Characterisation of Biodiesel on IC Engine

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Abstract— This study explores the different performance characteristics and emission of different pollutants using different blends in a variable compression ratio (VCR) engine. Biodiesel synthesized from cotton seed oil using a heterogeneous catalyst was investigated for emission analysis on a single-cylinder VCR engine with various blending ratios as well as load. Blends (biodiesel + diesel) of B00, JB15, B30, B45, B60, B75 and B100. The emission parameters, such as nitrogen oxides (NOx), carbon monoxide (CO), sulphur oxide(SOx), Crabon dioxide(CO2) and hydrocarbon (HC), were studied and compared to diesel fuel. Results showed that, among the blends prepared from methyl ester of Cotton seed oil, B30 and B45 shows reduction in emissions of CO and HC up to 30 and 40%, respectively, with an increment of NOx emission up to 25% at the lowest load and compression ratio (CR) of 17.5. The performance parameter brake specific fuel consumption (BSFC), mechanical efficiency (ME), brake power (BP), indicated power (IP), volumetric efficiency (vol. eff.) were studied and compared to diesel fuel. Results showed that, among the blends B30 and B45 shows all performance parameter near about diesel fuel at compression ratio (CR) 14 and 17.5.

Key words: Biodiesel, IC Engine

I. INTRODUCTION

Energy is a major need for the development of country and the increase in population needs more energy for both economic and social development. The petroleum products and fossil fuels are a predominant source of energy. Increase in petroleum prices and environmental pollution necessitated exploring some renewable alternatives to conventional petroleum fuels.Also depleting fossil fuels, vehicular population, increasing industrialization, environmental pollution, and stringent emission norms emphasis on the need of alternative fuels.

Diesel fuel is largely utilized in the transport, agriculture, commercial, domestic, and industrial sector for generation of power and substitution of even a small fraction of total consumption by indigenous alternative fuels particularly of bio origin will have significant impact on economy, the environment, the development of agro based industries in the region of the alternative fuels. Biodiesel obtained from vegetable oils is considered to be promising alternative fuel resulting in numerous environmental, economic and social benefits.

Biodiesel benefits include bio-degradable, non-toxic, free from sulphur (< 0.001%) and 40% less net carbon dioxide emissions. In addition it has high flash point (greater than 130 C) which helps biodiesel for transportation and storage. The important quality that biodiesel posses is that it decomposes more easily when they expose to environment and most importantly they can be produced easily compared to petrol and diesel. Another advantage of using biodiesel is that it eliminates the compound such as polycyclic aromatics hydrocarbons (PAH) and nitrated PAH that causes cancer in humans. The lubrication property of biodiesel dominates more when compared to diesel fuel and increases the engine life. Biodiesel causes less emission of carbon dioxide, hydrocarbon and particulate matter, which are dominating factors while compared to diesel. A long run endurance test has been conducted by researchers around the world and proved that it can be easily used in compression ignition engines without any major modification. The only drawback is that NOx emission is to be reduced. The concept of using vegetable oil as a fuel for diesel engine is nothing new, D.R.Rudolph Diesel first tested peanut oil as a fuel for his engine in 1895.In 1911 he stated that “the diesel engine can be fed with vegetable oils and would help considerably in the development of agriculture of the countries which use it”.

