Performance and Emission characteristics of single cylinder CRDI engine operating on cardanol oil and diesel fuel.

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ABSTRACT

Biodiesel is a fatty acid alkyl ester which is renewable, biodegradable and non toxic fuel which can be derived from any vegetable oil by Transesterification process. Biodiesel has become more attractive recently because of its environmental benefits and the facts that it is made from renewable resources. India imports more than seventy percent of the oil it uses and is looking for alternative fuel to reduce its dependence on imports. In India, bio fuels derived from non-edible oils is considered as a renewable alternative to the fossil diesel. The cost of the biodiesel is higher than diesel and hence in this work, cardanol was used as an alternative renewable fuel for the diesel engine. The compression ignition engine is the most popularly used prime mover. The compression ignition (CI) engine moves a large portion of the world's goods & generates electricity more economically than any other device. The application of bio diesel as a substitute for conventional petroleum fuel in diesel engine gain ever increasing demand throughout the world wide. In this research work the detailed investigation on performance and emission characteristics of four stroke single cylinder CRDI engine with variable loads(0,2.5,5,7.5,10KG) at different injection pressure(300,400,500 bar) operating with cardnol bio-fuel of volumetric blends like 10%,& 20% were studied. From the engine tests, it is observed that the brake power increasesas load increases. Brake specific energy conversion decreases with increase in brake power. Brake thermal efficiency increases with higher brake power and emission levels (HC, CO, NOX) were nominal up to 20% blends.

Key Worlds: *Compression Ignition, Characteristics, Cardanol bio fuel, Performance, Emission.*

1. INTRODUCTION

In our present day lifestyle, the internal combustion engines have already become an indispensable and integral part, particularly in the transportation and agricultural field. CI engines are the most trusted power sources which are preferred in the transportation industry also. Transport sector contributes significant amount of GHG emission. The vehicle population throughout the world is increasing rapidly; in India the growth rate of automotive industry is one of the largest in the world. It is quite evident that the problem cannot be solved with the conventional fossil fuels. This demands the search for a suitable alternative to conventional fossil fuels.

Biodiesel is a drop-in replacement for petro-diesel that is biodegradable, less toxic and can reduce harmful tailpipe combustion emissions (CO2, CO, UHC (unburned hydrocarbons) and PM) relative to petro-diesel. A biofuel is any fuel that is derived from biomass – recently living organisms or their metabolic by products, such as manure from cows. It is a renewable energy, unlike other natural sources such as petroleum, coal and nuclear fuels. Biofuels are called carbon dioxide neutral, because the carbon in biofuels was recently extracted from atmospheric carbon dioxide by growing plants. Where as, Biodiesel is chemically defined as mono alkyl esters of FAME (Fatty Acid Methyl Ester) type derived from renewable lipid sources obtained from transesterification.

2.MATERIALS AND METHOD.

2.1 Sample collection and pre-treatment

Cashew nut was collected from near by place Karkala. The shell was detached from the apple, washed and sun-dried prior to deshelling the nut. The cashew nut shell was further oven-dried and milled using a ball mill at the Petrochemical. The milled CNS was sieved to obtain a particle size range of 5 mm. The ground sample was stored at 4°C in a refrigerator for further experimentation.

Fig1: Cashew Nut Tree and Shell

2.2 Extraction of the CNS oil by Transesterification

According to the invention, CNSL is subjected to fractional distillation at 200° to 240°C under reduced pressure not exceeding 666 Pa in the shortest possible time, which gives a distillate containing cardol and the residual tarry matter.

This first distillate is then subjected to a second distillation under the same identical conditions of temperature and pressure when the anacardol distils over at a temperature of 205°C to 210°C and the cardol distils over at a temperature of 230°C to 235°C. The first step of the process is to get the decarboxylated oil by heating the oil to a temperature of 170°C to 175°C under reduced pressure of 3999-5330 Pa. The next two steps are the same as above for the production of both cardol or cordanol and anacardol.

