at maximum load, the same fuel produce 6.25% lower CO than diesel.

Fig.5 shows the variation of UBHC emission with respect to load. The UBHC value gradually increases with increase in load due to the increased amount of fuel injection at higher loads. While operating the engine with 20% biodiesel blend the UBHC emission decreases significantly when comparing with diesel fuel. At no load condition, the 20MOME 16.2% lower UBHC emission than diesel fuel and at maximum load, the same fuel produce 15.1% lower than diesel.

The NOx formation increases linearly with increase in load as shown in Fig. 6. This is because with increasing load, the temperature of the

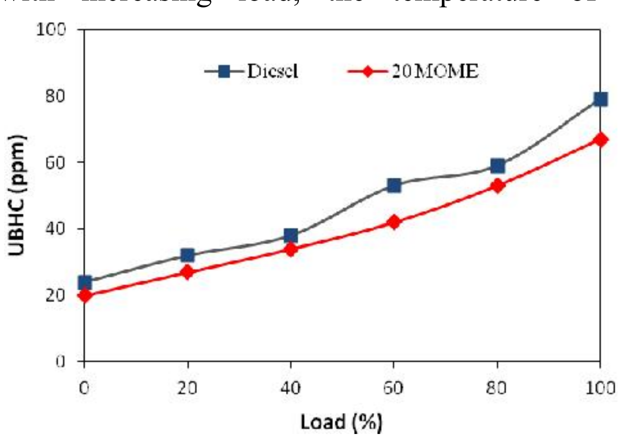


*Fig. 5*. UBHC emission vs. load

combustion chamber increases. From the figure, it is observed that the NOx emission of the biodiesel operated engine is higher than the standard diesel

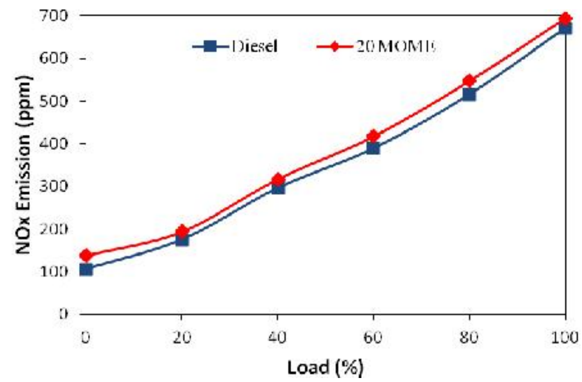


*Fig. 6*. NOx emission vs. load

operation. This occurs due to the presence of extra oxygen in the molecules of biodiesel which increases the in-cylinder temperature of the engine. At no load condition, the 20MOME 21.4% lower NOx emission than diesel fuel and at maximum load, the same fuel produce 3.17% lower than diesel.

## Conclusion

It was found that the 20MOME could be successfully used as a fuel in diesel engine with acceptable performance and better emissions than conventional diesel up to a certain extent. Form the experimental result, it is concluded that the existing engine could be operated on 20MOME without any modification.

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