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Certain Investigations on the Performance, Combustion, Emission Characteristics and Vibration Analysis of C.I Engine Using Canola Bio Diesel as an Alternative Fuel

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Abstract

The growing concern about energy resources and the environment has increased interest in the study of alternative sources of energy. To meet increasing energy requirements, there has been growing interest in alternative fuels like biodiesel to provide the suitable diesel oil for internal combustion engines. Biodiesels offer a very promising alternative to diesel oil since they are renewable and have similar properties.

With these objectives, the present work has focused on the performance of engine, measuring the exhaust emissions and vibration of diesel engine using canola oil and its blends with diesel. In this investigation, the blends are analyzed, and compared the performance, emission, exhaust emission and vibration with diesel using 5.2 kW Single cylinder, 4stroke diesel engine. And also the vibration of the same engine is measured for diesel and canola biodiesel at head and bottom of the engine by using vibro meter.

The performance and emission characteristics of blends are evaluated at variable loads and constant rated speed of 1500 rpm and found that the performance of B20 blend of canola oil gives result, that is near to the diesel and also found that the emission CO, CO2, HC are slightly increased and NO_x is reduced when compared to diesel. And the vibration is higher in bio diesel at head position were at the bottom is lowered compared with diesel.

Keywords: *Biodiesel, Canola oil, Performance, Combustion, Emission, Knocking, Vibration.*

1. Introduction

Most of the alternative fuels are renewable and can be obtained from natural resources; therefore it will decrease the dependence to petroleum. The various forms of alternative fuels are: biodiesel, ethanol, methanol, propanol, natural gas, hydrogen, electricity and p serial fuels. Depletion of the world petroleum reserves and increasing environmental concerns has stimulated the search for renewable fuels, such as biodiesel, in recent years. Biodiesel is the following alkyl esters and can be obtained by exchange of animal facts and vegetable oils. Of the various alternate fuels under consideration, biodiesel, derived from vegetable oils, is the most promising alternative fuel to conventional diesel.

The canola belongs to ‘Brassica’ family; Canola oil comes from pressed canola seeds also known as oil rapeseeds. Both canola seeds and rapeseeds are belonged to the exactly same genus; however, the name canola (Canadian oilseed- low acid) is labeled for modified plant developed by Canadian scientists.

A vibration is indicating the malfunction of engine. That is varying the injection profile strongly affect the bulk motion settling inside the combustion chamber. The maximum amplitude of the vibration provides information about combustion intensity, high amplitude may indicate early ignition or presence of a large amount of fuel in the cylinder prior to ignition, lower amplitude may indicate late ignition, injection malfunction or engine compression malfunction.

2.1 The Properties of Diesel fuel and Mango seed biodiesel

The properties of Canola oil are determined as per Indian standards (IS) method in fuel testing laboratory. Determination of viscosity, calorific value, Density, flash point and fire point are carried out using redwood viscometer, Bomb calorimeter, pensky apparatus respectively.

After transesterification the properties of Canola biodiesel was determined. It was found that the properties of Canola oil were similar to diesel. The properties of diesel and biodiesel were compared and tabulated in table1.

Properties	Diesel oil	Canola biodiesel
Density at 15^0 c in Kg/m^3	830	885

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Calorific Value kj/kg	42500	40755
Kinematic Viscosity cSt	2.1	6.0
Flash point in ^{0} c	56	140
Fire point in ^{0} c	65	175

Table -1: Fuel properties

3. Experimentation

3.1 Engine components

The various components of experimental set up are given below in fig.1 The important components of the system are

- The engine
- Dynamometer
- Smoke meter
- Exhaust gas analyzer

Fig -1: Photograph of experimental setup

Sl No	Parameters	Specification
01	Manufacturer	Kirloskar oil engines Ltd. India
02	Model	TV-SR, naturally aspirated
03	Engine	Single cylinder, DI
04	Bore/stroke	87.5mm/110mm
05	C.R.	16.5:1
06	Speed	1500 RPM, constant
07	Rated power	5.2KW
08	Working cycle	Four stroke
09	Response time	4 micro seconds
10	Type of sensor	Piezo electric
11	Crank angle sensor	1-degree crank angle
12	Injection pressure	200bar/23 def TDC
13	Resolution of 1 deg	360 deg with a resolution of

Table 2: Technical specifications of the Kirloskar diesel engine

4. Results and discussions

4.1 Introduction

This section consists of three types of experimental analysis of performance characteristics like brake thermal efficiency, specific fuel consumption, against brake power, emission characteristics like carbon monoxide (co) unburned hydrocarbon(HC), NOx, exhaust gas temperature against brake power and finally combustion characteristics like pressure, heat release rate, mass fraction burned against crank angle.

