ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 2.114

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

PERFORMANCE AND EMISSION CHARACTERISTICS OF COTTONSEED OIL METHYL ESTER IN A DISEL ENGINE

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ABSTRACT

This paper deals with the experimental investigation of blends of biodiesel from cottonseed oil and diesel in a diesel engine for performance and emission characteristics. Cottonseed oil biodiesel is having higher cetane number than diesel and higher viscosity than diesel and cottonseed oil is non-edible oil. Blends of biodiesel from cottonseed oil has been made in various proportions up to 30% volume with diesel and tested in a diesel engine. Results show that the emissions of carbon monoxide (CO) and unburned hydrocarbon (HC) has reduced for all the blends. Brake specific energy consumption for all the blends is lower than that of diesel. There was increase in brake thermal efficiency for all the blends than diesel fuel. There was slight increase in oxides of nitrogen (NO_x) for all the blends. As the biodiesel addition increases the lubricity and being non-edible oil there is a possibility of reducing the consumption diesel by a fossil fuel by using these blends as fuel for diesel engine
Keywords: Blends,biodiesel,performance,emissions,diesel engine

INTRODUCTION

Diesel engines are used for low fuel consumption and for getting higher efficiency. Diesel consumption is increasing all over the world and rapidly increasing the cost of petroleum fuels, so many investigations has been carried for a friendly alternative fuel to replace the consumption of diesel and petrol. A lot of alternative sources of fuels are available like vegetable oils, gases such as LPG, CNG and producer gas, alcohols such as methanol and ethanol etc., But among these alternative sources vegetable oils are well promising for alternative to diesel. Because vegetable oils are easily produced in rural areas, renewable and reduces emissions emitted from the engine.

The vegetable oil concept was tested by Dr. Rudolf diesel's in 1900 with using peanut oil as oil in the engine. During the recent years the biodiesel usage is grown in United States. Many researchers specified that the vegetable oils hold promise as alternative fuel for diesel engine [1-2]. Directly raw vegetable oils can be use in diesel engine but some problems will be occurred. Because of the raw vegetable oil contain high viscosity, low volatility lead to severe engine deposits, injector chocking and automatically engine performance has been reduced [3]. These problems can be eliminated by using transesterification process that is vegetable oil to methyl ester. By using the transeterification process viscosity of vegetable oil will be reduced and equal to diesel fuel.

So many oils present in the market such as canola, soya been, sunflower, corn, coconut, palm and castor oil etc., which are used for producing biodiesel by transesterification process. In this transesterification process methanol or ethanol will be added with employing a alkaline catalyst [4]. Cottonseed oil having a benefit of high calorific value, high cetane number and having low sulphur and aromatics, will not affect the engine performance [5]. Cottonseed oil having a great importance and it contains 15-25% in average oils.

Many investigations were carried out by the researchers on both raw cottonseed oil [6-8] and cottonseed oil methyl esters [9-12]. Some researchers concluded that using of raw cottonseed oil increase CO and HC emissions and accordingly NO_x emissions decrease. Geyer et al [13] and carroretto et al [14] concluded that cottonseed oil methyl ester (CSOME) in diesel engine reduce CO, HC and fuel consumption and increase NO_x emissions.

In this paper the performance and emission parameters from single cylinder, four stroke direct diesel engine using diesel fuel and biodiesel (CSOME) mixtures have been performed.

MATERIALS AND METHODS

Cotton seed oil was brought from market, Guntur, Andhra Pradesh state, India .Methanol and KOH was brought from Krishna ram Chemicals, Chennai

ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
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.Blend Properties were tested in italab private limited.

Purpose of this work

The purposes of this work were as follows:

1. To produce test quantities of methyl ester (biodiesel) from non edible CSO
2. To determine the fuel properties of blends B10, B20 and B30.
3. To compare the performances of a diesel engine using neat diesel fuel and biodiesel mixtures separately.
4. To compare the emissions of diesel engine using diesel and biodiesel.
5. Comparison of diesel, biodiesel and biodiesel blends properties.

Production of cottonseed oil methyl ester

The generation of biodiesel from cottonseed oil is utilizing by transesterification process. Transesterification process must be done in the presence of a catalyst. The selection of catalyst depends upon the PH value of cottonseed oil. It is lesser than 7, acid catalyst to be chosen. The wrong selection of catalyst leads to soap formation. PH estimation of cottonseed oil is more than 7 so we had utilized KOH (base catalyst) as catalyst for transesterification process.

The transesterification methodology of cottonseed oil was performed utilizing 35g potassium hydroxide as catalyst and 2lts methyl alcohol per 5lts pure cottonseed oil. To start with cottonseed oil was heated to about 55^0c in a reactor with capacity of about 20lts.

