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EVALUATION OF PERFORMANCE AND EMISSION CHARACTERISTICS OF BIODIESEL BLENDS WITH DIESEL IN A SINGLE CYLINDER DI DIESEL ENGINE

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ABSTRACT

Biofuel is an alternative fuels have been effectively applied world-wide in the transport, mainly due to running down the resources of crude oil, its increasing price, and also anticipated global climate changes. The wide variety of Vegetable Oils (edible and non edible) and animal oils are applicable as fuels in standard diesel engines. In this article the experiment was conducted on a single cylinder direct injection diesel engine is tested using animal oil blends B20 (20% animal oil and 80% diesel fuel) and B40 (40% animal oil and 60% diesel fuel) as fuels under variable load operating conditions at a constant speed of 1500rpm and their performance and emission characteristics were compared with diesel fuel. Here the engine was run successfully on a blend of B20 and B40 without any modification in engine parts. The results which are obtained for performance from B20 and B40 could not find slight progress than diesel fuel characteristics. The emissions result shows that increasing biodiesel concentration in the diesel fuel blend the carbon monoxide (CO) and hydrocarbons (HC) emissions are reduced. The smoke density was also reduced at some operating load conditions for biodiesel blends. In general, animal oil blends with diesel shows a considerable reduction in emissions.

Keywords*: Diesel; Biodiesel; CI Engine; Engine Performance; Exhaust Emission.*

NOMENCLATURE

CO	Carbon monoxide
HC	Hydrocarbon
CO_2	Carbon dioxide
BTE	Brake thermal efficiency
BSFC	Brake specific fuel consumption
DI	Direct injection
BP	Brake power
B20	20% biodiesel + 80% diesel
B40	40% biodiesel + 60% diesel
KW	Kilowatt
HP	Horsepower
Kg	Kilogram
RPM	Revolutions per minute
Cc	Cubic centimeter

INTRODUCTION

Diesel engines are largely used in many fields, including electric production, transport of passenger and cargo, industrial and agricultural activities. Petroleum fuels are being used in diesel engines, which has a broad range of use in all sectors. With a probable situation that oil demand cannot be met by petroleum based fuels, all the sectors that contributed by oil based energy will be negatively affected. With any probable petrol crises, for all the sectors the alternative fuels are vital to be developed. Now the use of bio-diesel is catching up all over the world, especially in developing countries. Biodiesel is an alternative fuel for diesel engine it can be manufactured from vegetable oils, animal fats and used cooking oils by transesterification process. Transesterification is a chemical reaction in which vegetable oils and animal fats react with alcohol (methanol or ethanol) in the presence of a catalyst.The output of the products from the reaction is fatty acid alkyl ester (biofuel) and glycerine [1].

The term biodiesel commonly refers to fatty acid methyl or ethyl esters made from vegetable oils or animal fats, whose properties are good enough to be used in diesel engines. The regulations limiting such properties are EN-14214 in Europe [2] and ASTM D-6751-03 in USA [3], although ethyl esters are not yet acknowledged as biodiesel in Europe [4]. Research papers presenting results of diesel engine emissions from biodiesel often ignore some of the basic properties of the biodiesel used [5], which makes it difficult to determine whether its quality has some effect or not.

In other cases, pollutants are being produced because of the combustion of petroleum based fuels in diesel engines. Pollutants from diesel engines consists of carbon monoxide (CO), carbon dioxide (CO2), sulphur dioxides (SO_x), oxides of nitrogen (NO_x) and particulate matter (PM). $NO_x$and PM are the two major pollutants of diesel engines [6]. It was stated by Lloyd and Cackete [7] that Diesel emissions contribute to the development of cancer; cardiovascular and respiratory health effects, pollution of air, water, and soil; soiling; reductions in visibility; and global climate change. Research on reducing emissions resulted from diesel engines and studies on decrease fuel consumption are being found worldwide, especially in EU countries. There are many works on reliable researching and implementations and useful results have been came to exist.

