Experimental Analysis of Cotton Seed oil Biodiesel in a Compression Ignition Engine

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***Abstract*— Biodiesel known as fatty acid ethyl ester (FAEE) was produced from cotton seed oil (triglycerides) by transesterification with ethanol in the presence of catalyst (NaOH). Cotton seed oil is chosen as potential biodiesel for the present investigation based on the availability in India. Catalyst concentration and molar ratio of ethanol to cotton seed oil were the most significant variables affecting percentage conversion. Expeller method was employed to extract cotton oil from its seed and was subjected to single stage transesterification due to the presence of more than 20% of free fatty acid content.Results showed that lesser HC and CO emission for biodiesel blends when compared with diesel**

***Index Terms*— cotton seed oil,biodiesel,transesterification and fatty acid ethyl ester.**

I. INTRODUCTION

Bio-diesel refers to a vegetable oil or animal fat based diesel fuel consisting of long chain alkyl (ethyl, methyl, prophyl) esters. Bio-diesel is typically made by chemically reacting lipids (e.g., vegetable oil, soybean oil, animal oil) with an alcohol producing fatty acid esters. Transesterification is also called alcoholysis , which uses alcohols in the presence of catalyst (e.g., base, acid, or enzyme depending on the free fatty acid content of raw material) that chemically breaks the molecules of triglycerides into alkyl esters as biodiesel fuels and glycerol as the by-product [1]. The most commonly used alcohols for the transesterification include methanol, ethanol, propanol, butanol, amyl alcohol. Different vegetable oils such as soybean oil, kapok seed oil, castor oil, rapeseed oil, Jatropha curcas oil, cottonseed oil are considered as alternative fuels for diesel engines [3]. The important advantages of vegetable oils as fuel are that they are renewable, can be produced locally, cheap and less pollutant for environment compared to diesel fuel. The seed contains 17–25 wt. % oil [3]. The fatty acid composition of cotton seed oil is mainly linoleic (55.2–55.5%), palmitic (11.67–20.1%), and oleic acids (19.2–23.26%) [3]. Transesterification is the process of converting the triglycerides of vegetable oils to their monoester by reacting them with alcohols in the presence of a catalyst. In general, biodiesels contain 10% to 11% oxygen by weight, have a higher cetane number than petroleum diesel, have no aromatics, and show some attractive environmental benefits, such as lower emissions of CO, CO2, and unburned hydrocarbons (HC) [4]. Biodiesel is commonly produced through chemical transesterification, a process in which triglycerides in vegetable oils or animal fats react with an alcohol in the presence of a catalyst. The transesterification process results in desirable biodiesel properties such as low viscosity, low molecular weight and high volatility, which overcome common problems such as an incomplete combustion, poor atomization, ring sticking, severe engine deposits, and injector coking that are encountered when natural oils and fats are used [4].

II. MATERIALS AND METHODOLOGY

A. *Materials:*

Ethanol, sodium hydroxide were purchased from Biochemical laboratory, Chennai. Crude cotton seed oil derived from expeller, i.e. screw pressed cotton seed was obtained from oil mill.

B. *Transesterification of crude cotton seed oil (FAEE):*

The crude cottonseed oil reacted with ethanol in the presence of sodium hydroxide to produce ethyl esters of fatty acids (biodiesel) and glycerol. To optimize the above transesterification process, a three-level-five-factor fractional factorial experimental design was employed. The crude cottonseed oil was precisely quantitatively transferred into an Erlenmeyer flask immersed in the Gyratory water bath shaker. Then specific amount of sodium hydroxide (by weight of crude cottonseed oil) dissolved in the required amount of ethanol was added. The reaction flask was kept in the water bath under constant temperature with defined agitation throughout the reaction. At the defined time, sample was taken out, cooled, and the biodiesel (i.e. the ethyl ester in the upper layer) was separated from the by-product (i.e., the glycerol in the lower layer) by settlement overnight under ambient condition. The percentage of the biodiesel yield was determined by comparing the weight of up layer biodiesel with the weight of crude cottonseed oil added.