Transesterification

Cardanol oil sample, unhydrous methyl alcohol 99% grade laboratory reagent type and sodium hydroxide was selected as the catalyst. About 4 grams of catalyst was dissolved in 200 ml methanol to prepare alkoxide, which is required to activate the alcohol. The solution was stirred vigorously for 20 minutes in a covered container until the alkali was dissolved completely. Mixture was protected from atmosphere carbon dioxide and moisture as both destroy the catalyst. The alcohol catalyst (NaOH) mixture was then transferred to the reactor containing 700 ml moisture free crude CNSL oil. Stirring of the mixture was continued for 90 minutes at a temperature between 60-65 degrees. The round bottom flask was connected to a refractor condenser and the mixture was heated for approximately three hours.

Fig2: Extracted Cardanol Oil

2.3 Blends of Cardanol And their Properties

Table 1: Properties of Blends, HB, C& pure Diesel

Sl. no	Blends	Diesel	Cardanol	Kinematc Viscosity @ 40^0C	Density (kg/m3)	Calorific Value (KJ/Kg)	Flash Point (^{0}C)
1	D100	100	-	2.28	834	42000	42
2	C100	-	100	8.5	930	39770	185
3	C10+D90	90	10	2.902	843.6	41777	56.3
4	C20+D80	80	20	3.524	853.2	41554	70.6

3. ENGINE TEST RIG AND EXPERIMENTATION

Experimental Procedure

Here in this study a constant speed of 1500 rpm for engine and fixed compression ratio of 18:1 were maintained. The standard engine was experimented at five different loads in increasing order of 0, 2.5, 5, 7.5, 10 KG. The standard IP and injection timing of the testing engine were 300 Bar and 23^0C BTDC respectively. For applying loads during the experimentation eddy current dynamometer was used. Emissions were recorded by multi gas analyzer MGA-2. The engine was put to idling for 15 minutes before every set of experimentation at minimum possible load for the purpose of attaining steady state. The readings were taken for standard operating conditions of the engine varying different loads and then the standard injection pressure of the engine was varied and the same procedure was repeated for other two injection pressures varied i.e. 400 and 500 bar injection pressures. The above procedure was repeated for different blends of biodiesel. Modified injection pressure results were compared for performance and emission results with standard injection pressure using both diesel and biodiesel. In each set of experimental test readings, brake thermal efficiency, specific fuel consumption, BP and concentrations of CO, HC & NOX were taken at four different loads.

Table 2: Engine Specification

Engine		
Sr No.	**Parameters**	**Specification**
1	Type	4-stroke, single cylinder, water cooled, constant speed, (CRDI) Diesel engine (Kirloskar)
2	Bore	80mm
3	Stroke	110mm
4	Speed	1400-1500 RPM
5	HP	5 HP
6	Starting	Crank Start
7	Lubrication	Forced
8	Compression Ratio	18:1
9	Cubic Capacity	553cc