Research and developing alternative diesel engine fuel is one of these studies. The alternative diesel fuels must be technically acceptable, economically competitive, environmentally acceptable and easily available [8]. Researches on biodiesel derived from vegetable oils and animal fat are being maintained to alternate this kind of fuels to petroleum based diesel fuel.

Biodiesel may also be produced from less expensive fats, including inedible tallow, pork lard and yellow grease. These raw materials can be suitable for biodiesel production. Besides, their high cetane number and heating values are close to the diesel fuel and their oxygen content makes animal fats to have surplus advantages [9]. Animal fats are highly viscous and mostly in solid form at ambient temperature because of their high content of saturated fatty acids. The high viscous fuels lead to poor atomization of the fuel and result in incomplete combustion. Transesterification and emulsification are two main solutions that have appeared as effective methods for using animal fats in diesel engines. The fuel produced by these methods from animal fats and vegetable oil, reduces pollutant emissions and improves combustion [10]. Animal tallow generated biodiesel offers a wide range of energy, environmental.

The present paper tells that the experiment was conducted on a single cylinder direct injection diesel engine is tested using animal oil blends B20 (20% animal oil and 80% diesel fuel) and B40 (40% animal oil and 60% diesel fuel) as fuels under variable load operating conditions at a constant speed of 1500 rpm and their performance and emission characteristics were compared with diesel fuel. Here the engine was run successfully on a blend of B20 and B40 without any modification in engine parts.

FUEL PROPERTIES

The physical properties of the diesel and biodiesel blends like kinematic viscosity, dynamic viscosity, density, flash point, fire point were measured in the laboratory. The major properties of the fuels are shown in Table 1.

Table 1. Properties of biodiesel blends

Properties	Diesel	Animal Fat biodiesel	B20	B40
Density (kg/m^3)	831	867	838	845
Kinematic viscosity (CST)	2.89	4.86	3.36	3.95
Flash Point (^{0}C)	50	125	64	71
Fire Point (^{0}C)	56	145	70	77
Calorific value (KJ/kg)	42700	38450	41850	41000

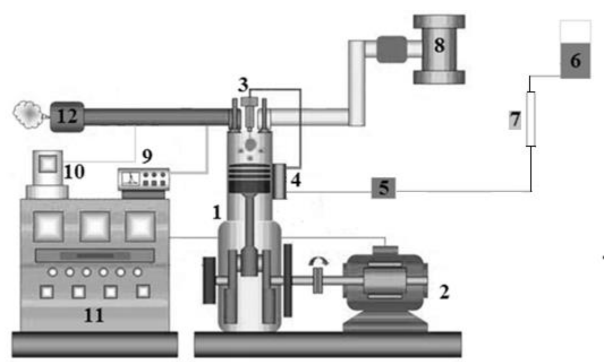
EXPERIMENTAL SETUP

Tests were carried out on a Kirloskar AV1 single cylinder water cooled; four stroke diesel engine developing a power output of 3.7 kW at rated speed of 1500 rev/min is used for this work and the specifications are shown in Table 2.

A DC shunt dynamometer is used for loading the engine. The fuel flow rate is measured on volume basis using a burette which is fixed between fuel tank and fuel pump and a stop watch. The carbon monoxide (CO), carbon dioxide (CO_2) and hydrocarbons (HC) emission were measured by the AVL exhaust gas analyzer and Smoke density was measured with the help of a Bosch smoke meter.

Table 2.Engine specification

Make :	Kirloskar
Model :	AV1
No. of cylinder :	1
Type :	Direct injection, water cooled, Four stroke
Bore × stroke (mm) :	80 × 110
Cubic capacity (Litre) :	0.553
Compression ratio :	16.5:1
Rated power (kW-HP) :	3.7 kW - 5 HP
Rated speed :	1500 rpm
Starting :	Hand start
Engine weight (dry) :	130 kg
Injection pressure :	200 bar



1. KirloskarAV1Engine 7. Fuel consumption measurement
2. DC shunt dynamometer 8. Air stabilizing tank
3. Injector 9. AVL exhaust gas analyser
4. Fuel pump 10. Smoke meter
5. Fuel filter 11. Dynamometer control
6. Fuel tank 12. Exhaust pipe

Fig. 1. Schematic of experimental setup

RESULTS AND DISCUSSIONS

All the performance and emissions characteristics results were plotted and compared for various blends of biodiesel with the help of following graphs.