With advent of cheap petroleum, appropriate crude oil fractions were refined to serve as fuels. Later in 1940s, vegetable oils were used again as fuel in emergency situations during the period of World War II. Because of the increase in crude oil prices, limited resources of fossil fuels. Due to the environmental concerns these days, there has been a renewed focus on the vegetable oils for the production of biodiesel fuels. Biodiesel is an oxygenated fuel and has potential to reduce the level of pollution and level of global warming. Biofuels provide 2.7 % of the worlds transport fuel as of 2010.According to the International Energy Agency; biofuels have the potential to meet more than a quarter of world demand for transportation fuels by 2010. Biodiesel, a clean renewable and environment friendly fuel, has recently been considered as the best substitute for the diesel fuel. It is produced from oil or fats by transesterification process. It is the reaction of a triglyceride (fat/oil) with an alcohol to form esters and glycerol. A triglyceride has a glycerin molecule as its base with three long chain fatty acids attached. The characteristics of the fat are determined by the nature of the fatty acids attached to the glycerin. The nature of the fatty acids can in turn affect the characteristics of the biodiesel. During the esterification process, the triglyceride is reacted with alcohol in the presence of a catalyst, usually a strong alkaline like sodium hydroxide. The alcohol reacts with the fatty acids to form the mono-alkyl ester, or biodiesel and crude glycerol. In most production methanol or ethanol is the alcohol used (methanol produces methyl esters, ethanol produces ethyl esters) and is base catalyzed by either sodium hydroxide. sodium hydroxide has been found to be more suitable for the ethyl ester biodiesel production; either base can be used for the methyl ester. A successful transesterification reaction is signified by the separation of the ester and glycerol layers after the reaction time. The heavier, co-product, glycerol settles out and may be sold as it is or it may be purified for use in other industries, e.g. the pharmaceutical, cosmetics etc.

II. EXPERIMENTAL SECTION

An experimental test rig was utilized in order to determine thermal performance evaluation and emission characteristics of a variable compression ratio compression ignition engine fuelled with Honne biodiesel and its blends with Diesel oil. The experimental test rig is used to conduct various test runs under different working conditions to evaluate the thermal performance and emission constituents of a bio-diesel run engine in comparison with that of a conventional diesel operated engine.

Fig. 1:

sr.	test description	reference		diesel blends	
		unit	limit	b00	b100
1	**Density**	**gm/cc**	0.800-0.900	0.830	0.874
2	**Calorific Value**	**MJ/Kg**	34-45	42.50	38.50
3	**Cetane No.**	-	41-55	49.00	50.70
4	**Viscosity**	**mm^2/sec**	3-6	2.700	5.1
5	**Moisture**	%	0.05%	NA	NA
6	**Flash point**	^{0}C	-	**64**	**138**
7	**Fire point**	^{0}C	-	**71**	**142**
8	**Cloud point**	^{0}C	-	**-4**	**3**
9	**Pour point**	^{0}C	-	**-9**	**1**
10	**Ash**	**%**	-	**0.05**	**0.05**

Table 1: Coposition Of Diesel B00 And Cotton Seed Oil B100

Make and Model	Kirloskar VCR Oil Engine TV1
Type	4-stroke single cylinder, water Cooled
Bore and stroke	80mm and 110mm
Compression ratio	17.5:1 (Modified to work at 12,13,14, 15,16, 17.5 and 18 CR)
Maximum Speed	1500rpm at constant speed
Exhaust Gas Analyzer Make	Indus Scientific Pvt. Ltd.
Software	IC Engine Combustion Analysis Software)
Measureable Gases	CO, CO_2, NOx, SOx and HC

Table 2: Engine Specification

III. RESULTS AND DISCUSSIONS

A. *Performance Parameters*

B. *Brake Power*

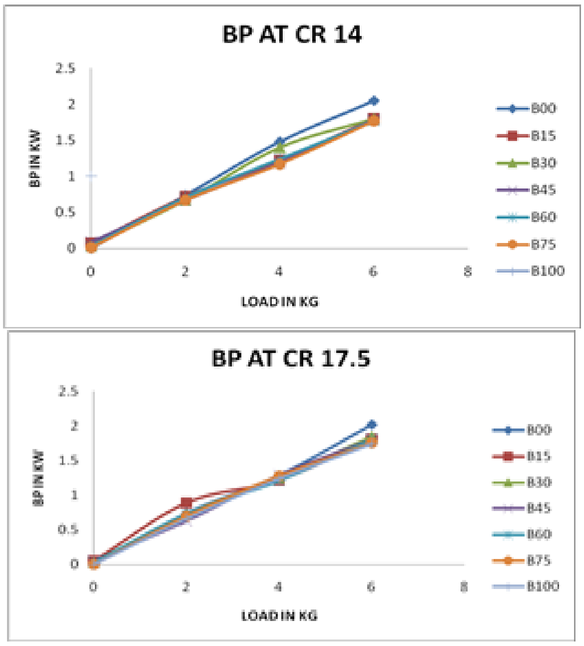

Fig. 2:

Fig. 2 indicates the graph of BP vs. Load at CR14 and CR17.5. The fig. Indicate that BP of all biodiesel blends as well as diesel fuel goes on increasing with increase in load and CR.The BP of blend B30 performances very close to BP of diesel fuel at both the CR.