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Figure (1) Raw Cotton seed oil Figure (2) cotton seed oil with ethyl ester

Figure (3) Glycerol separation

III. EXPERIMENTAL SETUP

The performance and emission tests were performed on a constant speed, single cylinder vertical air cooled diesel engine. The specifications of the engine used for the test is given below.

Table (1) Specification of the Engine

Engine	**Kriloskar TAF 1**
Type	Four stroke air cooled engine
Bore diameter	87.5mm
Stroke	110mm
Injection pressure	200 bar
No. of cylinder	Single cylinder
Compression ratio	17:5:1
Injection timing	23^{o}
Rated power	4.4 KW
Rated speed	1500 rpm

Cotton seed oil biodiesel FAEE were produced from the same crude oil. Based on the response surface methodology (i.e., temperature at 53 c, catalyst of NaOH at 1.0% based on weight of cotton seed oil, ethanol / molar ratio at 6, and reaction time of 45 min) with conversion of 97% was used to prepare FAEE in a temperature-controlled water bath shaker.

Figure (4) Experimental setup

IV. RESULTS AND DISCUSSIONS:

A. Performance characteristics

Brake thermal efficiency

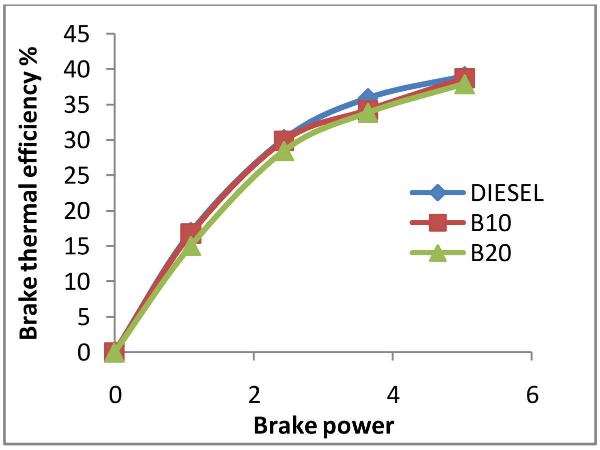

Figure (5) Variation of BTE with output power

In general the thermal efficiency depends on the combustion process which is a complex phenomenon that is influenced by several factors like cetane number, viscosity, calorific value. The variation in Brake thermal efficiency with respect to power output at various loads for conventional diesel and cotton seed oil biodiesel blends. The diesel fuel has the highest thermal efficiency because of its calorific value and viscosity as compared with cotton seed oil biodiesel. The amount of heat produced in the combustion chamber is more, further the combustion is complete and produced higher temperature.