At that point, the catalyst was mixed with methyl alcohol to dissolve and added to the heated cottonseed oil in the reactor. After the mixture was stirred for 1hr at a constant temperature 55^0c, it was exchanged to another container and separation of glycerol layer was permitted. Once the glycerol layer was settled down, the methyl ester layer formed at the upper part of the container was transferred to alternate vessel. After that, a washing methodology was carried out to remove some un reacted remainder of methanol and catalyst using distilled water and blown air. Then, a distillation process at about 110^0C was applied for removing water contained in the esterified cottonseed oil. Finally, the produced cottonseed oil methyl ester (COME) was left to cool down.

Properties

Table:1 Properties of diesel and cottonseed oil

Property	Diesel	Cotton seed oil
Calorific value (kJ/kg)	43000	39648
Flash point (^{0}C)	44	200
Fire point (^{0}C)	49	230
Viscosity (poise)	0.278	2.52
Density (kg/m^3)	835	850

Table:2 Comparison of diesel, biodiesel and blend properties

Property	Diesel	Cottonseed Methyl Ester	B10	B20	B30
Density @30^{0}C (g/cc)	0.815	0.850	0.953	0.971	0.990
Kinematic Viscosity @ 40^{0}C (cst)	3.5	6.0	2.69	2.85	3.05
Carbon Residue (% by weight)	<0.35	0.42	0.39	0.38	0.36
Flash Point (^{0}C)	44	200	24	23	22
Fire Point (^{0}C)	49	230	32	32	32
Cetane Index	53	64	53	55	58

Experimental setup and test procedure

The experimental setup comprises of single cylinder, four stroke, naturally aspirated diesel engine, an engine test bed and fuel heating equipment. The schematic outline of the experimental setup is shown in Fig. The specifications of the test engine are given in Table. The test bed contains instruments for measuring different parameters, for example engine torque,

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fuel consumption, air flow rate, fuel and air temperatures and exhaust emissions.

Table.3 Engine specifications

Description	Specifications
Bore	87.5mm
Stroke	110mm
No of cylinders	01
Compression ratio	17.5:1
RPM	1500rpm
Capacity of AC dynamometer	7.5KW at 1500rpm
Cubic capacity	662cc
Fuel Used	Diesel
Engine type	Single cylinder 4-stroke diesel engine
Rated power	1500rpm 10HP (7.5KW)
Cooling system	water cooled engine

Experiments were performed with diesel fuel and biodiesel blends B10, B20 and B30. The properties of these fuels are indicated in table. Another fuel tank used for storing COME was mounted on the fuel supply system. A three way switch was utilized to change the fuel supply to the engine from diesel fuel to COME while the engine was running.

Experimental setup

An AC dynamometer was utilized for measuring the engine torque. The fuel consumption measurement was performed by glass burette having a volume of 25ml and a stopwatch. A inclined manometer, a damping tank and an orifice plate were used for measuring air flow rate. The exhaust gas temperature was measured by K type thermocouple submerged into the exhaust pipe. Air and fuel inlet temperatures were also measured by thermocouple which is installed near the exhaust port outlet. The exhaust emissions of carbon monoxide (CO) and nitrogen oxides (NO_x) were measured by a MRU gas analyzer in ppm.

The tests of diesel fuel and COME blends were performed at full load-varied engine speed conditions. The engine was tested at constant speed 1500rpm. The engine was initially tested with diesel fuel to determine its base parameters. At that point same tests were performed with biodiesel blends.

RESULTS AND DISCUSSION

Variation of performance parameters

Brake thermal efficiency and brake mean effective pressure

The brake thermal efficiency was analyzed at all loads for cottonseed biodiesel blends and it is compared with neat diesel. Brake thermal efficiency is slightly increased for B10 and B20 compared to diesel. BTE for B30 is nearly equal to diesel fuel as shown in fig. Because of complete combustion the BTE was slightly higher than diesel fuel.

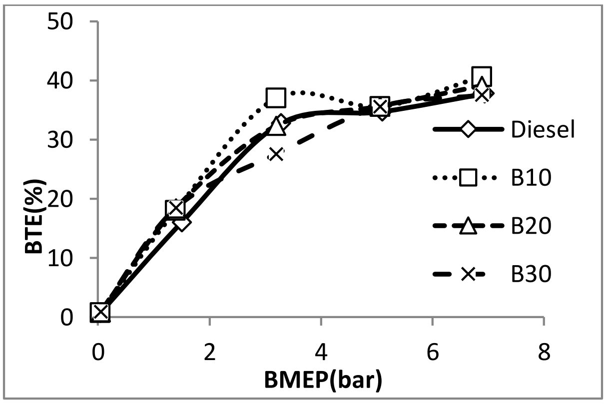

Fig.1.variation in BTE for CSOME blends and neat diesel

Brake specific energy consumption and brake mean effective pressure

Fig(2) shows the variation of BSEC and BMEP for cottonseed biodiesel blends with straight diesel.

