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Performance and Emission Evaluation of Diesel Engine with Datura Stramonium Oil-Diesel Blends

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***Abstract*—Biodiesel is a non-toxic, biodegradable and renewable alternative fuel that can be used in diesel engines with little or no modification. Biodiesel is currently expensive but would be more cost effective if it could be produced from low-cost oils (restaurant waste, frying oils and animal fats). These fuels have properties similar to fossil diesel oils and have reduced emissions from a cleaner burn due to their higher oxygen content. The current impending energy and environmental crises have revitalized the need to find more viable renewable resources.**

In this work an attempt is made to analyze the performance and emission characteristics of diesel and different blends of datura stramonium oil namely B10, B20, B30, and B40 on volume basis by using a computerized diesel engine-electrical dynamometer set up. Performance parameters such as brake power, brake specific fuel consumption, and thermal efficiencies are calculated based on experimental analysis of the engine. Emissions such as carbon monoxide, oxides of nitrogen, NO_X and unburned hydrocarbon were measured.

The results shown that the brake thermal efficiency for B10, B20 blends is found to be 1.5% higher than that of diesel at full load condition. The emission results reveals that reduced CO of about 40%, UHC of about 50%, smoke value of about 15% for B10 and B20 blends at full load condition.

***Keywords*—Bio diesel, brake thermal efficiency, Datura Stramonium oil, Four stroke single cylinder engine, Unburnt Hydro Carbons.**

I. INTRODUCTION

The internal combustion engine is the key to the modern society. Without the transportation performed by the millions of vehicles on road and sea we would not have reached the living standard of today. Internal Combustion Engines (ICEs) play a dominant role in the automotive industry owing to their simplicity, robustness and high thermal efficiency. The Internal Combustion (IC) Engine is perhaps the most wide-spread apparatus for transforming liquid and gaseous fuel to useful mechanical work. The reason why it's so well accepted can be explained by its overall appearance regarding properties like performance, economy, durability, controllability but also the lack of other competitive alternatives.

There are two kinds of internal combustion engines: Petrol and the Diesel. The combustion processes of them are very different. In the Diesel engine the combustion is initiated because of some special conditions of pressure and temperature However, in the Petrol engine the combustion is caused by a spark that ignites a mixture that has been premixed before.

Biodiesel is a clean burning fuel, which means that it does not give off harmful emissions that cause environmental effects. Since bio-diesel is oxygenated, diesel engines have more complete combustion with bio-diesel than with petroleum. Biodiesel is safer to use than petroleum diesel. The use of biodiesel in a conventional diesel engine results substantial reduction of un-burnt hydrocarbons, carbon monoxide, and particulate matter.

Fossil fuels are dwindling and in order to maintain the current levels of energy use and the transport systems we rely on we need to find alternatives. There are also environmental concerns about the effects of using fossil fuels such as pollution and climate change. Bio energy may be part of the solution to these problems Bio-energy is the energy derived from harvesting biomass such as crops, trees or agricultural waste and using it to generate heat, electricity or transport fuels. The benefits of bio-energy include, sustainable and renewable fuels, decreased carbon dioxide release into the atmosphere and turning the problem of waste into a source of energy. Bio-fuels can be 'effectively' carbon neutral and in some cases may use emissions from power plants as a carbon source. Bio-fuels could power our cars, heat our homes and maybe fuel our planes. Liquid bio-fuels represent the only sustainable alternative to current transport fuels.

It will take a decade or longer to develop new sources of bio-fuel from research being carried out today. Research is currently focused on developing bio-fuels from plant sugars while future options may include using synthetic biology techniques and algae to produce biodiesel directly.