Specific fuel consumption

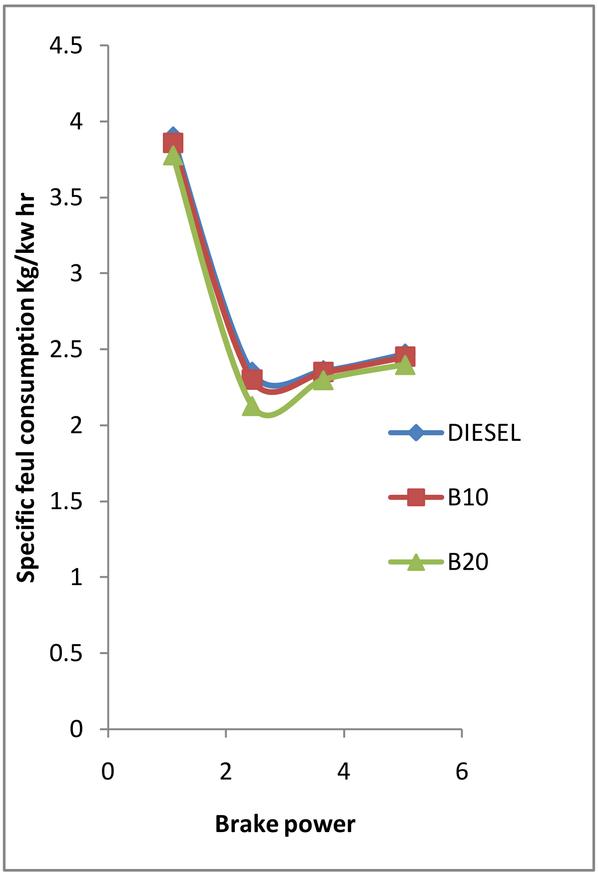

Figure (6) Variation of SFC with output power

It is an important parameter that a display how capable is the engine performance; it is inversely proportional to the brake thermal efficiency. The SFC of a engine can be defined it terms of SFC in Kg/KWHr. It represents the SFC for conventional diesel and cotton seed oil biodiesel blends at varying loading. Brake thermal efficiency is greater when compared to biodiesel blends hence the lowest SFC is recorded by conventional diesel when comparing it with cotton seed oil biodiesel blends. The main criteria for rise in SFC is the heating valve reduces when blend is increased

B. *Emission characteristics*

CO emission

The variation of CO emission for cotton seed oil biodiesel and diesel at various load of engine. It has been observed that the CO emission are increased with increase in engine load and decrease with increase in proportion of biodiesel in blends. The cause for the reduction in CO emission in because of more effective and complete combustion taking place due to the more number of oxygen content in biodiesel.

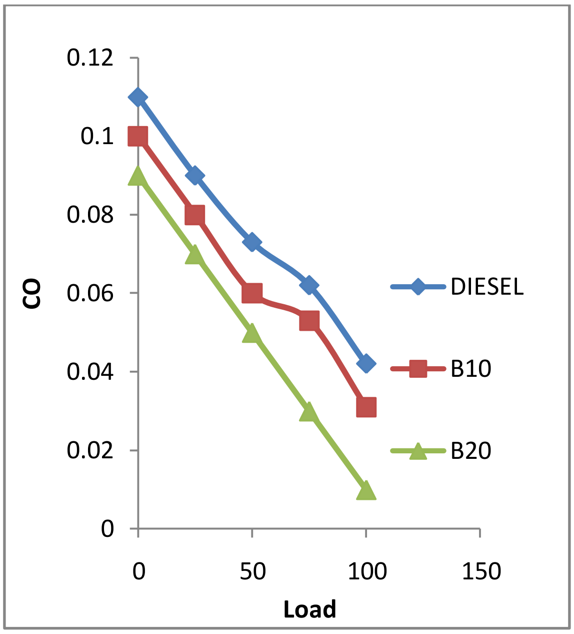

Figure (7) Variation of Carbon monoxide emission

NOx emission

NOx emission is caused mainly because of nitrogen parameter in air (78%) and operating temperature of engine. The reason for the higher NOx emission for blend is due to higher peak temperature. When the combustion , temperature inside the engine rises a particular limits , nitrogen unite with oxygen to create NOx. Hence the most significant factor that cause NOx formation is high combustion temperature and the combustion temperature increase the compression ratio increases, so as the compression ratio increases, the amount of NOx will increase.