4.2 Performance characteristics of diesel, blends of canola biodiesel on diesel engine

4.2.1 Brake Thermal Efficiency

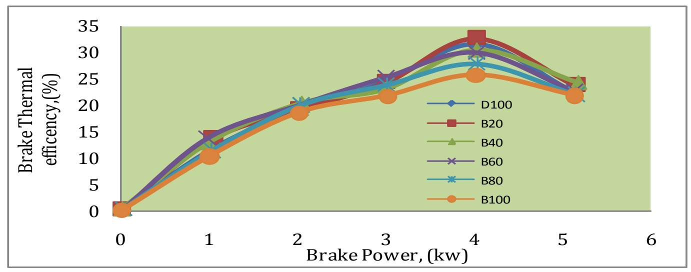

Fig -2: Variation of brake thermal efficiency with brake power

In fig.2 for the entire blends the brake thermal efficiency increases with brake power. The Increase in thermal efficiency due to high percentage of oxygen presence in the biodiesel, the extra oxygen leads to causes better combustion inside the combustion chamber. Brake thermal efficiency is always found to be lower with increasing the bio diesel blends (B20, B40, B60) as compared with diesel. This is because of the fuel properties such as higher viscosity, density and lower calorific value of bio-diesel blends as compared to diesel.

4.2.2 Specific fuel consumption

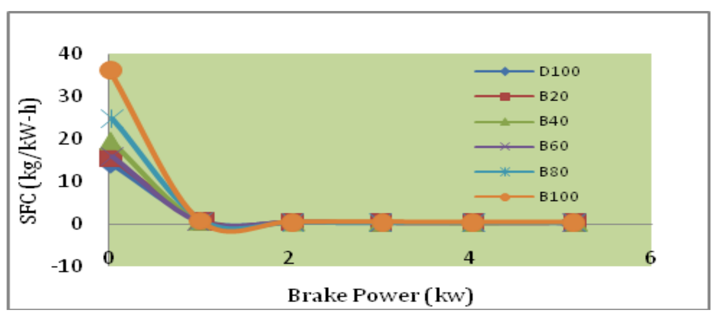

Fig -3: Variation of specific fuel consumption with brake power

It is observed from the graph that the SFC for biodiesel and their blends are higher than diesel.B20 and B40 blends are close to diesel at higher loads. The specific fuel consumption of all blends is more than that of diesel. This may be due to fuel density, viscosity and heating value of the fuels. The main reason for this could be that percent

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increase in fuel required to operate the engine is less than the percent increase in brake power due to relatively less portion of the heat losses at higher loads.

4.2.3 Exhaust Gas Temperature

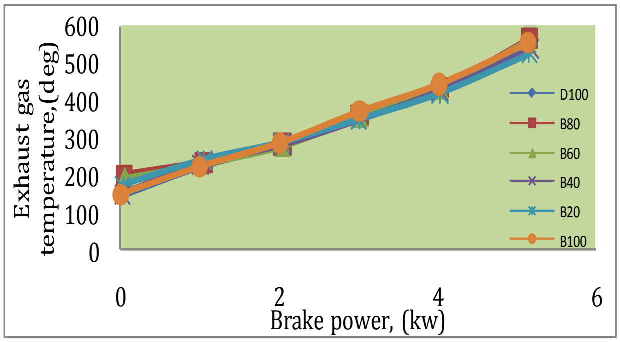

Fig -4: Variation of exhaust gas temperature with brake power

In fig.4 the exhaust emission temperature of all the biodiesel are higher than the diesel as it is evident from the graph. The exhaust gas temperature of all the blends and pure diesel increase as the load increases. It is observed that, at full load the exhaust gas temperature is maximum, this is because; at full load the chemically correct ratio of air and fuel is used, due to chemically correct ratio of air and fuel, high heat is generated inside the cylinder.