II. LITEERATURE REVIEW

Raheman & Kumari [1] have used an emulsified fuel containing 10% and 15% water by volume, prepared from a diesel blend with 10% Jatropha biodiesel (JB10) to evaluate the combustion characteristics of a 10.3 kW, single cylinder, 4-stroke, water cooled, direct injection (DI) diesel engine. Initially experiments have been conducted to determine the required hydrophilic–lipophilic balance (HLB). The results have showed that JB10 and its emulsified fuel have exhibited similar combustion stages to that of diesel with no undesirable combustion features observed such as an unacceptable increase of cylinder gas pressure. With increasing percentage of water, ignition delay has been found to be longer at higher engine loads. Reductions in emission of CO, CO2, HC and NOx have been observed for the emulsified fuel compared to JB10. Hence emulsified biodiesel can be recommended for use in place of biodiesel.

Sahoo & Das [2] have carried out combustion analysis of Jatropha, Karanja and Polanga based biodiesel as fuel in a diesel engine. The major objective of the present investigations is to experimentally access the practical applications of biodiesel in a single cylinder diesel engine used in generating sets and the agricultural applications in India. Diesel, neat biodiesel from Jatropha, Karanja and Polanga and their blends (20 and 50% by volume) have been used for conducting combustion tests at varying loads (0, 50 and 100%). The engine combustion parameters such as peak pressure, time of occurrence of peak pressure, heat release rate and ignition delay have been computed. Combustion analysis has revealed that neat Polanga biodiesel results in maximum peak cylinder pressure has been the optimum fuel blend as far as the peak cylinder pressure is concerned. The ignition delays have been consistently shorter for neat Jatropha biodiesel, varying between 5.9° and 4.2° crank angles lower than diesel with the difference increasing with the load. Similarly, ignition delays are found to be shorter for neat Karanja and Polanga biodiesel when compared with diesel.

III. DATURA STRAMONIUM OIL

Fig.1: Datura Stramonium Plant and Seeds

The Datura stramonium seeds were collected from the areas in and around Coimbatore district, Tamilnadu, India. The extraction of oil was carried out using mechanical expeller. The free fatty acid content in the oil was determined by titrimetric method. Two step Transesterification process, i.e. acid pretreatment step followed by base catalyzed Litty Koria and T. Thangaraj Journal of Ecobiotechnology 2/5: 42-46, 2010 method was used to produce biodiesel from Datura stramonium seed oil. The effect of alkali concentration on the yield of biodiesel was studied by varying the concentration ranging from 0.5% to 1.5% with 0.25 % increments. The effect of the molar ratio of methanol to oil on the yield of methyl ester formed from methanolysis was studied at various amounts of methanol. The different molar ratios of methanol to oil studied were 3:1, 5:1, 7:1, 9:1 and 11:1. The temperature was fixed at 65° C and catalyst concentration was fixed from the optimization studies. The Transesterification reactions were carried out to determine the optimum reaction time (30, 60, 90, 120 and 150 minutes). The biodiesel production was further optimized for reaction temperature by carrying out transesterification process at various temperatures ranges of 40- 50°C, 50-60°C, 60-70°C, 70-80°C and 80-90°C. The catalyst concentration was fixed at 1.0% and the methanol to oil ratio was fixed at 7:1 ratio for experiments with varying temperature and varying reaction time.

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IV. Experimental Work

In order to analyze the performance and emission characteristics of internal combustion engine, an experimental set-up was developed. In the present work, datura stramonium oil was used as biodiesel on volume basis. The experiment was carried out on a single cylinder water cooled direct injection computerized diesel engine. Eddy current dynamometer is used for loading i.e. electrical loading. The engine specifications are given in Table-1.

Fig.2 Four-stroke single cylinder computerized diesel engine test rig

Table I
Test Engine Specifications

Particulars	Specifications
Type	TV1
Make	Kirloskar oil Engine Ltd.
Arrangement of cylinders	Vertical
No of cylinders	1
Lubricant	SAE 20/SAE 40
Bore	87.5 mm
Stroke length	110mm
Rated speed	1500 rpm
Rated power	5.2 HP
Starting	Hand crank handling
Type of cooling	Water cooling
Ignition system	Compression ignition
Dynamometer	Electrical Dynamometer
Phase	3ϕ
Voltage	230V

