

## Experimental Investigation on Jatropha-Methanol Blends in Direct Injection Diesel Engines

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### ABSTRACT:

*This paper describes about the usage of Jatropha fuel in direct injection water-cooled diesel engine. In order to make use of Jatropha fuel in diesel engine, the properties of Jatropha oil has to be converted to diesel fuel, so for that methanol was added. There are three different blends are prepared by varying the ratio of Jatropha and methanol mixture, such as blend 1 (Jatropha 75%, methanol 25%), blend 2 (Jatropha 80%, methanol 20%), blend 3 (Jatropha 85%, methanol 15%). The prepared fuels are supplied to the conventional diesel engine, then the performance and emission characteristics were analysed. It is found that Jatropha methanol mixtures results are acceptable in half load and highly considerable in full load operation. Considerably torque developed is very low in low load than half and full load operations. Methanol addition has improved the performance and emission characteristics.*

### KEYWORDS:

*Diesel engine; Jatropha; Methanol ; Blends; Performance; Emissions*

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## 1. Introduction

As there is continuous usage of fossil fuel which leads to the increased atmospheric pollution and temperature, the alternative fuels are suitable to reduce the engine exhaust emissions without any major changes in performance and the design of engine. Jindal et al [1] investigated the effect of compression ratio and injection pressure on direct injection (DI) diesel engine with Jatropha methyl ester as fuel. They considered the brake thermal efficiency (BTE), brake specific fuel consumption (BSFC) and CO, CO<sub>2</sub>, HC, NO<sub>x</sub> and smoke opacity as emission parameters. They found that the increasing the compression ratio and injection pressure increases the BTE and reduces BSFC while generating lower emissions. Optimum combination for small size agricultural applications was found in compression ratio of 18. Avinash et al [2] experimented with karanja oil and its blends with mineral diesel up to 75% with and without preheating. They concluded that for all the blends i.e. 10%, 20%, 50% and 75%, the emission particularly oxides of nitrogen were decreased when the fuel was supplied with preheating. Karanja blends with diesel up to 50% with preheating have the potential to replace the mineral diesel. They obtained BTE of 30% for preheated oil and 24-27% for unheated oil. The BSFC for preheated lower blends was in improved trend and HC emissions were also low for lower blends for preheated and unheated oils.

Qi et al [3] experimentally investigated the use of methanol as additive at 5%, 10% in volume basis with the mixture of 50% diesel and 50% biodiesel. They

concluded that when the methanol is added with mixture, the combustion starts later than mixture of biodiesel and diesel. At low engine load of 1800 rpm, the peak pressure rise and cylinder peak pressure are lower than mixture of biodiesel and diesel, but heat release rate was similar to the base reading. At high load, when the fuel was mixed with methanol, the peak pressure rise and the heat release rate were higher than the base reading. Zhu et al [4] investigated the effect of addition of 5%, 10%, 15% of methanol and the ethanol in biodiesel in four cylinders naturally aspirated diesel engine. They concluded that the blended fuel gives lower NO<sub>x</sub> and particulate matter and thereby the biodiesel-methanol blends are more effective than biodiesel-ethanol blends. At high percentage of alcohol in the blend leads to increase of CO and HC emissions and considerably reduced the BTE.

Anand et al [5] investigated the multi cylinder turbo charged constant speed DI diesel engine under varying load with methanol blend and biodiesel derived from karanja oil without modifying the injection timing. They revealed that ignition delay increases the lower combustion duration and heat release rate while the peak pressure rate is decreased for fuel mixed with methanol than neat karanja biodiesel. Due to addition of 10% methanol, the BTE increases to a maximum of 4.2% at 80% load. At low load the unburned HC and CO emissions are considerably high for methanol blend than neat biodiesel. At high load these emissions are reduced for methanol blended fuel. When adding methanol, the significant amount of NO<sub>2</sub> and smoke are reduced.

Bayraktar [6] experimentally investigated on diesel-methanol-dodecanol blends in single cylinder water

cooled CI engine. Methanol concentration with the blends in the range of 2.5% to 15% and 1% dodecanol are added constantly in each blend to reduce the phase transition situation. The engine is operated with varying compression ratio of 19, 21, 23 and 25 at a speed of 1000 to 1600 rpm for each compression ratio. In the view of engine performance among different blends 10% methanol are suited for CI engine and the improvements are obtained up to 7% in the performance without modifying the engine design. In this paper Jatropa fuel mixed with methanol such as blend 1 (Jatropa 75%, methanol 25%), blend 2 (Jatropa 80%, methanol 20%), blend 3 (Jatropa 85%, methanol 15%) are supplied to the DI water-cooled diesel engine to assess the performance and emission characteristics.