4.3 Emission characteristics

4.3.1 Carbon monoxide

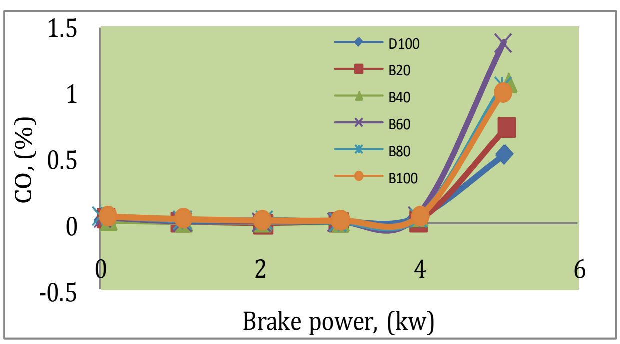

Fig -5: Variation of carbon monoxide with brake power

In the fig.5 at low loads (up to 40% load) the emission level of all fuels are similar. But in maximum load the emission of Biodiesel-diesel blends is slightly higher than that of diesel. This may be due to high viscosity and small increase in the specific gravity of the blended fuel reduce the consequence of fuel the spray pattern suppress the complete combustion. The emission of CO more in all blends as compare to the neat diesel.

4.3.2 Hydrocarbon

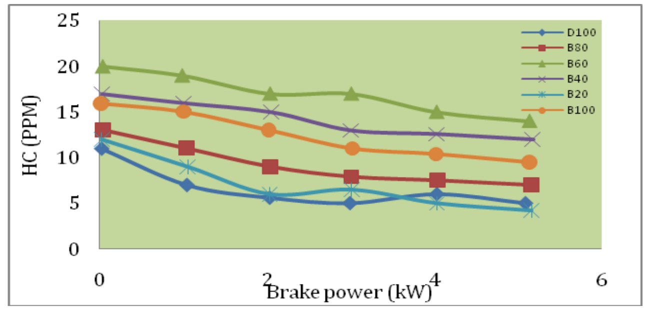

Fig -6: Variation of hydrocarbon with brake power

In fig.6 the HC emission is increased when compared with diesel due to less time available for mixture formation during the combustion process since biogas has a longer burning rate. The high HC emission was also attributed to an un burnt charge, leaving the cylinder during the period of positive wide valve overlap of the diesel engine. Under light load conditions, the fuel is stripped the sprays during ignition delay and mixed with air beyond the lean limit of combustion..

4.3.3 NO_X

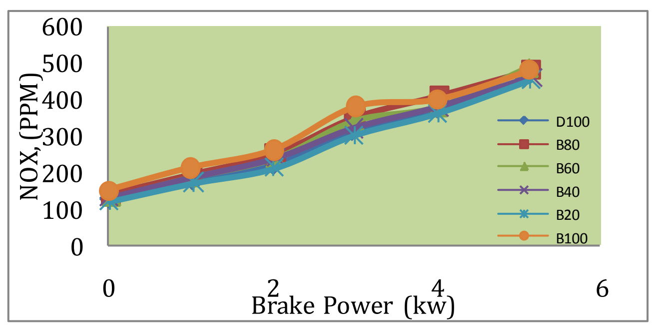

Fig -7: Variation of NOx with brake power

Fig 7. shows that the NOx emission increased with the increase of percentage ratio of biodiesel. NOx emission is primarily a function of total oxygen inside the combustion chamber, temperature, pressure, compressibility, and velocity of sound. Invariably biodiesel has high level of oxygen bound to its chemical structures. Thus, oxygen concentration in biodiesel blends fuel might have caused the formation of NOx . Furthermore, the increase of NOx emission is due to the higher cetane number of biodiesel which will reduce the ignition delay. The increase of NOx emission is a result of the reduced ignition delay. However, the NOx emissions can be reduced through engine tuning or using exhaust catalytic converter.

4.4 Combustion characteristics

4.4.1 Cylinder pressure with Crank angle

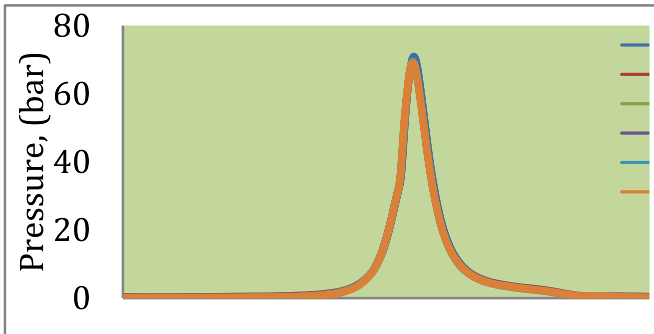

Fig -8: Variation of cylinder pressure with crank angle

The variation of cylinder pressure with respective crank angle for diesel and different blends of canola biodiesel are presented in fig.8 peak pressure of 70.89bar and 68.89bar are found for pure diesel and B40 respectively. From the test results it is observed that the peak pressure variations are less since the properties such as calorific value, viscosity and density are brought closer to diesel after transesterification of vegetable oil, no major variation in the pressure are found.

