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Performance Evaluation of Bio-Fuel Blends For Replacing Diesel in A Diesel Engine

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Abstract : This study is to investigate a bio-fuel to replace diesel consumption. Bio-diesel from cotton seed oil (non – edible) prepared bytrans-esterification process and ethanol anhydrous are blendedin various proportions, the properties of the blends are determined as per the ASTM standards. Blends containing 5%, 15%, 25% of ethanol and rest biodiesel are tested in a diesel engine for the performance and emission characteristics at various loads. Results are compared with diesel as base fuel. From the results it is observed that the BTE of allthe blends are closer to diesel. BSFC and emissions of CO, HC and NOx emission for the blends are lesser than diesel. The study shows that using of these blends can replace diesel to a greater extent and also reduce the emission affecting the environment impact.
Keywords : Bio-fuel, Cotton seed oil, Transesterification, Ethanol.

1. Introduction

The world major energy source is met by fossils fuel.As per the present study about the reservation of petroleum fuel includes diesel will deplete within 40 years the consumption rate is increased to 3% per annumThere is an insufficient availability of fossils fuel makes to find an alternative solution for the energy concerns. Dr.Rudolf Diesels developed a concept of vegetable oils as fuel for diesel engine on 19th century. [1-3]The Alternate thoughts against to conventional fuels aredue to the causes of environmental effects and the world's markets price fluctuation for petroleum. The researchers tried renewable fuels such as raw vegetable oil, waste cooking oil, biodiesel, methanol and ethanol[4–6]Vegetable oil and animal fat can be used as fuel after reacted with alcohol by the process of transesterification to make bio diesel. This can be used directly to diesel engine without any modifications [7-9].

C.D.Rakopouloset al. [10] studied that bio-fuels made from agricultural products (oxygenated by nature) may not only offer benefits in terms of exhaust emissions but also reduce the dependency of oil. Among these, vegetable oils or their derived bio-diesels (methyl or ethyl esters) and bio-alcohols are considered as very promising fuels the development of alternative fuel sources.MohdHafizil Mat Yasin et al. [11] investigated that the limitation in using biodiesel as fuel in diesel engine is viscosity. It plays an important impact under low temperature poor atomization, resistance to flow and it will affect the fuel injection quantity and quality. The alcohol additives will improve the viscosity by even small percentage of concentrations like 5% and 10%. Biodiesel fuels have higher lubricity than conventional fuels, but they can contribute to the formation of deposits, the degradation of materials or the plugging of filters, depending mainly on their degradability, their glycerol (and other impurities) content, their cold flow properties, and on other quality specifications [12-14]. Anand R et al. [15] suggested that world largest cotton seed production potential of 4.6 million tonnes of oil seeds per year was contributed by the first china and the second is India. Vinukumar Ket al.[16] studied that the

cottonseed which remains after the cotton is ginned will be used to produce cottonseed oil. Cotton seed oil is a waste product of the cotton industry, so it costs the food manufacturers next to nothing to procure a plentiful supply.C.D.Rakopoulos et al. [17] studied that Bio-ethanol and especially bio-diesels are considered as the most promising fuels (oxygenated by nature), having the added advantage of being derived from biological sources.

From these studies, the researchers have tried with bio-diesel[18-31] with diesel and ethanol also tried with additives. The present research work is to investigate an alternate bio-fuel to replace diesel and reduce the emission. Biodiesel from cotton seed oil and ethanol in various proportions are made and tested for the performance and emission characteristics in a diesel engine and the results are compared with diesel asbase fuel.

2. Experimentation

2.1. Biodiesel Preparation

The transesterification process of cottonseed oil prepared using 35g potassium hydroxide as catalyst and methyl alcohol 2lts per cottonseed oil 5lts. First, the cottonseed oil was heated to about 55^{o}C in a reactor with a capacity of about 20lts. Methyl alcohol and catalyst want to mix let it to be dissolve and added to the heated cottonseed oil in the reactor and stirred for 1 hr at a fixed temperature of about 55^{o}C, it was transferred to another container and allowssettling down the glycerol, the upper layer of methyl ester transferred to another vessel.Then distillation process at about 1100C for eliminates the water content in the esterified cottonseed oil. Cool down to get cottonseed oil methyl ester (CSOME)

2.2. Blend Preparation

Cotton seed oil Biodiesel and Ethanol are taken for the blend preparation. The blend is prepared by volume basis, three blends are prepared and the blend proportions is 95%, 85% and 75% of biodiesel and 5%, 15% and 25% of Ethanol respectively, the properties of the fuel blends are shown in the table 2.