- Brake thermal efficiency Vs Load (%)
- BSFC Vs Load (%)
- HC, CO, CO_2, smoke emissions Vs load (%)

Here the performance and emission characteristics results were discussed and analyzed the results in the following sections.

Brake specific fuel consumption

The variation of brake specific fuel consumption (BSFC) with load for different fuels is presented in Fig.4.1. For all fuels tested, BSFC is found to decrease with an increase in the load. The BSFC value for B20 and B40 biodiesel was found to be more than diesel fuel by about 7% and 8% respectively at 75% load. As the density of animal fat biodiesel was higher than that of diesel fuel, which means that some authors have reported higher density of fuel leads to more fuel flow rate for the same displacement of the plunger in the fuel injection pump, thereby increasing specific fuel consumption. One more reason is the calorific value of animal fat biodiesel which is 9-10 % less than that of diesel fuel. The lower heating value of biodiesel requires that a larger amount of fuel to be injected into the combustion chamber to produce the same power.

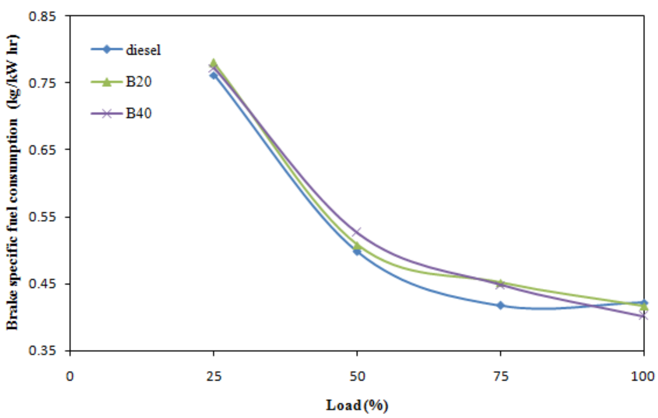


Fig. 2 Comparison of brake specific fuel consumption with load

Brake thermal efficiency

The variation of Brake thermal efficiency (BTE) with load for different fuels is presented in Fig.4.2. In all cases, brake thermal efficiency has the tendency to increase with increase in applied load. This is due to the reduction in heat loss and increase in power developed with increase in load.

It can be seen from the figure, that the thermal efficiency of diesel fuel is highest and it was decreased for B40 and B20 biodiesel fuel. The mean thermal efficiency for B20, B40 was less than that of diesel fuel by about 10%, and 7.6%, respectively. The animal fat methyl ester has a higher viscosity, density and lower heat value than the diesel fuel. The higher viscosity leads to poor atomization, fuel vaporization and combustion, and hence the thermal efficiency of biodiesel are lower than that of diesel fuel. Fuel consumption increases due to higher density and lower heating value consequently, thermal efficiency decreases.

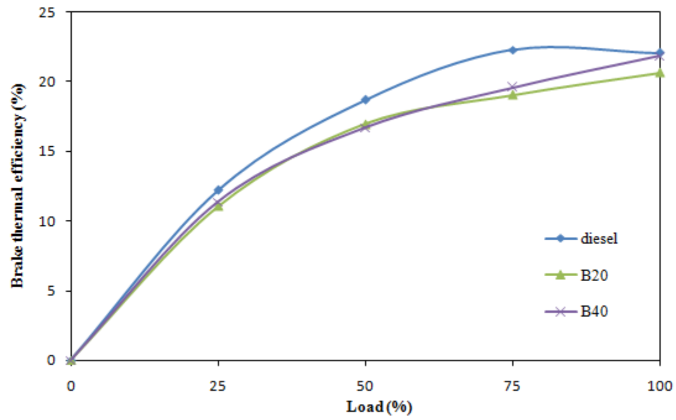


Fig.3 Comparison of brake thermal efficiency with load

HC emissions

The emissions of unburned hydrocarbon variation with load for different fuels are presented in Fig. 4.3. As the load increases, unburned HC emissions decrease for all of the cases due to the increase in combustion temperature associated with higher engine load.