V. Results And Discussions

A. Brake Specific Fuel Consumption

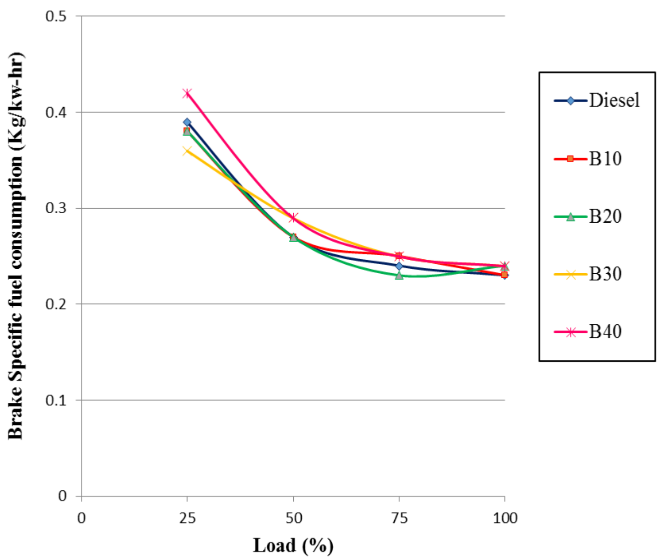

Fig.3 Load vs Brake Specific Fuel Consumption

The result for the variations in the brake specific fuel consumption (BSFC) with load is presented in the Fig.3 Brake-specific fuel consumption (BSFC) is the ratio between mass flow rate of the tested fuel and brake power. In general, the BSFC is found to increase with raising the biodiesel quantity with the blends under all ranges of engine load. The BSFC of a diesel engine depends on the relationship among fuel injection system, fuel specific gravity, viscosity and heating value. When increasing biodiesel proportion in blends, calorific value decreases and leads to increase the flow rate of the blends for maintaining the same operating conditions. At all load conditions, B10 and B20 gives near similar BSFC values when compared to diesel.

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B. Brake Thermal Efficiency

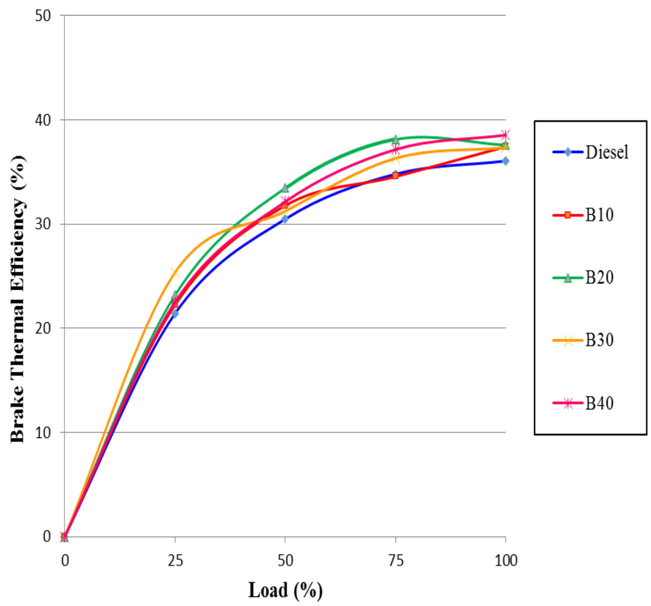

Fig.4 Load vs Brake Thermal Efficiency

The variation of brake thermal efficiency with respect to load for Datura stramonium oil blend and diesel are shown in Fig.4. It can be seen from graph that the B10 and B20 fuel blends incidentally gives higher efficiencies at all loads. The diesel fuel produced the lowest thermal efficiency at all loads. The higher thermal efficiency of the biodiesel blend may be due to their low heat input requirement for a given engine load. The brake thermal efficiency of B10 and B20 blends are increased around 1.5% at full load condition when compared to diesel.