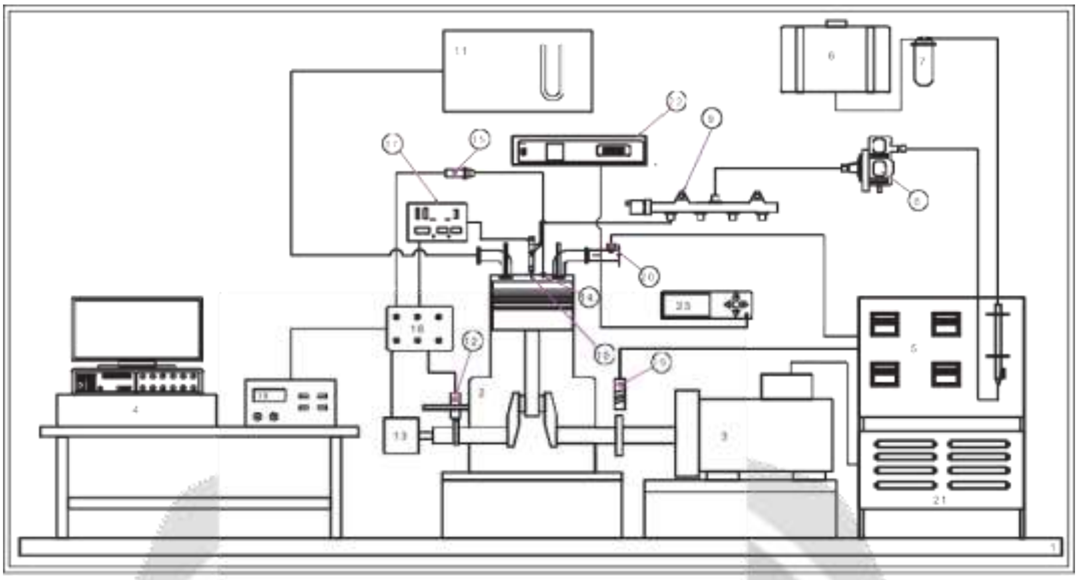

Fig3: Schematic of the experimental setup

1.Base, 2.Engine, 3.Alternator, 4.Data acquisition system, 5.Control panel with Fuel measurement system, 6.Fuel Tank, 7.Filter, 8.High Pressure pump, 9.Common Rail, 10.Solenoid injector, 11.Air Box, 12.TDC Sensor, 13.Shaft encoder, 14.Pressure Transducer, 15.Charge Amplifier, 16.BNC box, 17.Injector Driver circuit, 18.Power Supply, 19.RPM sensor, 20.Temperature sensor, 21.Load Bank, 22.Smoke opacity meter, 23. Gas Analyzer

5. RESULTS & DISCUSSION

5.1. PERFORMANCE ANALYSIS OF B10 & B20 BLENDS AT INJECTION PRESSURES

5.1.1 Variation of S.F.C with Load

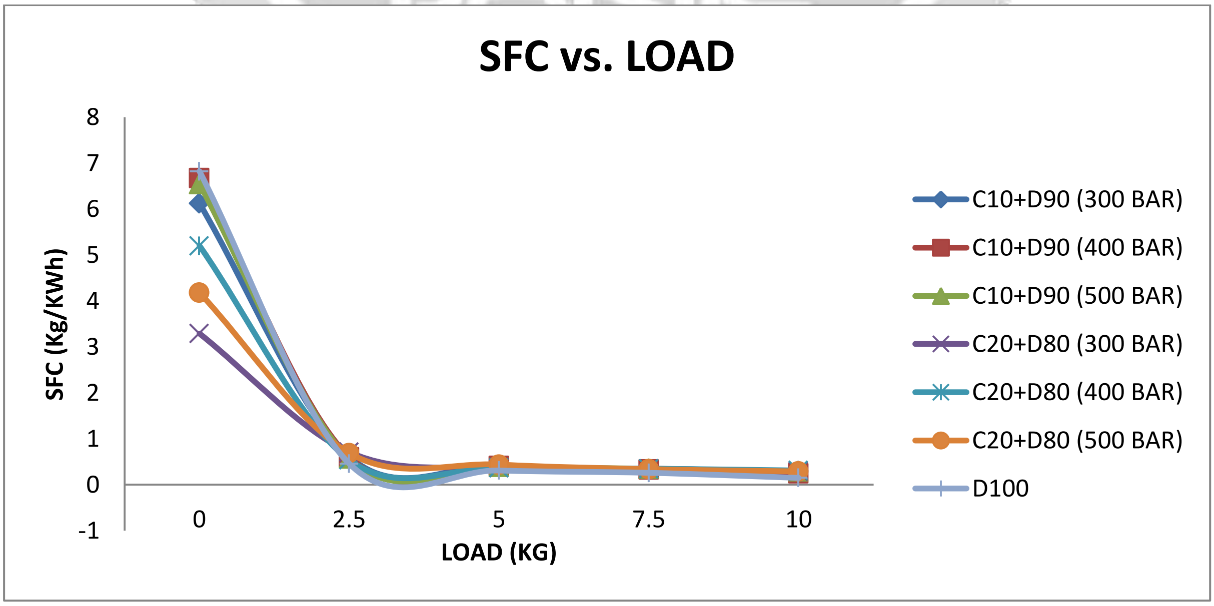

Fig 4: showing variation of BSFC v/s LOAD.

Figure 4 shows the variation BSFC with load at different injection pressures for C10 & C20 blend. Compare to diesel BSFC value for biodiesel is less because of lower calorific value. For Cardanol blend the value of BSFC is lesser than value obtained for diesel.