C. *Brake Specific Fuel Consumption*

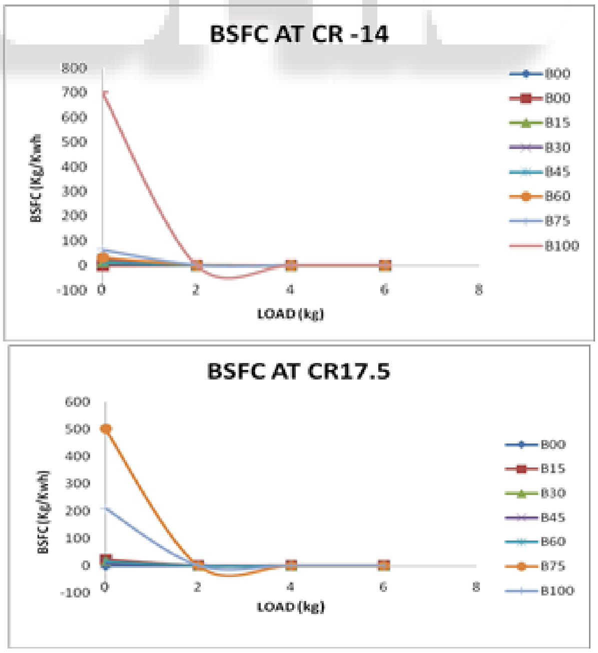

Fig. 3:

Fig. 3 indicates the graph of BSFC vs. Load at CR14 and CR17.5 The fig. Indicate that BSFC of all biodiesel blends as well as diesel fuel goes on decreasing with increase in load and CR. The BSFC of blend B30 and B45 performances very close to BSFC of diesel fuel at both the CR.

D. Brake Thermal Efficiency

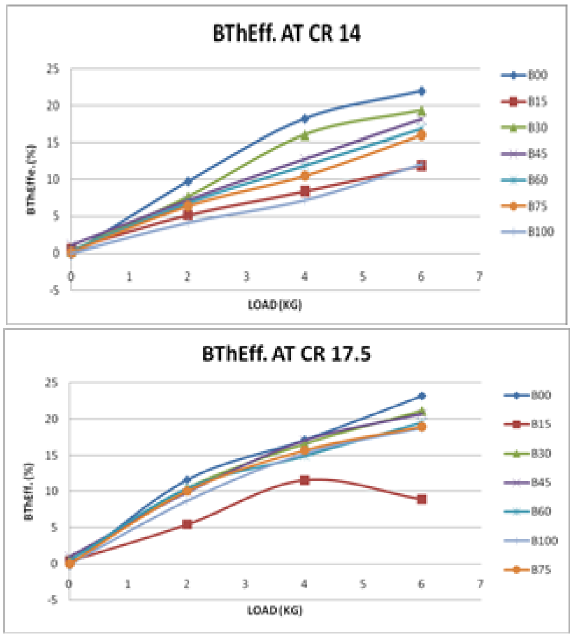

Fig. 4:

Fig. 4 indicates the graph of BThEff vs. Load at CR14 and CR17.5.The fig. Indicate that BThEff of all biodiesel blends as well as diesel fuel goes on increasing with increase in load and CR.The BThEff of blend B30 performances very close to BThEff of diesel fuel at both the CR.