## 2. Jatropa-Methanol blends

Generally free fatty acid content in Jatropa is high, hence it becomes necessary to remove it. In order to use the Jatropa oil in conventional diesel engine, the properties must be equal to diesel fuel properties. So the chemical process of trans-esterification was carried out by adding methanol as additive. First pure Jatropa oil is poured into a conical flask and it is heated to 50°C. A mixture of concentrated H<sub>2</sub>SO<sub>4</sub> (0.5%) and required amount of methanol was heated separately at 50°C and then the mixture is added in the heated Jatropa oil flask. The mixture was then allowed to settle for 24 hours in a separating funnel and then the settled glycerine was drained out. The heated water was supplied to remove unwanted matter in the blends of any excess glycerine. The blend was heated to remove any water content, until the mixed water in pure form is extracted, this process is repeated. Methanol was added in three different proportions of 25%, 20%, and 15% by volume with the Jatropa oil. This trans-esterification process was carried out by maintaining 0.1% of KOH.

## 3. Experimental setup

Single cylinder water cooled DI diesel engine having power output of 3.50 kW was used for this experimental work. Detailed specification of the engine and its combustion and performance parameters are given in Table 1. Photographic view of the experimental setup is shown in Fig. 1. Engine was operated at ambient temperature-27°C for different loads with different blends at a speed of 1500rpm. The load on the dynamometer, airflow rate, fuel flow rate, exhaust temperature, manifold pressure, cooling water flow rate, cylinder liner temperature, pressure time signal, injection pressure, crank angle, HC, CO, CO<sub>2</sub>, NO<sub>x</sub> and smoke emissions were noted after allowing enough time (10 to 15 minutes) for the reading to stabilize.

**Table 1: Engine specifications**

Parameter	Value
Cylinder bore diameter	87.50 mm
Stroke length	110 mm
Connecting rod length	234mm
Compression ratio	17.5
Swept volume	661.45 cc
Air density	1.17 kg/m <sup>3</sup>

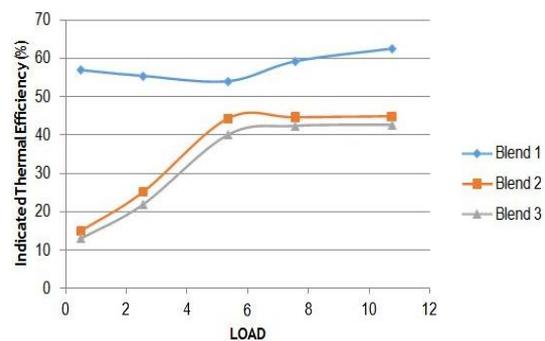
Parameter	Value
Adiabatic index	1.4
Polytropic index	1.28
No. of cycles	10
Cylinder pressure reference	4 bar
Cylinder pressure smoothing	2 bar
TDC reference	0
Orifice diameter	20mm
Orifice coefficient of discharge	0.60
Dynamometer arm length	185 mm
Fuel pipe diameter	12.40 mm



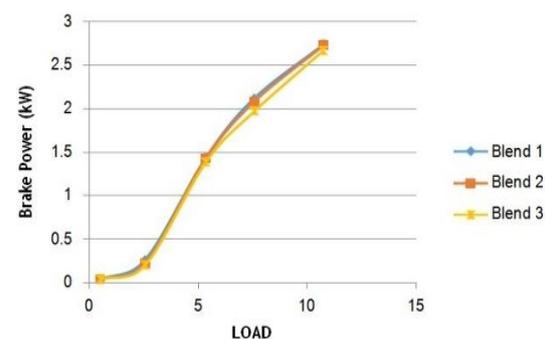
**Fig. 1: Photographic view of experimental setup**

## 4. Performance characteristics

From Fig. 2, it is clear that when the load increases the indicated thermal efficiency (ITE) also increases for all the blends. Among three different methanol blends, higher methanol blend gives higher ITE at all loads of operation. From Fig. 3, it is clear that when the load increases the brake power also increases for all blends. Comparing the three blends, blend 1 gives higher brake power in all the load conditions.



**Fig. 2: Load (kg) vs. ITE**



**Fig. 3: Load (kg) vs. Brake power**

Fig. 4 shows the variation of SFC with respect to load. It is evident that when the load increases the SFC decreases for all the blends. At no load engine operation there was huge consumption of Jatropha-methanol mixture than the consumption at the higher load.