5.1.2 Variation of S.F.C with Load

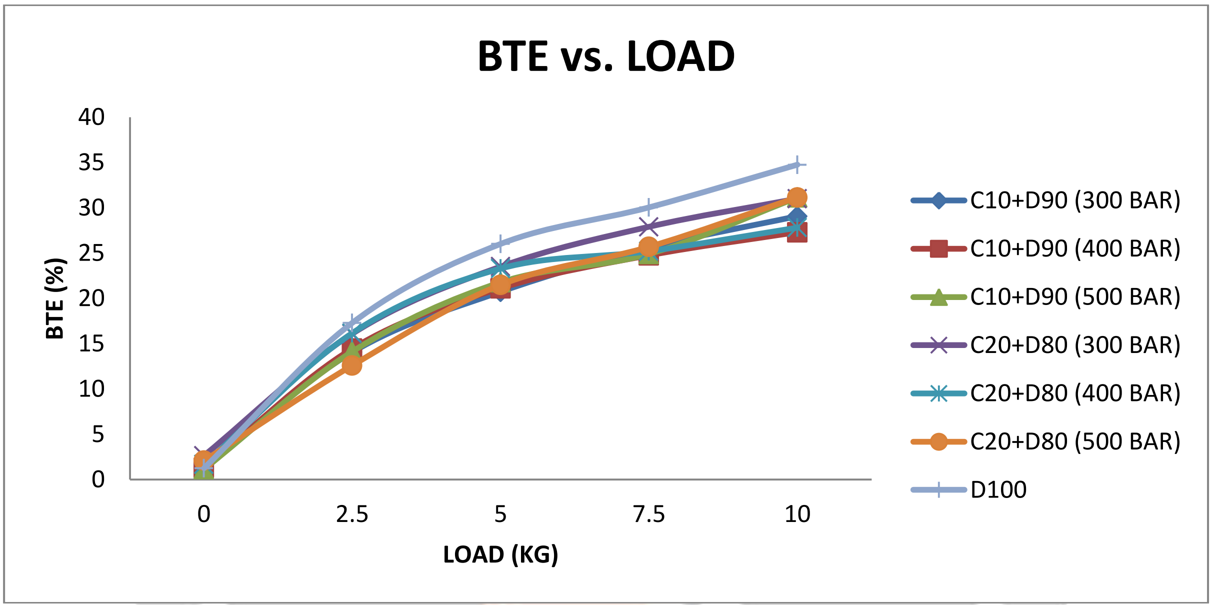

Fig 5: showing variation of BTE v/s LOAD.

Figure 5 shows that the value of BTE obtained for diesel are nearly same with all the blends at different injection pressures. Because of lower energy content of Cardanol as compared to Diesel which gives lower values of brake power, the decrease in BTE value is observed with increase in injection pressure. C20+D80 blend at 300 bar gives nearer value compared to diesel.

