

# Evaluation of Engine Performance and Emissions of a Twin Cylinder Diesel Engine Fuelled with Biodiesel and Ethanol Blends

Ankit Verma, C. Thamocharan, Ravi Kumar Sharma

**Abstract**— A comprehensive study on the fuel mixture containing ethanol and bio-diesel as an alternative fuel has been carried out. This report deals with the exhaust emission of bio-diesel on twin cylinder diesel engine. The objectives of this report are to analyse the fuel consumption and the emission characteristic of a twin cylinder diesel engine that are using bio-diesel obtained from *Jatropha* plant seeds compared to usage of ordinary diesel that are available in the market. This report describes the setups and the procedures for the experiment which is to analyse the emission characteristics and fuel consumption of diesel engine due to usage of the both fuels. Detail studies about the experimental setup and components have been done before the experiment started. Data that are required for the analysis is observed from the experiments. Calculations and analysis have been done after all the required data needed for the thesis is obtained. The experiment used diesel engine with no load conditions. A four stroke Twin cylinder diesel engine was adopted to study the brake thermal efficiency, brake specific energy consumption, mechanical efficiency, brake power, volumetric efficiency, indicated thermal efficiency and emissions at full load with the fuel of fraction ethanol in bio-diesel. In this study, the diesel engine was tested using ethanol blended with bio-diesel at certain mixing ratios of (B:E)- 75:25, 70:30 ethanol to bio-diesel respectively with the addition of diesel additive available in the store for trouble free starting. By the end of the report, the successful of the project have been started which is Kirloskar engine is able to run with bio-diesel blend but the engine needs to run by using diesel fuel first, then followed by bio-diesel blend and finished with diesel fuel as the last fuel usage before the engine turned off. The performance of the engine using blended fuel compared to the performance of engine with diesel fuel. Experimental results of blended fuel and diesel fuel are also compared.

**Index Terms**—Alternative fuels, Biodiesel- Ethanol blend (BE-blend), Diesel, Ethanol, Performance, Emissions.

## I. INTRODUCTION

Diesel particulate matter (PM) is an air is toxic and probably carcinogenic and the global energy crisis in the 1970s prompted many countries to search for alternative energy sources. The use of vegetable oil ester-based biodiesel and ethanol-based E-diesel occurred primarily as a direct result of that fuel crisis. Both biodiesel and E-diesel (blends of ethanol

in diesel) are currently being used in fleet vehicles in the European Union and the United States. This has led to serious consideration on seeking alternatives to replace diesel fuel for diesel engines. The use of bio fuels that are based on renewable resources has many advantages as well. Bio-diesel blends i.e mixture of *Jatropha* Oil and Ethanol are an ideal alternative to dwindling resources. The increasing dependence on imported crude oil also has led to a major interest by non-fossil-fuel-producing countries like ours. Biodiesels are biodegradable, nontoxic, and it can significantly reduce toxic emissions and particulate matter (PM), an increase in total hydrocarbon, while carbon monoxide and nitrogen oxides could increase or decrease depending on the engine type and operating conditions (Merritt et al. 2005; Li et al. 2005). Ethanol is alternative fuel for diesel engine. Its bio-mass based renewable fuel, it offers reduction in life cycle of Co<sub>2</sub> and it shows a significant PM reduction. Recently, the economy has also become much more favorable in the production of ethanol and it is able to compete with the standard diesel fuel. With calorific value marginally higher than regular diesel at 51900kj/kg as compared to 44800kj/kg. Ethanol is a low cost oxygenate with high oxygen content (35%) that has been used in ethanol–diesel fuel blends. The use of ethanol in diesel fuel can yield significant reduction of particulate matter (PM). However, there are many technical barriers to the direct use of ethanol in diesel fuel due to the properties of ethanol, including low cetane number of ethanol and poor solubility of ethanol in diesel fuel in cold weather. In fact, diesel engines cannot operate normally on ethanol–diesel blend without special additives, these additives have many benefits as well primarily they add cetane number and improves cold start ignition and warm-up., plus they optimizes combustion efficiency, shortens the ignition delay, Improves fuel oxidation stability with much more direct benefits to the engine life. By the previous studies it is also found that the ethanol–biodiesel–diesel fuel blends had better properties of water tolerance and stability than ethanol–diesel (Shi et al., 2005). One result of that study was the more reduction of PM with ethanol–biodiesel–diesel fuel blends compared to the biodiesel–diesel fuel blends, even if the blend ratios of additive to diesel fuel were the same. The PM reduction appeared to be related to the amount of oxygen content in the fuel blends (Shi et al., 2005). Based on that study, the blending of biodiesel, ethanol and diesel fuel is considered as a promising alternative fuel for diesel. The diesel engine used in this study was a two cylinder four stroke Kirloskar engine. Regulated emissions of PM, nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), total unburned hydrocarbon (THC), and carbon dioxide (CO<sub>2</sub>) were investigated and they were compared with the emissions of diesel fuel.