C. Exhaust Gas Emissions of Carbon Monoxide

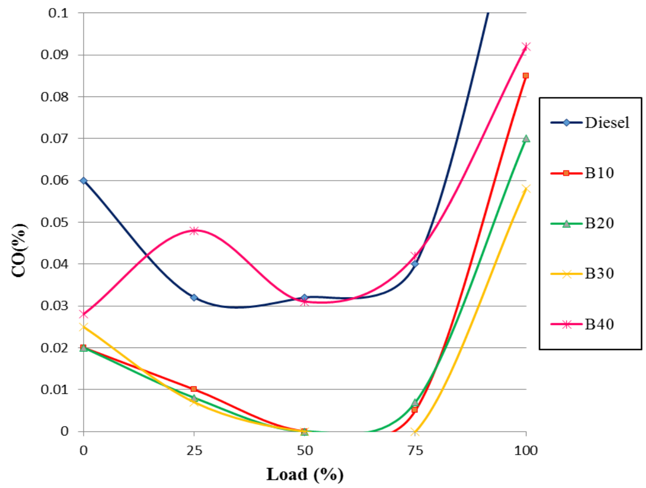

Fig.5 Load vs Carbon Monoxide

The Fig.5 shows the variation of carbon monoxide (CO) emission of Datura stramonium bio diesel with diesel at various load conditions. It is well known that better fuel combustion usually resulted in lower CO emissions. The carbon monoxide, which arises mainly due to incomplete combustion, is a measure of combustion efficiency. The CO emissions of B10, B20 and B30 at all loads are evidently lower than those of diesel fuel. This is due to the fact that biodiesel which contains more number of oxygen atoms leads to more complete combustion.

D. Smoke Value

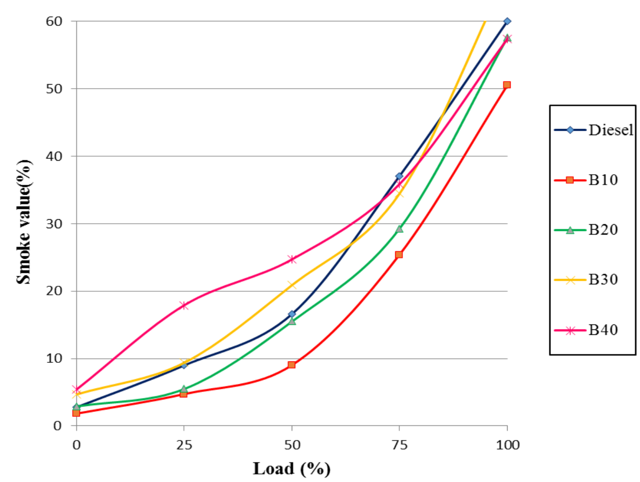

Fig.6 Load vs Smoke Value

The variation of smoke emission with different loads for diesel fuel and blend B10 is shown in Fig.6 Generally, smoke is formed due to incomplete combustion. Improvement of combustion will cause decrease in smoke density. For biodiesel mixtures, smoke value is less compared to diesel fuel. Due to heterogeneous nature of diesel combustion, fuel-air ratios, which affect smoke formation, tend to vary within the cylinder of a diesel engine. Smoke formation occurs primarily in the fuel-lean zone of the cylinder, at high temperatures and pressures. From the graph, it is clear that at all load conditions, B10 and B20 gives lower smoke values when compared to diesel.