5.2 Emission Analysis OF B10 & B20 BLENDS AT INJECTION PRESSURES

5.2.1 Variation of S.F.C with Load

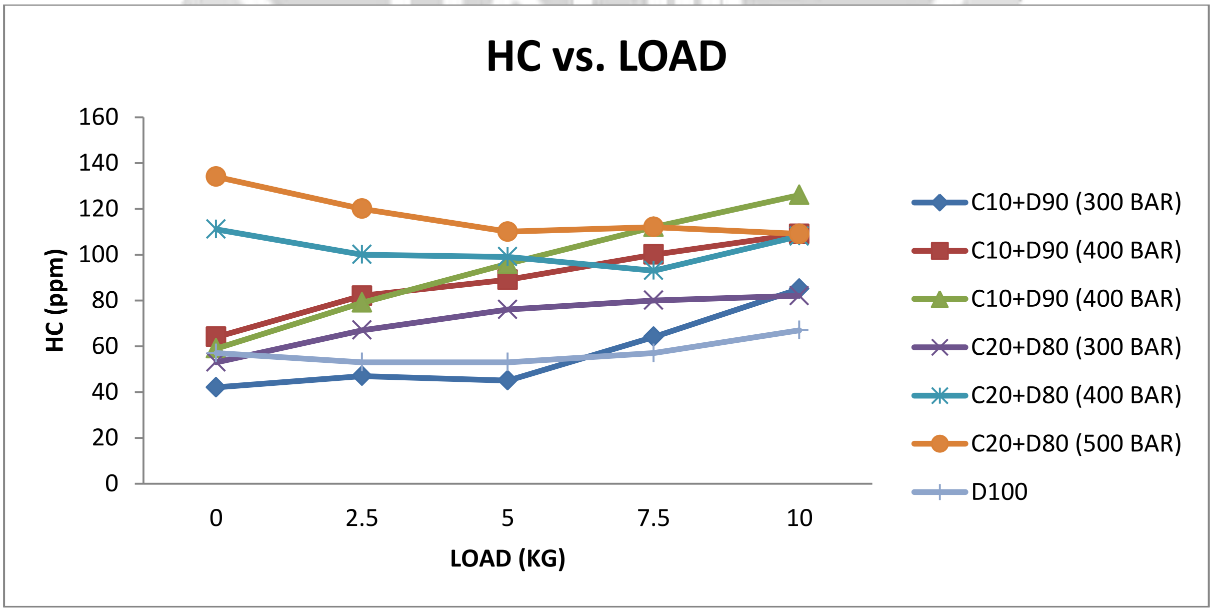

Fig 6: showing variation of BTE v/s LOAD.

From the figure 6 it is observed HC emission of C20+D80 at 300 Bar was less than that of Diesel, this is because of the sufficient availability of oxygen at higher temperatures results in complete combustion.

5.2.2 Variation of S.F.C with Load

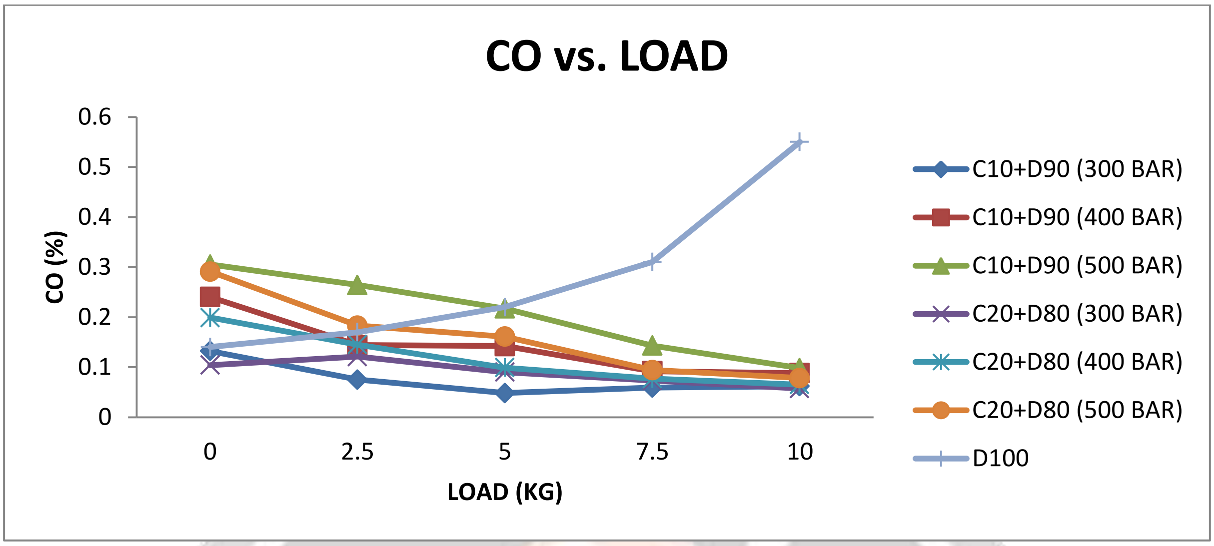

Fig 7: showing variation of CO v/s LOAD.

From the figure 7 it is found CO emission is less for the biodiesel blends compare to diesel also CO emissions found decreasing with increase in injection pressure. The biodiesel blends shows lower values of CO as compared to pure diesel this is due to extra amount of oxygen content present in the biodiesel. This extra oxygen results in oxidation of CO into CO_2 which reduces CO emission. CO emission is less for C20+D80 at 300 Bar blend compared to all the Biodiesel blends.

