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Performance and Emission Characteristics of CI Engine Fueled with Esterified Cottonseed Oil

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Abstract: Vegetable oils can fuel diesel engines, but their high viscosity, low volatility and poor cold flow properties have led to the investigation of various derivatives. Among the different possible sources, bio-diesel fuels derived from triglycerides by transesterification with methanol or ethanol have received the most attentions. The main advantages of using biodiesel are its renewability and its biodegradability and does not contribute to a rise in carbon-dioxide in the atmosphere and consequently to the greenhouse effect. This study investigates the use of methyl esters of cottonseed oil and its blends as fuel for a CI engine. Cottonseed oil is not ideally suited as an engine fuel as such because of its high viscosity and low volatility. A process of transesterification has to be done to improve the properties of cottonseed oil to make it comparable with diesel. Properties of the methyl ester of cottonseed oil was evaluated and compared with diesel. The esterified fuel was used to evaluate the performance combustion and emission characteristics of a single cylinder, direct injection diesel engine. The data thus generated were compared with the data obtained using diesel. The engine exhibited a very good performance without any problem of combustion. It is suggested that, the methyl ester of CSO and its blends can be used as an alternate fuel for diesel engine.

Key words: Cottonseed oil · Bio-diesel · Fuel Efficiency · Biodegradability · Low volatility

INTRODUCTION

With gas prices soaring, people are looking for cheaper, renewable sources of fuel for their vehicles. Bio-diesel fuel is used in diesel engines and it is domestically available, renewable organic resources, such as vegetable oils and animal fats. Bio-diesel burns cleaner (i.e. produces fewer emissions) than traditional petroleum diesel fuel and is biodegradable, making it an interesting alternative fuel option in terms of both environmental protection and energy independence [1].

Bio-diesel fuels are most commonly available are really blends of bio-diesel and petroleum diesel. A significant distinction needs to be made flanked by bio-diesel and blends. Bio-diesel is normally mixed with diesel to form a bio-diesel blend. As stated above, a mixture of bio-diesel and diesel is not biodiesel, but is referred to as a bio-diesel blend. Pure bio-diesel, also acknowledged bio-diesel, is commonly noted as B100, indicating that the fuel has 100 percent biodiesel and 0 percent diesel. The most common bio-diesel blend is B20, which contains 20 percent biodiesel and 80 percent diesel. In this project we produce bio-diesel from cottonseed oil (i.e. transesterified cottonseed oil) and to compare the performance and characteristics of diesel engine using diesel and bio-diesel blends [2].

Problems CSO in DI Engine: The problems encountered during engine test with vegetable oils were studied and classified into two groups

- Operational problems
- Durability problems

The operational problems include carbon deposits on injector, carbon deposits on piston and rings and also gum formation. In order to reduce the viscosity of vegetable oils, heating of oils has been tried out. Heating the oils however, transfer its spray characteristics more like diesel oil. Conversion of the vegetable oil to the simple ester of methyl and ethyl alcohols is called as Bio-diesel (ester) and it is a possible way to overcome almost all the problems in the vegetable oils, including the crankcase polymerization problems.

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Effects of injection pressure has been investigated to use the vegetable oil in diesel engine and the conclusion is that this injection pressure could improve the performance and it has been suggested that the endurance testing of the engine was essential for checking the gum formation in the combustion chamber.

Bio-Diesel: Bio-diesel refers to a diesel-equivalent, processed fuel derived from biological sources (such as vegetable oils), which can be used in unmodified diesel-engine vehicles. It is thus distinguished from the straight vegetable oils (SVO) or waste vegetable oils (WVO) used as fuels in some modified diesel vehicles.

Bio-diesel refers to alkyl esters made from the transesterification of vegetable oils or animal fats. Bio-diesel is biodegradable and non-toxic and produces significantly fewer emissions than petroleum-based fuel [3].

Bio-diesel

Cotton: In our country cotton plant cultivate in more lands around 8 million hectares. Since 2002 -2003, the production of cotton with a production of 2.5 million metric tones. India is third rank in cotton production [4].

