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Engine Performance and Emission of a Twin Cylinder Diesel Engine Fuelled with Biodiesel and Ethanol Blends with the Fraction of Fuel Additives

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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. Reduces knock, noise, misfiring, shock load and engine wear. It reduces knock, noise, misfiring, shock load and engine wear. 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.*

Keywords--- *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

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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 (Merrittet 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 Co2 and it shows a significant PM reduction. Recently, the economy has also become much more favourable 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 Optimises 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 fours stroke Kirloskar engine. Regulated emissions of PM, nitrogen oxides (NO_x), carbon monoxide (CO), total unburned hydrocarbon (THC), and carbon dioxide (CO_2) were investigated and they were compared with the emissions of diesel fuel.

II. Project Background

Recently, changing the engine operating parameters such as valve timing, injection timing, and atomization ratio has been carried out in many studies on the internal combustion engines (ICE) aiming to reduce the exhaust emissions . At the same time, depletion of fossil fuels and environmental considerations has led to investigations on the renewable fuels such as methanol, ethanol, hydrogen, and biodiesel. Particularly ethanol can be obtained from many fossil and renewable sources. Biodiesel is an alternative fuel for diesel engine. The esters of vegetable oils and animal fats are known collectively as biodiesel. It is a domestic, renewable fuel for diesel engine derived from natural oil like Jatropha oil. Biodiesel has an energy content of about 12% less than petroleum-based diesel fuel o n a mass basis. It has a higher molecular weight, viscosity, density, and flash point than diesel fuel.

Ethanol-(C_2H_5OH) is the simplest of alcohol and originally produced by the destructive distillation of wood and sugarcane .However, ethanol can be produced from many fossil and renewable sources which include coal, petroleum, natural gas, biomass, wood landfills and even the ocean. In energy deficit countries like India, Ethanol can provide a sustainable solution against petroleum crisis due to the following reason:

Ethanol can be manufactured from a variety of carbon based feedstock such as natural gas and biomass (e.g., wood). As India is rich in all these sources, use of ethanol would diversify country's fuel supply and reduce its dependence on imported petroleum. Ethanol is much flammable than gasoline and results in less severe fires when it does ignite. So far fire safety purpose it is better than petroleum. Diesel Additive which is a concentrated formula containing highly active solvents, polymers, surface active agents, cetane improvers and corrosion and oxidation inhibitors. Improves engine performance year-round. It reduces the formation of injector nozzle deposits, Optimises combustion efficiency, increases cetane rating by 2 to 5 numbers, improves cold start ignition and warm-up, Shortens the ignition delay. It reduces knock, noise, misfiring, shock load and engine wear. Provides a quieter, smoother running engine with longer engine life, prevents rusting in fuel distribution and storage system, improves fuel oxidation stability.

III. PROJECT OBJECTIVES

The objectives of this project are to analyse the fuel consumption and the emission characteristic such as oxygen(O2), carbon dioxide(CO2), carbon monoxide(CO), nitrogen dioxide(NO2) and oxides of nitrogen(NOx) in a twin cylinder diesel engine that are using jatropha bio-diesel with ethanol is mixed compared to usage of ordinary diesel that are available in the market.

IV. 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 and 30:70 (ethanol: biodiesel) by volume which was denoted by BE-blend in the current literature. The setup is provided with a resistance load bank, DELTA 1600Lexhaust gas analyser 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

Properties of Diesel, Jetropha oil and Ethanol

Table 2: properties

Properties	Diesel	Jetropha oil	Ethanol
Density at 20^0c g/cc	0.852	0.926	0.729
Cetane no.	46	38	6
Calorific value [MJ/kg]	45	39.5	29.7
Flash point^{o}C	76	228	13.5
Cloud point^{o}C	-6	6	-
Fire point^{o}C	56	44	98.6
Boiling point,^{0} C	180–330	-	78
Viscosity, cS at 40^0C	3.11	3.04	1.2

V. 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 and70:30 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.

VI. 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.

6.1 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.