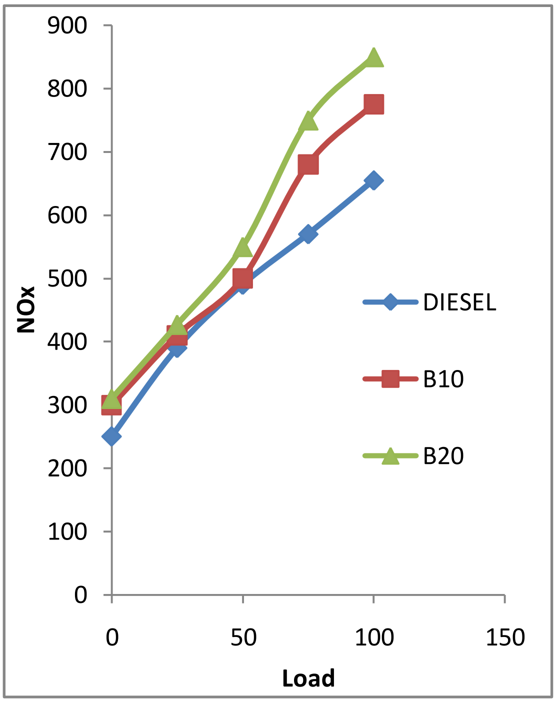

Figure (8) Variation of Nitrogen oxide emission

Hydrocarbon emission

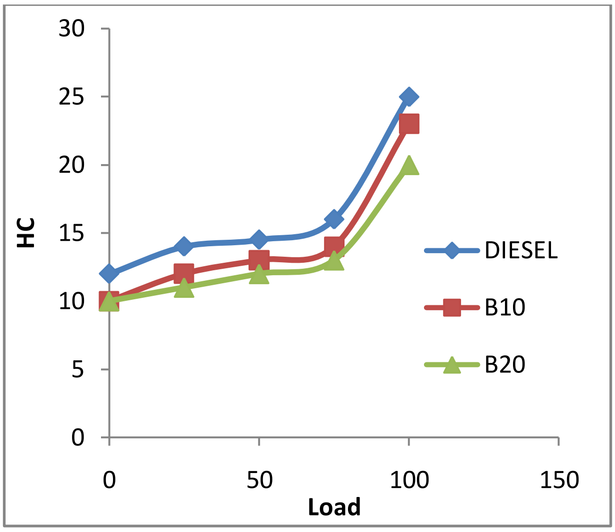

Figure (9) Variation of Hydro carbon emission

The HC emission increase with increase with increasing load and decrease with increase in amount of biodiesel in blend. Almost similar to CO emissions , HC emission also occurs when the fuel fails to ignite completely inside the combustion chamber. The variations in HC emission for conventional diesel fuel and cotton seed oil biodiesel. Viscosity effect in turn atomization is more predominant than the oxygen availability either inherent in fuel or present in charge. When compared to diesel, the oxygen availability in the bio diesels is more. The blend with compression ratio 18 emits fewer hydrocarbons.

Oxygen content

As discussed earlier the oxygen content in biodiesel is more when compared to conventional diesel this is because more oxygen content in the biodiesel. The oxygen content in biodiesel at zero load was nearly 20% and diesel it was 17% and full load it was 15% in biodiesel and 14.5% in diesel.

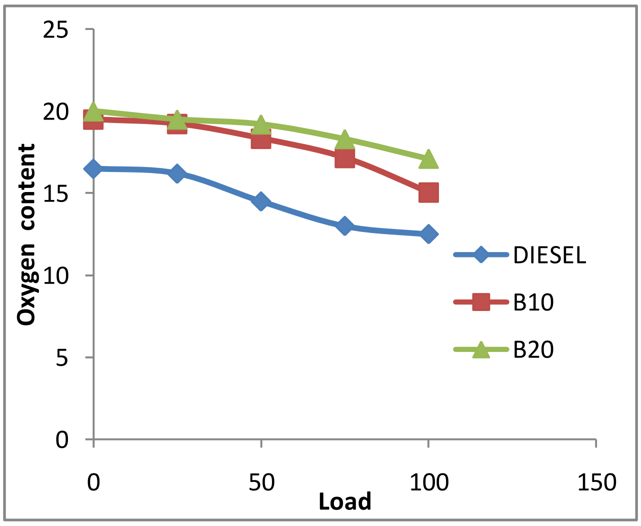

Figure (10) Variation of oxygen content

V. CONCLUSION

This project aims at determining the adaptability of cotton seed oil biodiesel as an alternative fuel for use in single cylinder air cooled Compression Ignition Engines. In this analysis, biodiesel was made from pure cotton seed oil by the process of transesterification. The prepared biodiesel was then blended with diesel in the following proportions (10% and 20%) and then tested in a single cylinder direct injection diesel engine to obtain the performance and emission characteristics. The similarities of various chemical properties of cotton seed oil biodiesel with diesel display its adaptability for use as an alternative fuel. These are following conclusions drawn from this investigation

- The brake thermal efficiency was slightly lower in biodiesel blends when compared with diesel fuel
- The SFC increases with increase in biodiesel content in the fuel blend due to lesser calorific value in the blend
- But in terms of emission HC and co emission was found to be less in biodiesel blends when compared with diesel due to its oxygen content
- The NOx emission was found to be higher in biodiesel blends when compared with diesel due to rise in operating temperature of the engine when biodiesel was used as fuel.

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