Production of Top 3 Cotton Growing Countries (In Million Metric Tons) Country Year:

Table 3.1.3: Top Cotton Production Countries

Country	2001-02	2002-03	2003-04
China	5.32	4.55	4.90
USA	4.42	3.95	3.96
India	2.69	2.50	2.85

Source: Cotton: World Statistics September 2003 published by ICAC

Properties: Cottonseed oil has following physical and chemical properties.

Physical Properties:

Appearance	: pale yellow liquid
Net calorific value: 40358 KJ/Kg	
Melting point	: 0 - 5°C
Auto-ignition temperature	: 343°C
Kinematic Viscosity: 32.7 m^2/s	
Flash point	: 210°C
Density	: 0.9098 g/cm^3
Cetane number	: 42
Iodine number	: 110-115

Chemical Properties:

- Stable, Combustible, Incompatible with strong oxidizing agent.
- Non-toxic, heat and light sensitive.

Bio-diesel Production

Transesterification: In the production process cotton seed oil, methanol and catalyst is used in the tank. The combination is heated and stirrer for at least minimum 1hr time. Then it is allowed to cool without stirring. Two layers are formed. The bottom layer consists of glycerol and top layer is of ester [5].

Biodiesel: alcohol + ester → different alcohol + different ester.

The process is performed in bio-diesel plant. The detailed description of bio-diesel plant is described below

Transestrification Procedure:

- Two litre of Cottonseed oil is mixed along with 400ml of methanol and 7gms of catalyst (potassium hydroxide).
- The mixture is poured into the cylindrical flask of the plant.
- Then the mixture is heated and stirred for one hour at the range of 60 - 65°C.
- Thermocouple will maintain the temperature of mixture throughout the process.
- The mixture is drained out from the plant and allows cooling.
- Separation of glycerol and Biodiesel is processed out [6].

20% of methanol + Cottonseed oil → Biodiesel + glycerol

Properties of Esterified CSO: After transesterification, the esterified cottonseed oil has following properties

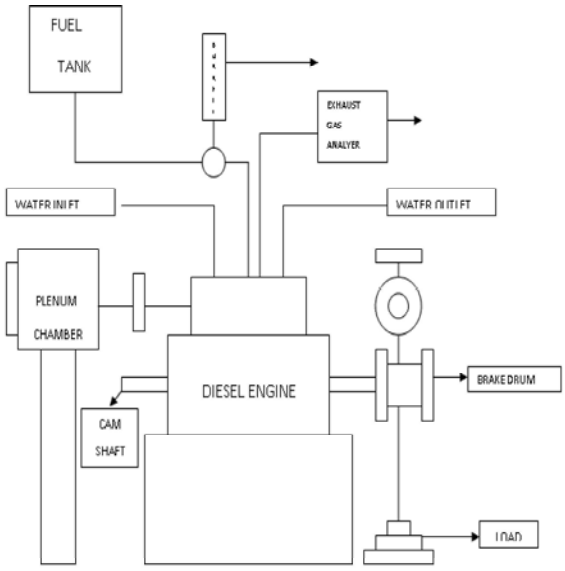
Net calorific value	: 42735 KJ/Kg
Auto-ignition temperature	: 303°C
Kinematic Viscosity	: 4.9 m^2/s
Flash point	: 180°C
Density	: 0.8748 g/cm^3
Cetane number	: 45

Testing of Calorific Value: The calorific value each biodiesel blends will vary. So we have to find the calorific values of each blend. Calorific value of each blend can determined using Bomb calorimeter. One gram of fuel whose calorific value is to be determined is taken in crucible.

- The crucible is then placed in bomb which is filled with oxygen at a pressure of 30atm.
- An electrical wire is inserted in the bomb in such a manner it is in close contact with the fuel so that it may ignited.
- The bomb is tightly closed so that no air leak is there.
- The bomb is placed in a weighed amount of water whose temperature is noted using thermometer.
- The water is stirred throughout the experiment.
- After showing constant temperature, the fuel is ignited using electric connection. The maximum temperature obtained is noted.
- The bomb is then removed and allowed to cool and content of the bomb is carefully washed.
- The experiment is repeated for all the blends of biodiesel [7].