6.2 Brake thermal efficiency

Figure 2, shows the variation of brake thermal efficiency with respect to the proportion of biodiesel– ethanol blends at different loads. From the plot it is observed that as load increases brake thermal efficiency is also increases for diesel as well as blends of biodiesel- ethanol. At full load condition, the brake thermal efficiencies obtained are 6.75%, 12.98% and 11.96% for the diesel, BE-70:30, BE-75:25 respectively. Among the two blends of biodiesel- ethanol the maximum BTE is 12.98% which is obtained from BE-70:30. The BTE using BE-70:30 is increased by 6.23% as compared to the diesel at full load condition. The increment in Brake thermal efficiency is due to better combustion because of high calorific value and less viscosity of waste plastic oil.

6.3 NOx Concentration

Figures 3, shows the variation of NOx level with respect to proportion of biodiesel and 1ethanol blends at different loads.NO_x tends to increase with load, this increase in NO_x is explained by the fact that at low loads, but as the load increases, the temperature also increases which in turn increases the NO_x emissions. Results shows that NOx is comparatively higher with BE-70:30. It is found that NOx emission increases with increase in load. 100% Diesel and BE-70:30 has higher NOx level when compared to blend of BE-75:25. This is due to addition of ethanol to the blends which has the property of emitting less nitrogen oxides when it is burnt. NO_x 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_x emissions. Many studies indicate that oxygenate fuel blends could cause slight increases in NO_x emissions as well.

6.4 CO Concentration

Figures 4, shows the variation CO level with respect to proportion of biodiesel and ethanol blends at different loads. From the graph it is clear that the CO level decreases as the proportion of BE- blends. This is due to the fact that engine is not optimized to run with diesel oil blends or waste plastic oil, so there is a large possibility of rich fuel-air mixture in the cylinder and the higher specific fuel consumption resulting in a higher CO level at low speed.

At constant speed, CO emissions from BE-blends 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. Carbon monoxide occurs in engine exhaust. It is a product of incomplete combustion due to insufficient amount of air in the air fuel mixture or insufficient time in the cycle for the completion of combustion. CO level is comparatively less when compared to diesel.

6.5 HC Concentration

Figure 5, shows that the variation of HC level with respect to proportion of waste plastic oil and diesel blends with the fraction of methanol at different loads. HC level is found to be low for BE- blend compared to diesel. Unburnt 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 fuelled with BE-blend.