It was observed that biodiesel fuel blends show lower emissions than that of diesel fuel. Average emissions of B20 and B40 blends were lower by 26 % and 22 % than that of diesel. The possible reason is oxygen content in the biodiesel, which leads to a more complete and cleaner combustion. In addition the higher cetane number of biodiesel reduces the combustion delay, and such a reduction has been related to decreases in HC emissions.

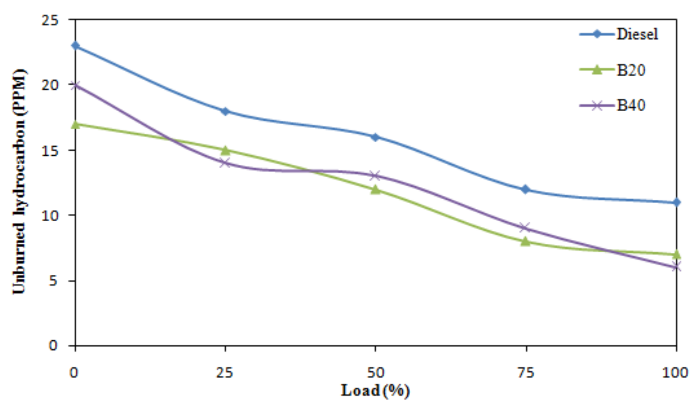


Fig.4 Comparison of Unburned hydrocarbon emissions with load

Carbon monoxide emissions

The variations of CO emissions in load for different test fuels are presented in Fig. 4.4. It can be observed that both biodiesel-diesel blend and biodiesel-diesel-ethanol blend shows lower CO emissions than that of standard diesel fuel. The possible reason for this decrease in emissions is, the more oxygen content of biodiesel and its blends. In addition, it is likely that biodiesel has C/H ratio that is less than for diesel fuel, Because of this reason diesel fuel has highest value especially at mid ranges of loads.

It can also be observed that CO emissions trend is not linear. CO formation is significantly affected by in-cylinder temperature. It is reported in the literature that when the fuel blends are used, the combustion process can be dissimilar for different tests, therefore; performance and emissions results can be different. In the figure, it can be observed that emissions of B20 fuel are highest at lower and higher loads. The temperature can cause this result.