5.2.3 Variation of S.F.C with Load

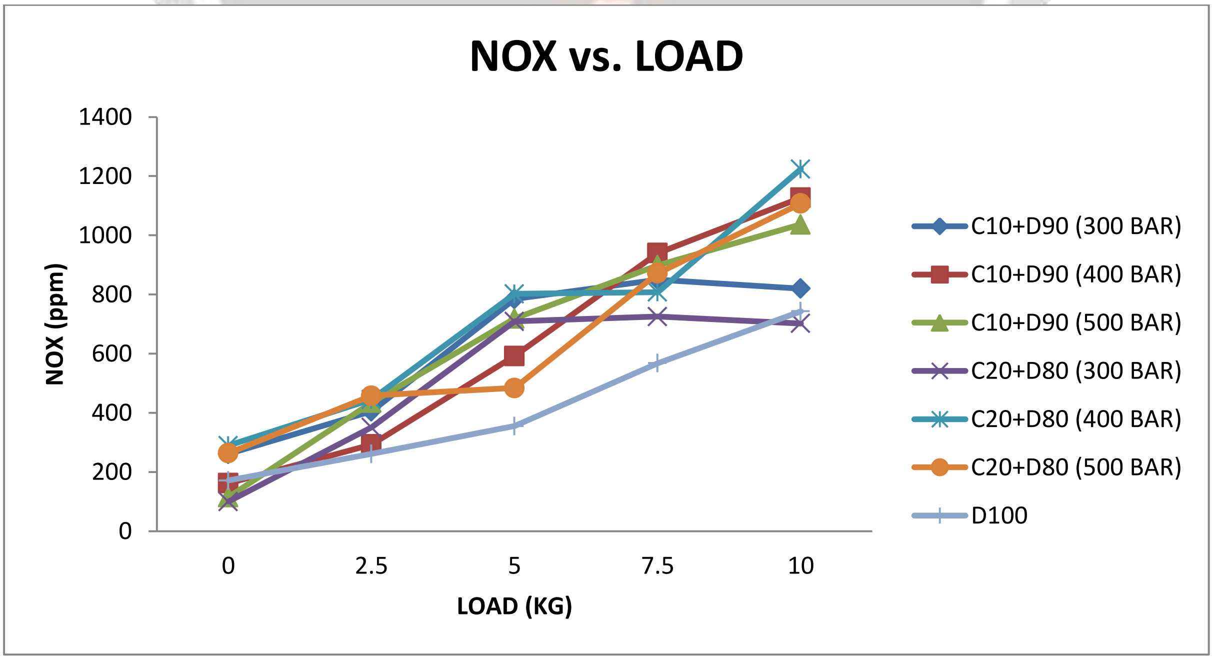

Fig 8: showing variation of NOX v/s LOAD.

Figure 8 shows that for both blends and with increase in injection pressure NO_X emission increases. This is because of higher temperature at high injection pressure and high oxygen content of biodiesel. The oxygen content present in the biodiesel reacts with nitrogen present in the intake atmospheric air at high temperatures and results in higher values of NO_X emissions. It is observed that NO_X emission is less at lower injection pressure i.e., 300 Bar.

6.CONCLUSION

A Single Cylinder CRDI Engine was operated successfully using Cardanol Oil Blends as the soul fuel. The following conclusions are made on the experimental results.

- CNSL satisfies the important fuel properties as per the ASTM specification of Biodiesel.
- Engine works smoothly on Cardanol fuel Blends with performance comparable to diesel Operation.
- The S.F.C was found to be less for the different blends compared to diesel.
- The value of BTE obtained for diesel are nearly same with all the blends at different injection pressures. . C20+D80 blend at 300 bar gives nearer value compared to diesel.
- HC emission of C20+D80 at 300 Bar was less than that of Diesel, this is because of the sufficient availability of oxygen at higher temperatures results in complete combustion.
- CO emission is less for the biodiesel blends compare to diesel also CO emissions found decreasing with increase in injection pressure. CO emission is less for C20+D80 at 300 Bar blend compared to all the Biodiesel blends.
- It is observed that NO_X emission is less at lower injection pressure i.e., 300 Bar.

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