E. Unburnt Hydrocarbon Emissions

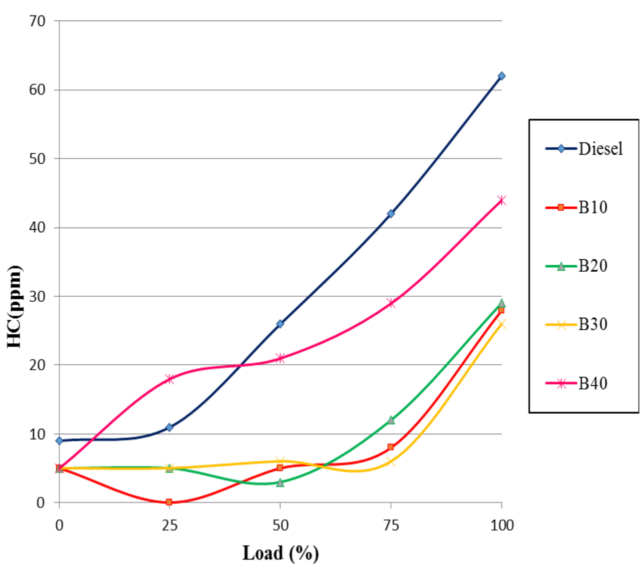

Fig.7 Load vs Unburnt Hydro Carbons

The variation of hydrocarbons with respect to load for tested fuels is depicted in Fig.7 it is an important parameter for determining the emission behavior of the engine. From the results, it can be noticed that increasing biodiesel in the blend reduces significantly HC emissions comparatively to diesel. This is due to the increase in oxygen content in the blend which improves the combustion quality in the combustion chamber. It can be noticed that at full load condition for all the blends, the reduction in HC emissions can reach 50% in comparison with diesel fuel.

F. Exhaust Emissions of Nitrogen Oxides

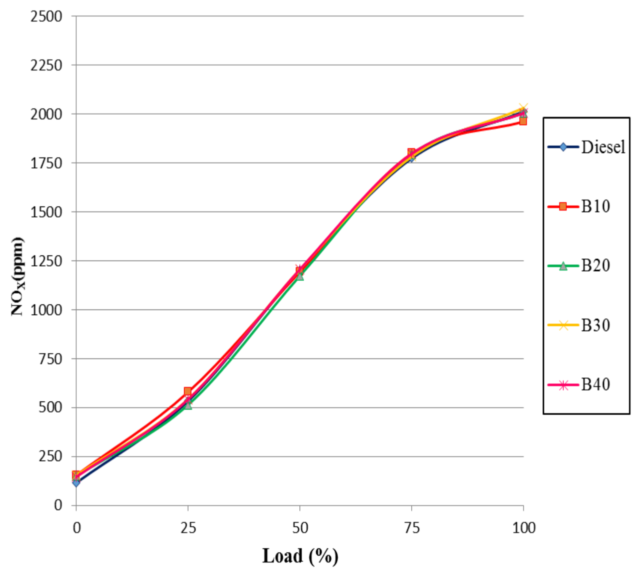

Fig.8 Load vs Nitrogen Oxides

Fig.8 shows the variation of nitrogen oxides (NOx) emission with different loads for the diesel and B10. There are mainly three factors namely oxygen concentration, combustion temperature, and time which affects the NOx emissions. As the load increases, the concentration of NOx is also increasing. The graph clearly shows the diesel NOx is slightly higher than the biodiesel blends. At particular loads NOx emissions of biodiesel and its blends are higher than those of diesel fuel. Higher values of combustion temperature and presence of oxygen with biodiesel result in an increase in NOx generation.

VI. CONCLUSIONS

Performance and emission characteristics of diesel (C.I) engine with blends of biodiesel of datura stramonium oil with diesel are tested in this experimental investigation. From this investigation, it can be concluded that the biodiesel blends B10 and B20 gives better performance and emission results compared to the diesel. The results of this work may be summarized as follows.

- At all load conditions, B10 and B20 gives near similar BSFC values when compared to diesel.
- The brake thermal efficiency of B10 and B20 blends are increased around 1.5% at full load condition when compared to diesel.

- CO emissions of B10, B20 and B30 are evidently 40% lower than those of diesel fuel.
- At full load condition for all the blends, the reduction in UHC emissions reaches 50% in comparison with diesel fuel.
- At all load conditions, B10 and B20 gives nearly 15% reductions in smoke values when compared to diesel.
- At particular loads NOx emissions of biodiesel blends are higher than those of diesel fuel.

VII. Scope Of Future Work

The present work can be extended by varying the different blends of biofuel with the diesel and the engine can be tested for better performance with various alternative fuels also.

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