E. Friction Power

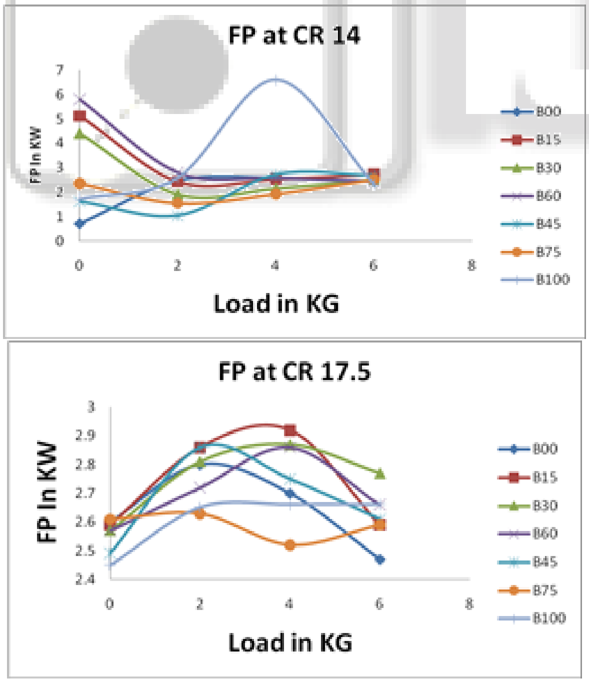

Fig. 5:

Fig. 5 indicates the graph of FP vs. Load at CR14 and CR17.5.The fig. Indicate that FP of all biodiesel blends as well as diesel fuel goes on increasing with increase in load upto 4kg then after FP is decreasing at CR17.5.FP in CR14 all biodiesel blends as well as diesel fuel goes on decreasing with increase in load.The FP of blend B45 performances very close to FP of diesel fuel at both the CR.

F. Indicated Power

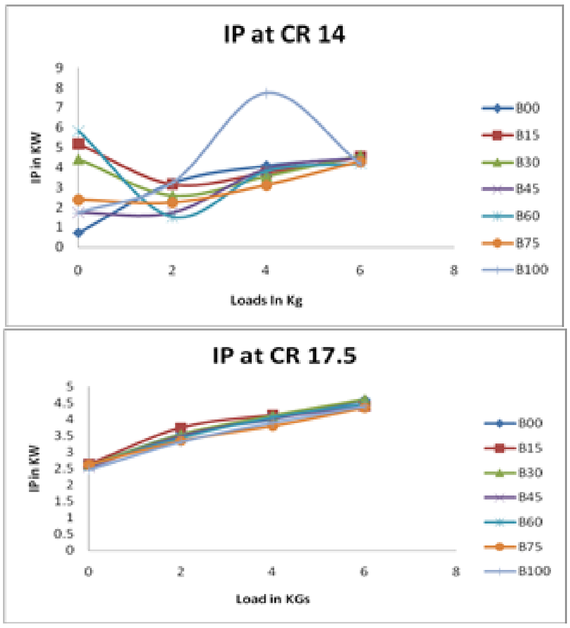

Fig. 6:

Fig. 6 indicates the graph of IP vs. Load at CR14 and CR17.5.The fig. Indicate that IP of all biodiesel blends as well as diesel fuel goes on increasing with increase in load at CR17.5.IP in CR14 all biodiesel blends as well as diesel fuel goes on decreasing with increase in load without biodiesel B100.The IP of blend B45 performances very close to IP of diesel fuel at both the CR.

G. Mechanical Efficiency

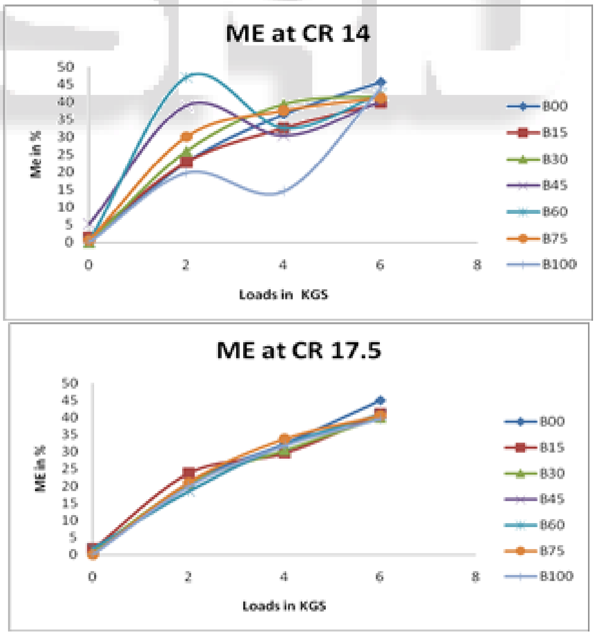

Fig. 7:

Fig. 7 indicates the graph of ME vs. Load at CR14 and CR17.5.The fig. Indicate that ME of all biodiesel blends as well as diesel fuel goes on increasing with increase in load and CR.The ME of blend B45 at CR 17.5 and blend B15 and B30 at CR 14 performance very close to ME of diesel fuel at both the CR.