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## II. EXPERIMENTAL SETUP

Commercial diesel fuel used in regular gas stations was employed in this study as baseline diesel fuel and it was obtained locally. Provided by a local supplier, the biodiesel and the ethanol used in this study was analysis-grade anhydrous ethanol (99.7% purity). The ratios of fuel blend were 25:75 (ethanol: biodiesel) by volume which was denoted by BE-blend in the current literature. The setup is provided with a resistance load bank, DELTA 1600L exhaust gas analyzer and Diesel smoke meter..., etc for performance and emissions analysis.

Specifications of engine are shown in Table 1.

**Table 1: Engine specifications**

Engine Make	Kirloskar
Engine Type	Four stroke Twin cylinder diesel engine
No. of cylinders	2
Stroke	110mm
Bore	87.5mm
Method of cooling	Water cooled
Horse power HP	10HP
Type of starting	Crank start
Lubrication	Forced
Compression ratio	17.5:1
Rated speed RPM Max	1800
Air tank type	Square
Orifice diameter	20mm
Load type	Electric load bank
Cubic capacity	0.661 Litres
Digital temperature indicator	0-999 Degree
Digital RPM indicator	0-9999 RPM

## III. PROPERTIES OF DIESEL, JETROPHA OIL AND ETHANOL

**Table 2: properties**

Properties	Diesel	Jetropha oil	Ethanol
Density at 20°C g/cc	0.852	0.926	0.729
Cetane no.	46	38	6
Calorific value [MJ/kg]	45	39.5	29.7
Flash point °C	76	228	13.5
Cloud point °C	-6	6	-

## IV. EXPERIMENTAL PROCEDURE

Experiments were initially carried out on the engine using diesel as fuel in order to provide base line data. The various ratios of BE-blend were prepared and made to run on the engine. The blends were prepared on the proportions of (B: E)

75:25 and 70:30 with a fraction of diesel additive on volume basis. The engine was started using neat diesel and allowed to run for at least 30 minutes before taking observations. After engine conditions stabilized and reached to steady state, the base line data were taken. Load was varied using the alternator load bank and the same was recorded. Gaseous emissions, fuel consumption were also recorded from the respective sensor. In case of different ethanol and biodiesel blends, the engine was started on diesel and when engine became sufficiently heated; the supply of diesel was substituted by different ethanol and biodiesel blends for which a two way valve was used. All the data at different loads and blends were recorded only when engine reached to steady state.

## V. RESULTS AND DISCUSSION

The performance and exhaust emission parameters of the engine with biodiesel and ethanol with a fraction of fuel additive at different blend ratios are presented and discussed below.

### A. Specific fuel consumption

At higher temperature the effect of proportion of ethanol – biodiesel blends with a fraction of fuel additive on specific fuel consumption (SFC). At different loads the variation of SFC with load at different ratios of blends such as BE : blend - 75:25, 70:30 are almost equal to diesel. The reasons behind this results are lower energy value substitute ethanol is added to the bio- diesel blends, thus engine responds to the load by increasing the fuel flow. Thus SFC decreases with the increase in thermal efficiency.

### B. Brake thermal efficiency

From the plot it is observed that as load increases brake thermal efficiency is also increases for diesel. The increment in Brake thermal efficiency is due to better combustion because of high calorific value and less viscosity of BE-blend.

### C. NO<sub>x</sub> Concentration

NO<sub>x</sub> tends to increase with load, this increase in NO<sub>x</sub> is explained by the fact that at low loads, but as the load increases, the temperature also increases which in turn increases the NO<sub>x</sub> emissions. This is due to addition of ethanol to the blends which has the property of emitting less nitrogen oxides when it is burnt. NO<sub>x</sub> is comparatively decreased when compared to diesel fuelled engine. The effect of BE- blends on emissions is complex and is not conclusive. Either cetane number, fuel density or aromatic fuel composition can influence on NO<sub>x</sub> emissions. Many studies indicate that oxygenate fuel blends could cause slight increases in NO<sub>x</sub> emissions as well.

### D. CO Concentration

At constant speed, CO emissions from BE-diesel were greater than those from diesel fuel at most tested modes. In full load tests, CO emissions decreased at high speeds and increased at low speeds. Although BE-blend and diesel fuel blends were reported to reduce CO emissions. CO level is comparatively less when compared to diesel.

### E. HC Concentration

HC level is found to be low for BE- blend compared to diesel. Un-burnt hydrocarbon emissions are the direct result of incomplete combustion. Thus HC level is comparatively reduced with increase in the loads, this is due to diffused combustion, increased temperature and after burning phenomenon. HC is decreased moderately when the diesel engine was fueled with BE-blend.

### VI. CONCLUSION

Based on the performance and emissions of Biodiesel-Ethanol blend. It is concluded that the BE-blend represents a good alternative fuel with closer performance and better emission characteristics to that of a diesel. From the above analysis the BE-blend shows better performance in the sense of better performance characteristics like Brake thermal efficiency, Specific fuel consumption and decrease in the emission parameters like CO, HC except NOx.

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