2.3. Engine Testing setup

The layout of the Engine setup chosen to carry out experimentation is shown in the fig 1. And table 1 shows the specification of the engine. The engine is connected to a DC electrical eddy current dynamometer to loading. The emission of the test engine was analysing by smoke meter and the gas analyser which is connected to the exhaust

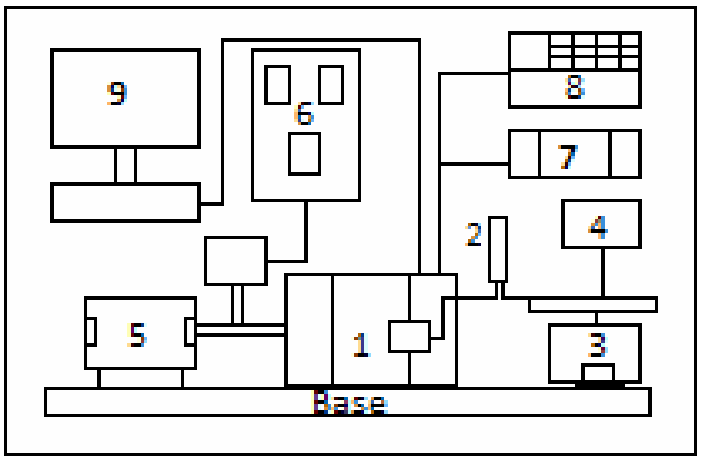

Fig.1. schematic diagram of experimental setup

1. Test Engine
2. Fuel Burette
3. Weighing Unit
4. Fuel Tank
5. Dynamometer
6. Volt Meter
7. Smoke Meter
8. Gas Analyser
9. Control Unit

Table.1. Engine Specification

Property	Description
Name	Kirlosker oil engine.
No. of cylinders	1
IS rating at 1500 rpm	4.41 kW(bhp)
Bore	87.5mm
Stroke	110 mm
Cubic capacity	0.662 liters
Nominal compression ratio	17.5:1
Fuel timing by spill (BTDC)	23 Deg
Nozzle opening pressure	200-205 kg/cm²
BMEP	5.44 kg/cm²

Table.2. properties of fuel

Sn	Properties	Diesel	Ethanol	CSOME	B95E05	B85E15	B75E25
1	Density @ 15°c (kg/m^3)	840	821.6	862.4	860.3	856.2	852.2
2	Kinematic viscosity @40C (cSt)	2.6	1.1	3.5	3.38	3.14	2.9
3	Flash point (°c)	70	13	200	190	172	153
4	Fire point (°c)	55	-	56	53	47	42
8	Cetane Number	50	8	38	36	33	30
9	Oxygen content (wt. %)	0	35	10.49	5.85	7	8.3
10	Gross caloric value kJ/kg	43000	27000	35660	35227	34361	33495
11	Latent heat of evaporation kJ/kg	250	840	230	130.2	160.7	191.2

3. Results and Discussion

3.1. Performance parameter

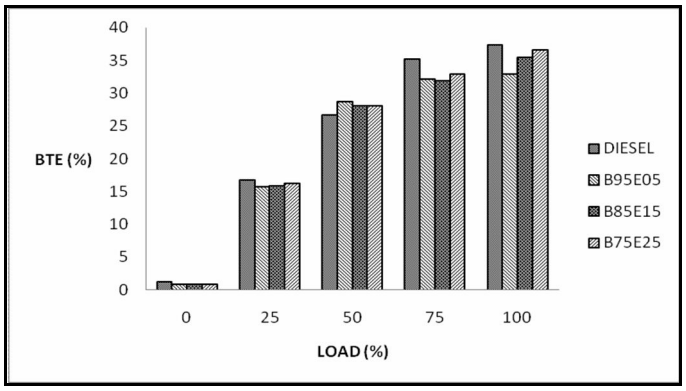

Fig.2. Variation of Brake Thermal Efficiency with loads

Fig.2. shows the variation of the brake thermal efficiency (BTE) with loads. It is observed that the BTE of the blends are higher than diesel in part load for all the blends and closer and lower for the blends at higher loads. The blend B95E05 shows maximum decrease of BTE in higher loads and for other two blends are increased compare to the blend B95E05 in a proportion of ethanol added in the blends. Lower calorific value and lower cetane number resulting in decrease of BTE for the blends compare to the diesel.