H. Volumetric Efficiency

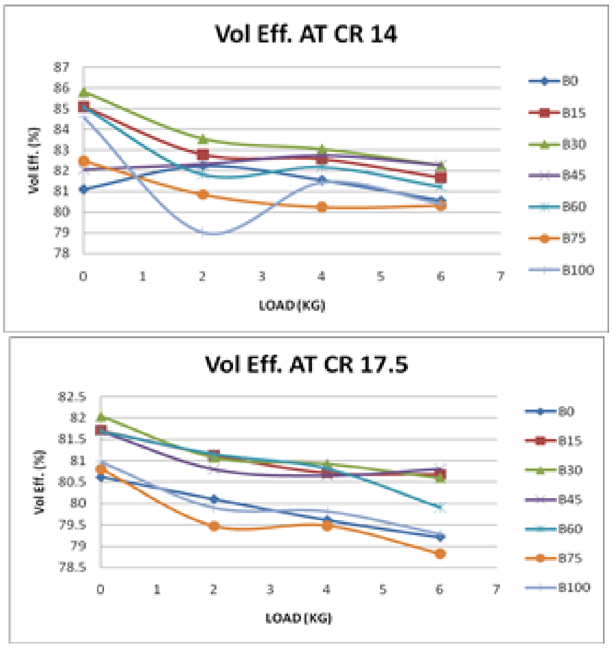

Fig. 8:

Fig. 8 indicates the graph of VolEff vs. Load at CR14 and CR17.5 The fig. Indicate that VolEff of all biodiesel blends as well as diesel fuel goes on decreasing with increase in load at CR 14 and CR 17.5. The VolEff of blend B45 at CR 14 and blend B100 at CR 17.5 performances very close to VolEff of diesel fuel at both the CR.

I. Emission Analysis

1) HC Emissions

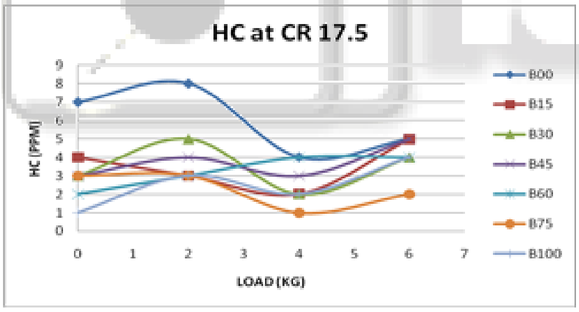

Fig. 9:

Fig. 9 indicates the graph of HC emission vs. Load at CR17.5.The fig. Indicate that HC emission of all biodiesel blends as well as diesel fuel and goes on continuously vary with increase in load at CR 17.5. Show in fig. The mean percentage of HC with cotton seed biodiesel as compare to Diesel is decrease of the order of 20% to the 25% from B30 to B75 respectively.

CO_2 Emissions:-

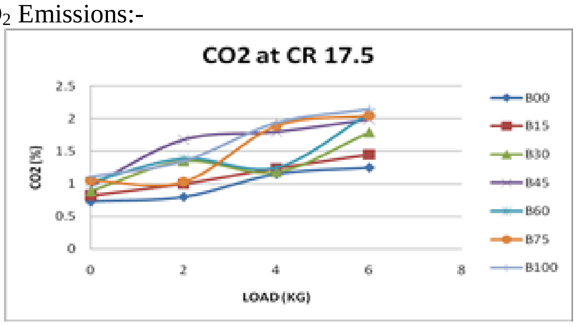

Fig. 10:

Fig. 10 indicates the graph of CO_2 emission vs. Load at CR17.5.The fig. Indicate that CO_2 emission of all biodiesel blends as well as diesel fuel and goes on continuously increase in load at CR 17.5. Show in fig. The mean percentage of CO_2 with cotton seed biodiesel as compare to Diesel is increase of the order of 10% to the 20% from B15 to B75 respectively.