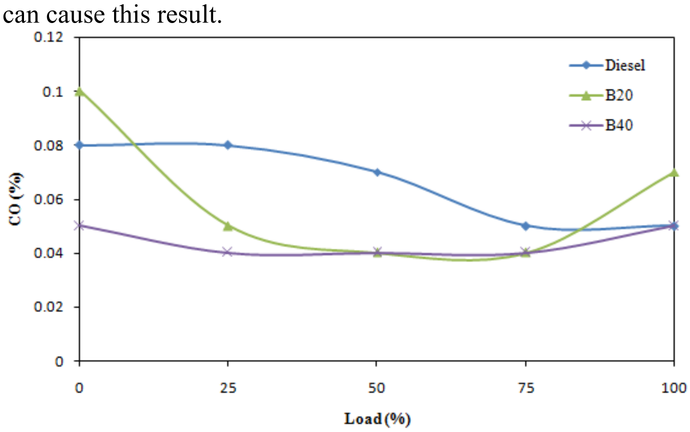


Fig.5 Comparison of Carbon monoxide emissions with load

Carbon dioxide emissions

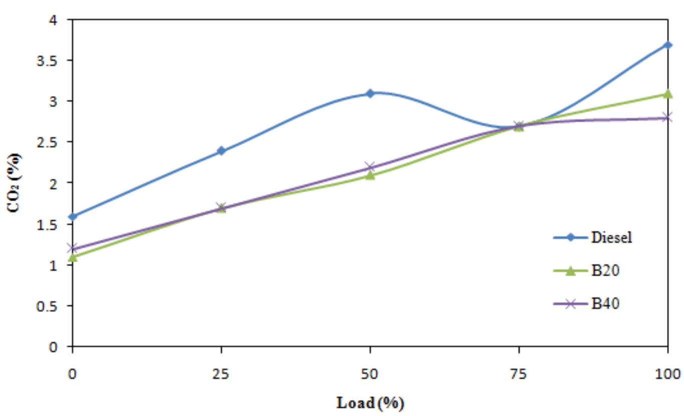


Fig.6 Comparison of Carbon dioxide emissions with load

The variation of CO_2 emissions with load for different test fuels is presented in Fig. 4.5. The CO_2 for B20, B40 fuels for most of the load ranges explained that combustion is more complete for both mentioned fuels. B20 and B40 fuels are having good oxygen enrichment and better combustibility. The CO_2 of biodiesel blends are considerably less than that of standard diesel fuel.

Smoke emissions

The variation of smoke emissions with load for different test fuels is presented in Fig. 4.6. The smoke emissions were less than for the diesel fuel. The difference is significant, especially at higher loads. Smoke levels are high at high power outputs. This is due to the presence of fuel rich core at high loads.

The average smoke for B20 and B40 were less than that of diesel fuel by 24.4%, 44% respectively. The smoke reduction when using biodiesel is explained by oxygen content in the fuel that contributes to complete fuel oxidation. The carbon content in animal fat methyl ester is lower than diesel fuel. The more carbon a fuel molecule contains, the more likely it is to produce soot. Conversely, oxygen within a fuel decreases the tendency of a fuel to produce soot.

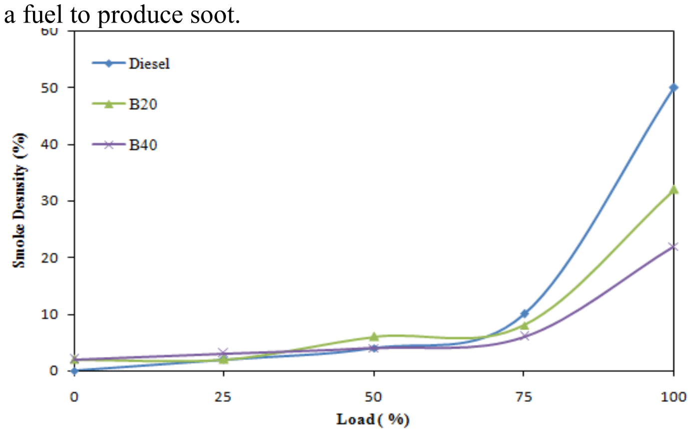


Fig.7 Comparison of Smoke emissions with load

CONCLUSIONS

The present paper investigation tells several tests were carried out on a four stroke, single cylinder vertical water cooled direct injection diesel engine using diesel and animal fat biodiesel at different volume proportions like B20 and B40. From the experimentation following conclusions were drawn.

- Viscosity and density of animal fat biodiesel are found to meet ASTM D 6751 and EN 14214 specifications. The values are found to be very close to that of diesel. The calorific value is found to be lower than that of diesel.
- BSFC of B40 and B20 blends are found to be higher than that of diesel.
- The thermal efficiency of diesel fuel is highest and it was decreased for B20 and B40 biodiesel fuels. The mean thermal efficiency for B20, B40 was less than that of diesel fuel by about 10%, and 7.6%, respectively.
- HC emissions were observed that biodiesel fuel blends show lower emissions than that of diesel fuel. Average emissions of B20 and B40 blends were lower by 26 % and 22 % than that of diesel. The possible reason is

oxygen content in the biodiesel, which leads to a more complete and cleaner combustion.

- The CO emission was observed that emissions of B20 fuel are higher at lower and higher loads and B40 was found to be enhanced than diesel Co emission.
- The CO_2 for B20 and B40 fuels are considerably less than that of standard diesel fuel because of good oxygen enrichment and better combustibility.

The average smoke for B20 and B40 were less than that of diesel fuel by 24.4%, 44% respectively.

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