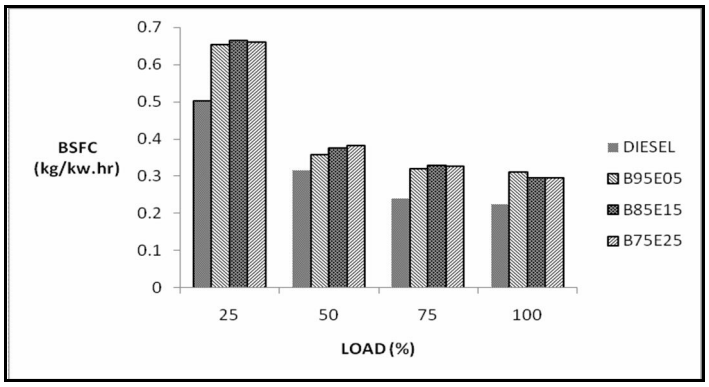

Fig.3.Variation of Brake Specific Fuel Consumption with loads

Fig.3. shows the variation of the brake specific fuel consumption (BSFE) with loads. It is observed that the BSFC for all the blends are higher compared to diesel for all the loads. B95E05 showing higher BSFC than all the blends in full loads. BSFC for all the blends are lower at higher loads Compared to lower loads. The higher density and lower calorific value of the blends results the increase in BSFC compared to diesel.

3.2.Emission parameters

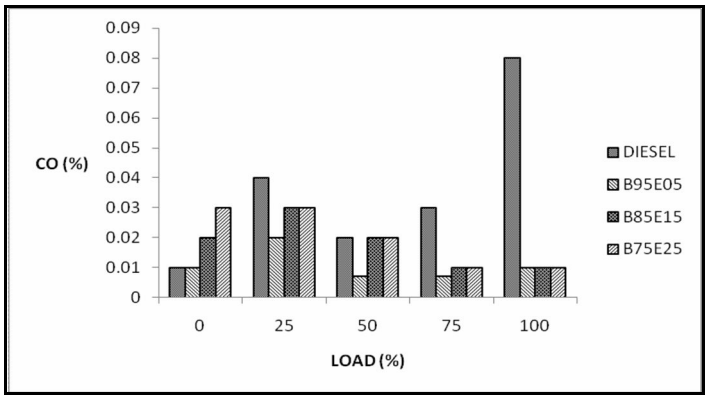

Fig.4. Variation of Carbon Monoxide with loads

Fig.4. shows the variation of the Carbon Monoxide emission with loads. It is observed that the CO emission for all the blends are lower or equal compared to the diesel except no load condition. In full load there is an 87% of reduction of CO are showing compared to diesel. Complete combustion for the blends results in the reduction of CO emission as compared to diesel.

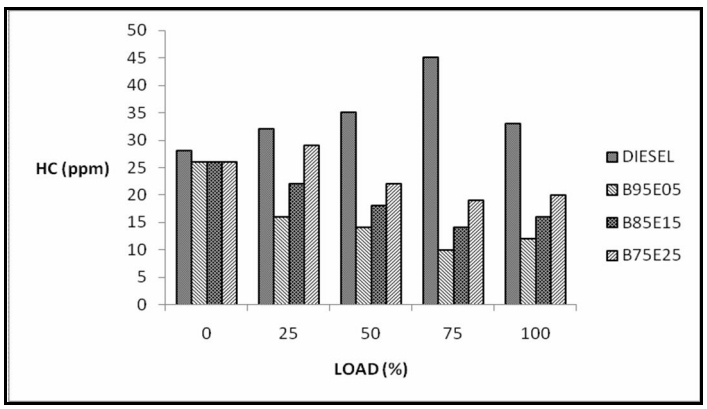

Fig.5.Variation of Hydro Carbon with loads

Fig.5. shows the variation of the Hydro Carbon emission with loads. It is observed that there is reduction of HC for all the blends at all the loads. The B95E25 is the least HC emission observed. The decreasing trend of the HC for the blends is proportional to lesser ethanol content presence in the blends. Lower HC emission at higher loads compared to lower loads is due to the increase of average mean temperature of the combustion chamber.