S.no	Sample	Temp	CV (KJ/KG)
1	DIESEL	309.3	43962.211
2	B10	309.2	42939.834
3	B20	309.1	41917.457
4	B40	308.9	39872.703
5	B60	308.7	37827.949

Experimental: The experimental model consists of diesel engine, Exhaust analyzer and brake drum. The engine used in the experimental investigation is a constant speed kirlosker engine, four stroke single cylinder, DI engine, vertical engine.



Specification:

1. BHP	: 3.7 Kw
2. Speed	: 1500 Rpm
3. Bore	: 80 Mm
4. Stroke	: 110 Mm
5. Loading: Brake Drum Dynamometer	
6. Radius Of Brake Drum	: 152.4 Mm
7. Type of Cooling	: Water Cooling
8. Orifice Diameter	: 0.02 M
9. C_d Of Orifice	: 0.62

Testing of Emission:

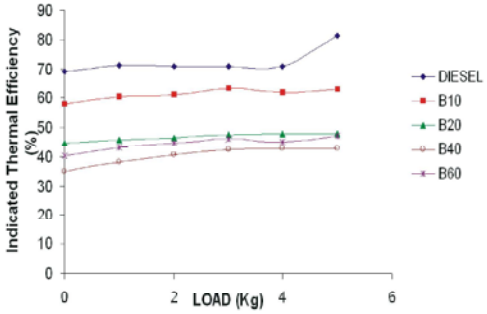
- The engine is start to run at no load condition for sometime.
- Exhaust gas analyzer is fitted in the exhaust manifold.

- Reading were taken for the following,
  - % of CO_2 and CO.
  - ppm of HC and NO.
- Engine is stopped at no load.
- The experiment was conducted for different blends of esterified cottonseed oil with diesel.

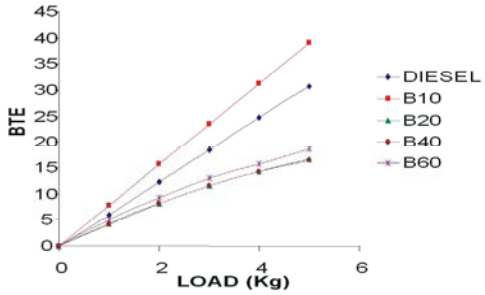
Performance Characteristics

Fuel Efficiency: The performance characteristics curve for DI engine is drawn for diesel and its blends.

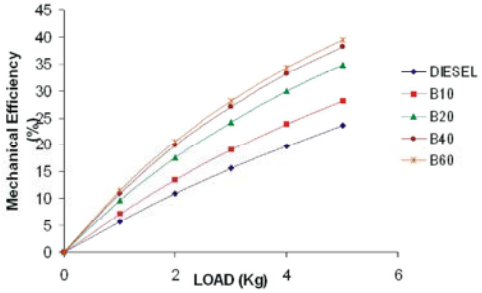
- Load Vs BSFC
- Load Vs BTE
- Load Vs ITE
- Load Vs Mechanical Efficiency [8].



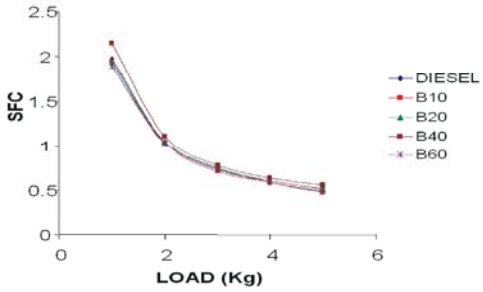
Comparison of Indicated Thermal Efficiencies of Cottonseed Oil Blends with Diesel:



Comparison of Brake Thermal Efficiencies of Cottonseed Oil Blends with Diesel:



Comparison of Mechanical Efficiencies of Cottonseed Oil Blends with Diesel:



BSC Vs loads

Emission Characteristics

Emission Types

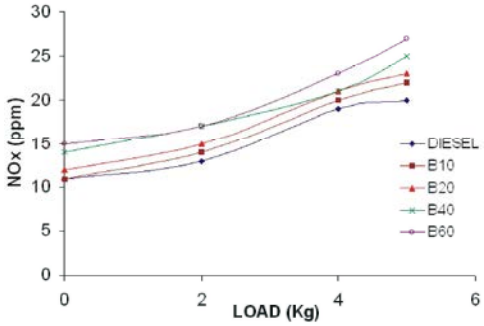
NOx: Might be due to poor atomization of the CSO and diesel blends, for the reason that of higher viscosity, high density and poor volatility.