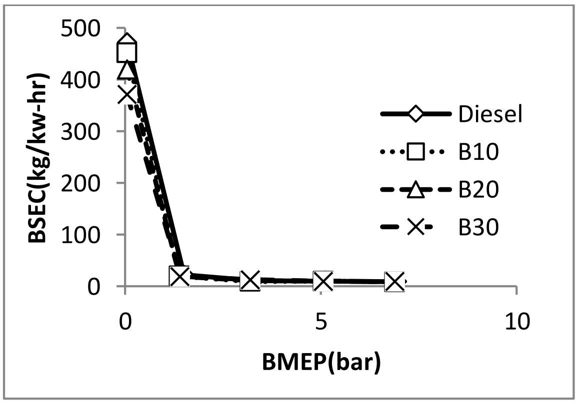

Fig.2.variation in BSEC for CSOME blends and neat diesel

From the above plot it is absorbed that the BSEC for CSOME are decreasing and these blends are giving better values as compared to the diesel fuel.

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At full load condition BSEC was decreased for both the fuels.

Exhaust emissions with neat diesel fuel and biodiesel mixtures

CO Emission

Fig(3) shows the present variation of the CO emissions of the test engine for CSOME with reference to diesel fuel. From below plot it is clearly observed that CSOME results lower emission when compared with diesel fuel. Apart from diesel fuel one important property of biodiesel is it high oxygen content of about 10%.The O_2 content of biodiesel promotes oxidation of carbon in the fuel during combustion, thus leading to lower CO emission in comparison to diesel fuel. Biodiesel from cottonseed oil havng more O_2 content than diesel due to its leads to a more complete and cleaner combustion.

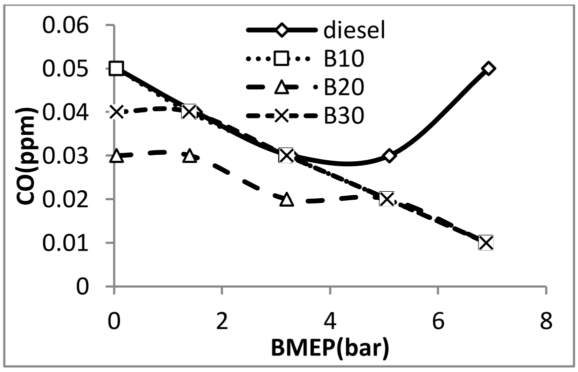

Fig.3.variation of CO emission with BMEP for CSOME blends and neat diesel

HC Emission

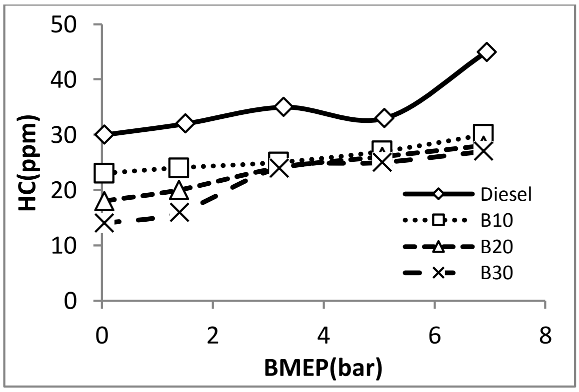

Fig.4.variation of HC emission with BMEP for CSOME blends and neat diesel

Hydrocarbons in diesel engines are formed due to incomplete combustion of fuel. HC emission for CSOME was lower than diesel fuel. At full load condition HC emissions were increased for both diesel and CSOME. The overall HC emission was reduced 35% compared to diesel for CSOME blends as shown in above fig.

NO_x emissions

In case of diesel engine NOx emissions are important due to high peak flame temperature in the combustion process. The NO_x emissions was plotted in fig() and NO_x emissions are increasing at full load condition for both diesel and CSOME bends. At all loads CSOME blends shows high NO_x than diesel fuel. Due to better combustion of biodiesel due to its higher O_2 content and high temperature in the cylinders cause more NO_x emissions.