Figure1. Variation of Specific fuel consumption with load

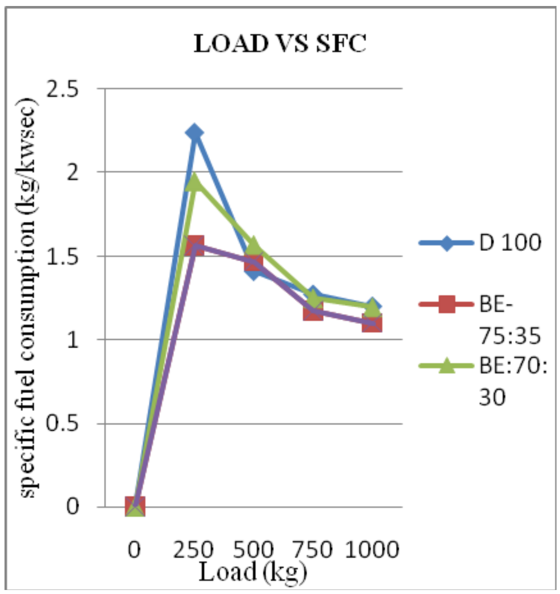

Figure2. Variation of Brake thermal efficiency with load

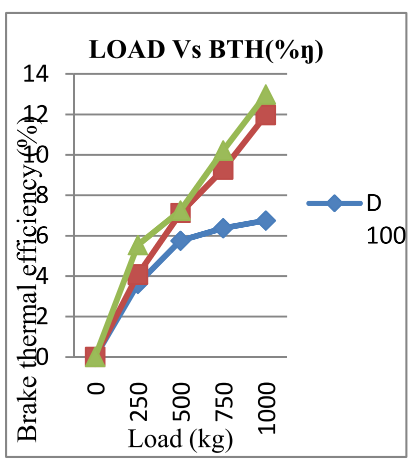

Figure 3. Variation of oxides of nitrogen with load

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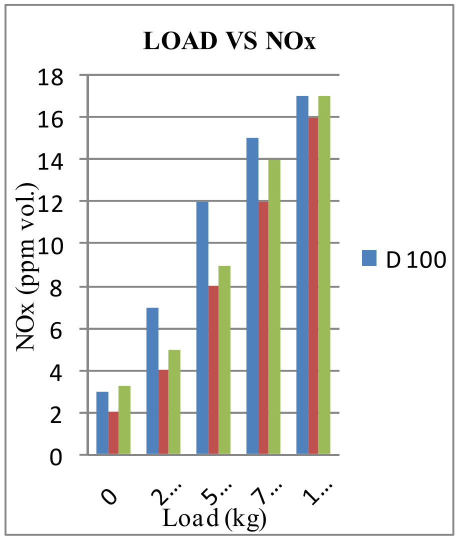


Figure 4. Variation of carbon monoxide with load

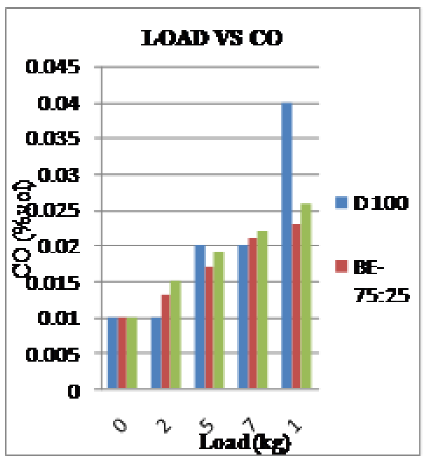


Figure 5. Variation of Unburnt Hydrocarbons with load

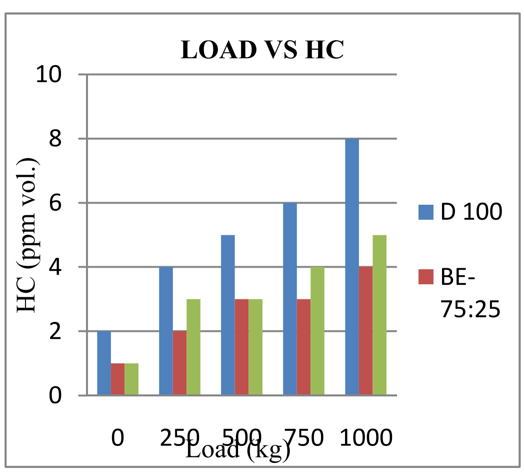
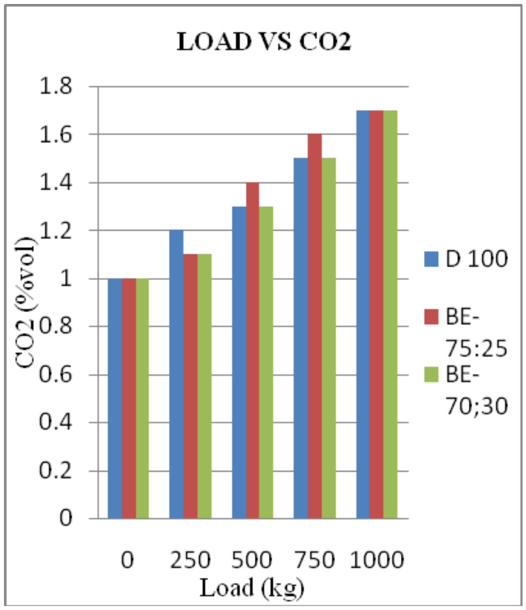


Figure 6. Variation of Carbon dioxide with load



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