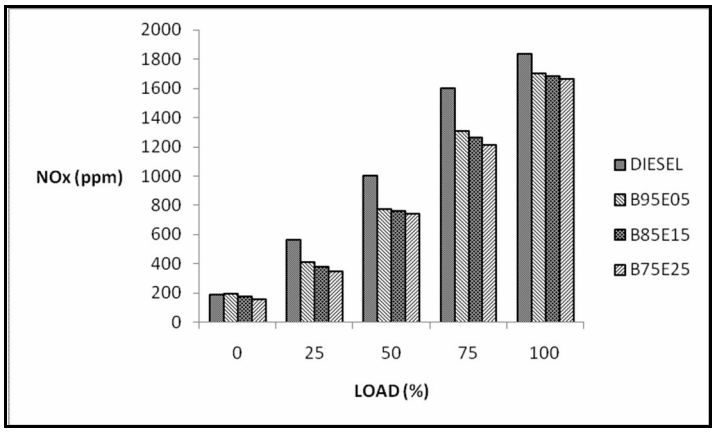

Fig.6. Variation of Oxides of Nitrogen with loads

Fig.6. shows the variation of the Oxides of Nitrogen emission with loads. The NOx emission is lesser for all the loads and for all the blends compared to diesel. The decreasing trend of the blends is proportional to the ethanol added in the blends. The reduction of NOx is due to the higher latent heat of evaporation characterise of ethanol.

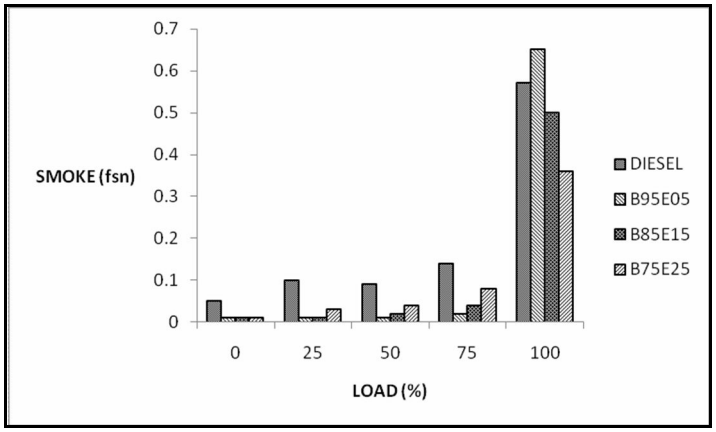

Fig.7.Variation of Smoke with loads

Fig.7. shows the variation of the smoke emission with loads. It is observed that the smoke for all the blends is lower compared to diesel except B95E05 blend at full load. The decreasing trends of the blends at full load are proportional to the ethanol added in the blends.

4. Conclusions

BTE for the blends are higher in part load and at full load closer to diesel for the blend containing 25%Ethanol. Maximum reduction of BTE is 12% reduction compared to diesel.

BSFC for the blends are higher compare to diesel however there is not much increase in the BSFC at full load.

CO emission for the blends is lower than diesel at full load the CO emission for the blends are reduced up to 87%.

HC emission for the blends is lower than diesel at all the blends for all the loads. The blend B95E05 shows the minimum HC at full load and reduced up to 63% compared to diesel

NOx emission for the blends is lesser than diesel for all the blends for all the loads. The minimum NOx emission for the blend B75E25 and reduced up to 9% compared to diesel.

Smoke emission for the blends is lower than diesel except the blend B95E05 at full load the lesser smoke for the blend B75E25 is reduced up to 36%

It may be concluded that these fuel blends can replace diesel to certain extent. Also future research work may be performed for higher ethanol addition to biodiesel.

Nomenclature

BD	bio-diesel
E	ethanol
CSO	cotton seed oil
CSOME	cotton seed oil methyl ester
BTE	brake thermal efficiency (%)
BSFC	brake specific fuel consumption (kg/kw.hr)
HC	hydro carbon (ppm)
CO	carbon monoxide (%)
NOx	oxides of nitrogen (ppm)
B95E05	blend of biodiesel 95% and ethanol 05%
B85E15	blend of biodiesel 85% and ethanol 15%
B75E25	blend of biodiesel 75% and ethanol 25%

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