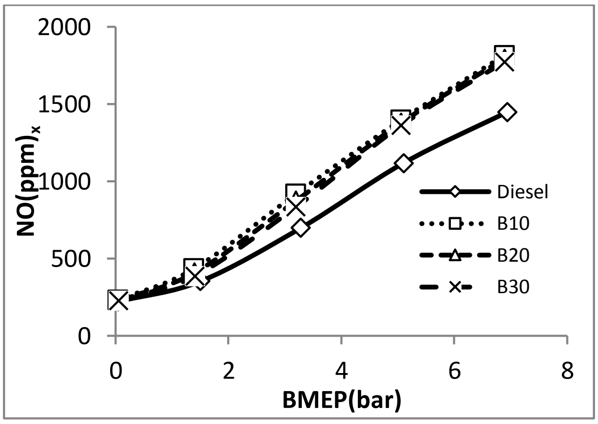

Fig.5.variation of NO_x emission with BMEP for CSOME blends and neat diesel

Exhaust gas temperature

Fig(6) shows that EGT analysis of the engine with CSOME blends and diesel as a function of BMEP.

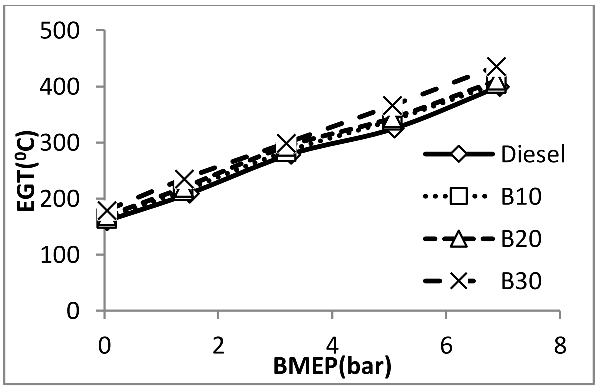

Fig.6.variation of EGT with BMEP for CSOME blends and neat diesel

EGT increases with increase in the percentage of cottonseed oil in the blend. B30 blend having more exhaust gas temperature compared to B10 and B20 with reference to diesel fuel. Due to high viscosity exhaust gas temperature is high.

Smoke

The variation of smoke emission with BMEP for neat diesel fuel and CSOME blends were shown in Fig. For 10% and 20% biodiesel mixtures, smoke emission was less compared to neat diesel fuel. For 30% of biodiesel mixture has slightly more smoke emission than diesel fuel. Because of heterogeneous nature of diesel combustion, fuel-air ratios affect the smoke formation. Smoke formation occurs mainly in the fuel-rich zone of the cylinder at high temperature and pressures. Partially substitution of biodiesel mixtures in diesel engine the smoke formation can be limited.

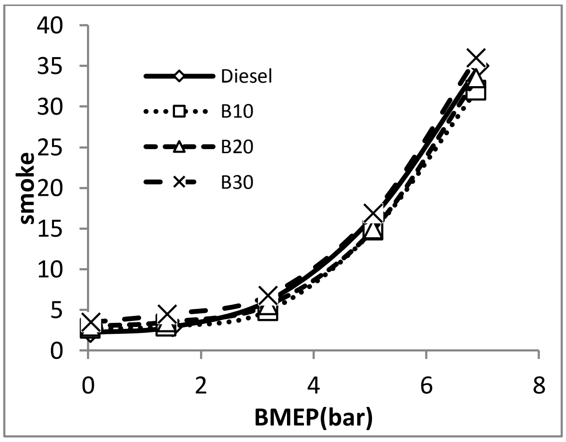

Fig.7.variation of smoke emission with BMEP for CSOME blends and neat diesel

CONCLUSION

The experimental results shown in this paper that engine performance and emissions of CSOME blends where run on the diesel engine and compared with standard diesel fuel.

- Properties of CSOME blends are nearly equal to the diesel fuel.
- The maximum yield of biodiesel from cottonseed oil is 90% by transesterification process.
- There were increase in BTE of CSOME blend s B10 and B20 and BTE of B30 is nearly equal to diesel fuel.
- BSEC gives better values than diesel fuel and B30 having low BSEC than B10 and B20.
- CO and HC emissions are less compared with standard diesel fuel. The reduction of HC emission is less for B30 is 30%.
- NO_x emissions for CSOME blends higher than that of diesel fuel and B30 blend having slightly more than B10 and B20.
- It was observed that smoke emission for B10, B20 has less and B30 recorded more smoke than diesel fuel with 2.85%.

Cottonseed oil promising as an best alternative fuel source of diesel engine because of its high heat content. It can be directly used as diesel fuel but having a major problem was cottonseed oil having high viscosity. From this investigation, test results showed that 20% cottonseed oil and 80% diesel (B20) for suitable it to be used as diesel fuel without any modification of engine.

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ACKNOWLEDGEMENTS

Author is sincerely thanking the Internal Combustion Engines lab facility of Hindustan Institute of Technology & science, Chennai given opportunity to test blends

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ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
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