It cause of ground- level ozone, acid rain, respiratory disease, water quality determination and global warming. NOx emission increases for esterified cottonseed oil blends. For B60 it is high than B20 [9].

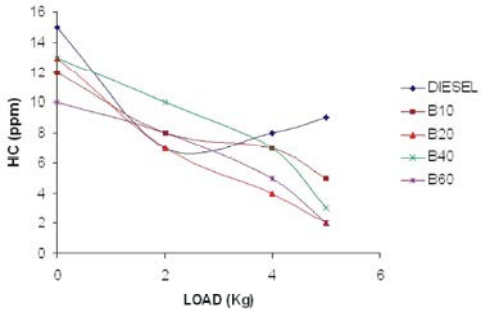
HC: This might be unpaid to poor atomization of the blends, for the reason that of high viscosity, more density and reduced volatility. The HC gets increased when it breaks power raised and it affects proper mixture formation. It is seen that, the HC of the engine for diesel is 5% high compare to blends of diesel and CSO.

CO: This might be due to overall richness of air fuel ratio, longer duration of diffusion combustion phase and reduced oxygen concentration. The emission is increased due to poor atomization of fuel and incomplete combustion.

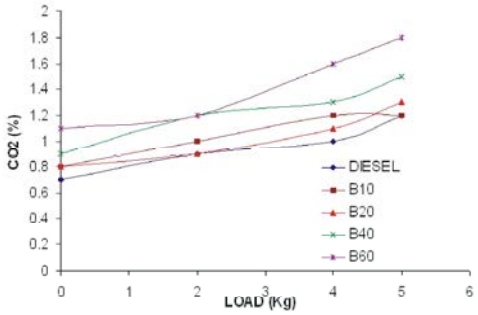
Carbon monoxide is formed from incomplete combustion at some time



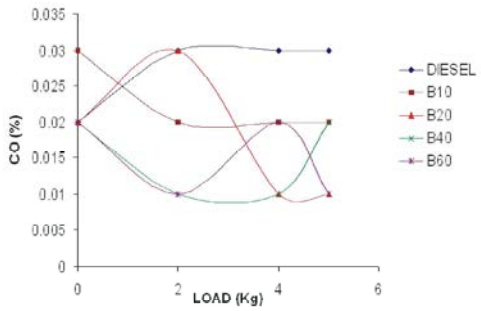
Comparison of Nitric Oxide Emission of Cottonseed Oil Blends with Diesel:



Comparison of Hydro Carbon Emission of Cottonseed Oil Blends with Diesel:



Comparison of Carbon Dioxide Emission of Cottonseed Oil Blends with Diesel:



Comparison of Carbon Monoxide Emission of Cottonseed Oil Blends with Diesel:

RESULTS AND DISCUSSION

The result part is taken from the present study and compared with diesel.

- There is a noteworthy improvement in the heat rate with decreased viscosity.
- Diesel engine working without modification of this blends
- Blend 40 is higher BTE compared with blends and diesel.
- NOx increase with increase with increase of load percentage biodiesel blends. Exhaust of carbon dioxide is high in B60 is compared with diesel [10-13].

CONCLUSION

The production of esterified cottonseed oil is done on Biodiesel plant. BTE and ITE of the engine improved for B10 than diesel. Mechanical Efficiency of the engine has been improved for the blends of esterified CSO. HC Emission value is reduced for ester CSO than diesel.

On a whole, we concluded that the blends of esterified CSO can be used as engine fuel without much problem.

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