2) NOx Emissions

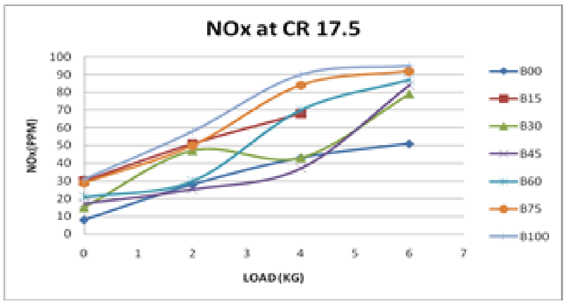

Fig. 11:

Fig. 11 indicates the graph of NOx emission vs. Load at CR17.5.The fig. Indicate that NO emission of all biodiesel blends as well as diesel fuel and goes on continuously increase in load at CR 17.5. Show in fig. The mean percentage of NOx with cotton seed biodiesel as compare to Diesel is decrease of the order of 2% to the 10% from B45 to B75 respectively.

3) CO Emissions

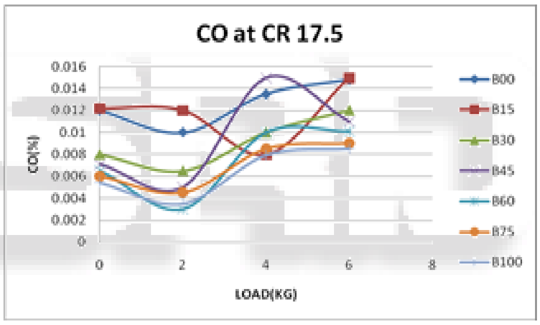

Fig. 12:

Fig. 12 indicates the graph of CO emission vs. Load at CR17.5. The increase in blend proportion reduces CO emissions because oxygen promotes complete combustion. It is found that the CO emissions increase from no load to full load condition for all the fuels tested. At full load of 6kg, it is seen that there is a 50% reduction in CO emissions when cotton seed biodiesel is used as compared to Diesel oil.

4) SOx Emissions

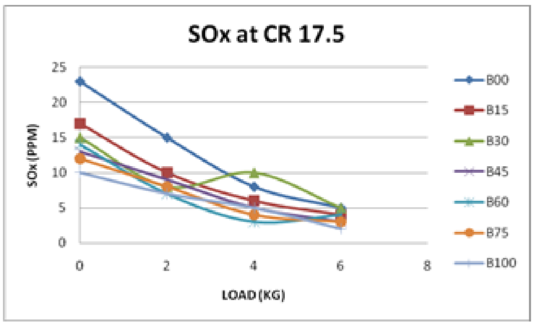

Fig. 13:

Fig. 12 indicates the graph of SOx emission vs. Load at CR17.5.The fig. Indicate that SOx emission of all biodiesel blends as well as diesel fuel and goes on continuously decrease with increase in load at CR 17.5.

Show in fig. The mean percentage of SOx with cotton seed biodiesel as compare to Diesel is decrease of the order of 40% to the 50% from B15 to B75 respectively.

IV. Conclusion

The experimental study is conducted on four strokes, VCR diesel engine using cotton seed biodiesel blends with diesel. The Performance parameters and emission analysis is evaluated by running the engine at different combination of preset CRs and varying load. The Performance parameters BP, BSFC, IP, FP, ME, BThEff, VolEff and Emission constituents measured are HC, CO, CO_2, SOx and NOx. Based on the experimental studies, following are the important observations made and conclusion drawn thereon.

From the large number of experimental data for Performance parameters and Emission constituents obtained for various input parameters such as load, CR and blend, picking up an optimum combination of the input parameters manually is not possible. The effect of blend proportion, load and CR create multi-objective scenario.

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