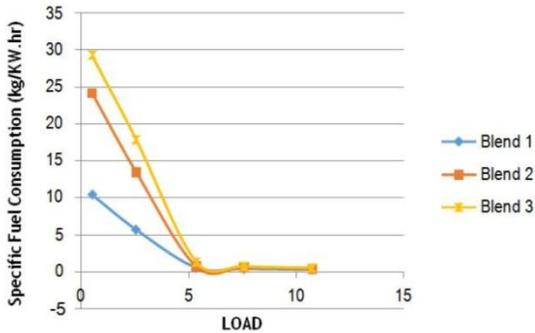


Fig. 4: Load (kg) vs. Specific fuel consumption

### 5. Emission characteristics

The non-dispersive infrared and electrochemical measurements were made to record HC, CO and NOx emissions. From Fig. 5, it is clear that for all the blends, when the load increases the CO emission percentage decreases. Blend 1 gives lower CO emission percentage than all other blends. Variation of CO2 emission with respect to the load is shown in Fig. 6. When the load increases the CO2 emission also increases. The engine operated with blend 1 gives higher CO2 emission due to complete combustion reaction. Considerably at higher loads of engine operation all the blends give higher CO2 emission. Fig. 7 shows the variation of NOx with respect to load. When the load increases, the NOx emission also increases for all the blends at all loads of operation. Due to proper mixing of fuel and air molecules complete combustion happens in blend 1 than all other blends at all of engine operations.

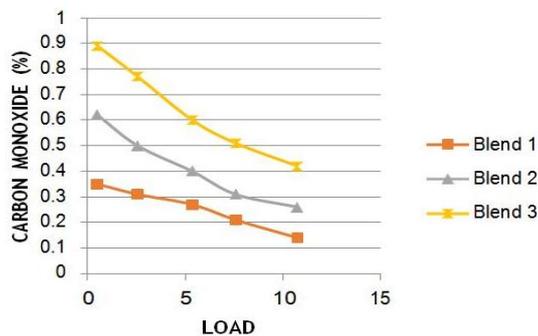


Fig. 5: Load (kg) vs. CO

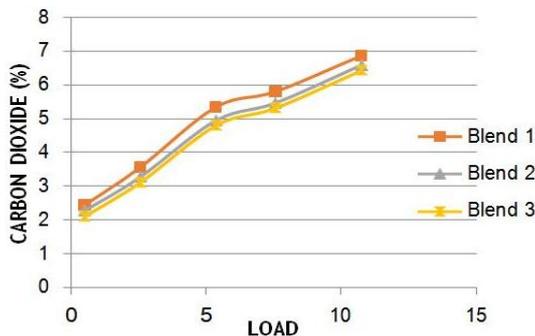


Fig. 6: Load (kg) vs. CO<sub>2</sub>

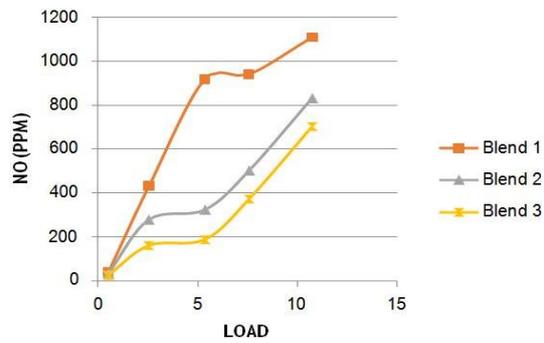


Fig. 7: Load (kg) vs. NO<sub>x</sub>

Load vs. Unburnt HC emission is shown in Fig. 8. When the methanol addition increases the HC emission decreases. Blend 1 gives lower HC emission than blend 2 and blend 3 at all loads.

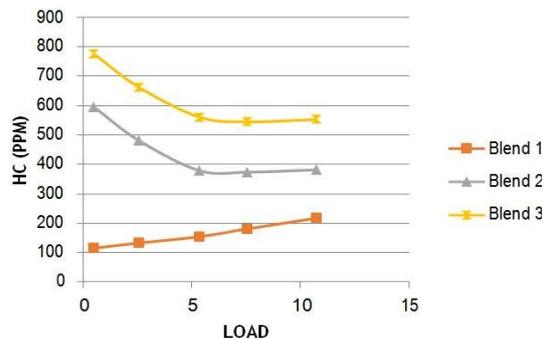


Fig. 8: Load (kg) vs. HC

### 6. Conclusion

For the three different blends of engine operation, when the methanol addition in Jatropha oil increases the performance parameters of ITE, and brake power increased and specific fuel consumption decreased. In emission point of view, when the methanol addition increases the emission of carbon monoxide and hydro carbon decreased but carbon dioxide and nitric oxide emission increased. At high load operation Jatropha-methanol blends gives acceptable performance and emission characteristics. Compared to all the blends, blend 1 gives higher ITE and brake power at all loads of CI engine operation.

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