4.4.2 Heat Release Rate with Crank Angle

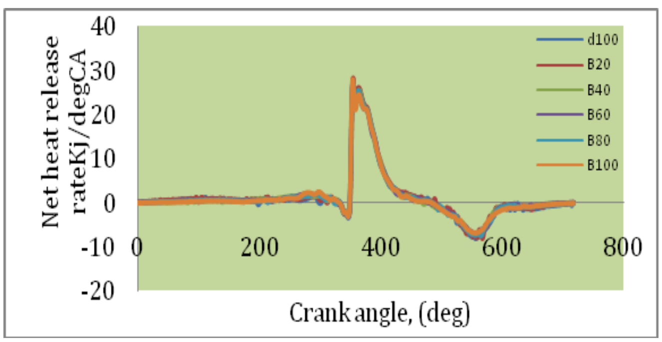

Fig -9: Variation of heat release rate with crank angle

The fig.9 shows that the variation of the heat release rate with crank angle. It is observed that all the blends of canola oil traces the path of pure diesel and the B20 blend heat release rate is little bit greater than that of pure diesel at peak.

4.4.3 Mass fraction burned with Crank Angle

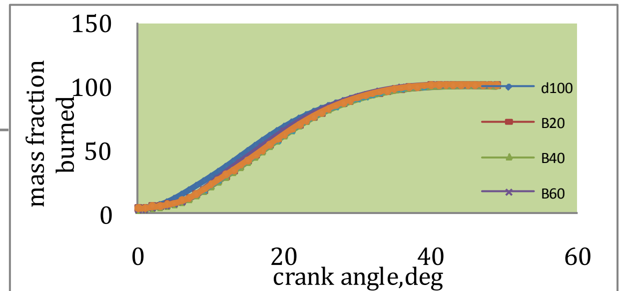

Fig -10: Variation of Mass fraction burned with crank angle

The fig.10 shows that the variation of the mass fraction burned with crank angle. It is observed that all the blends of canola oil traces the path of pure diesel and all blend heat release rate is little bit greater than that of pure diesel at peak.

Vibration characteristics:

The vibration of the engine is measured in terms of acceleration by using the devise called 'Card Vibro' the portable vibration meter. The vibration is measured at two positions of the engine one at head and another at bottom for both diesel and biodiesel.

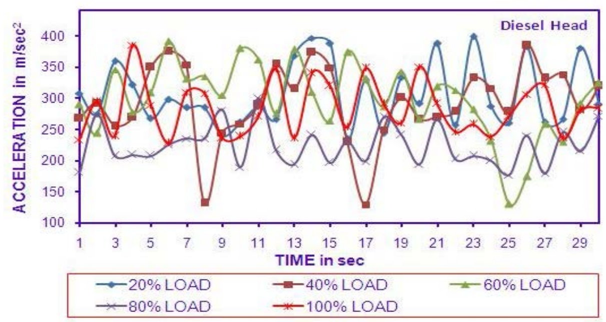

Fig.11 Time Vs Acceleration (Diesel Head)

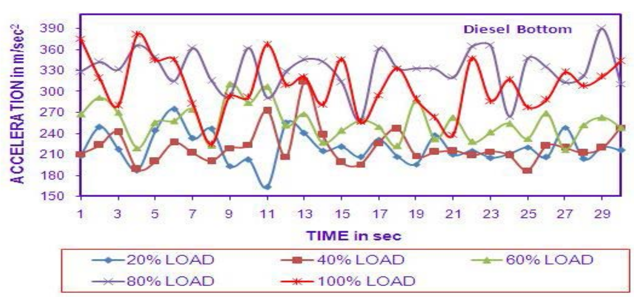

Fig.12 Time Vs Acceleration (Diesel Bottom)

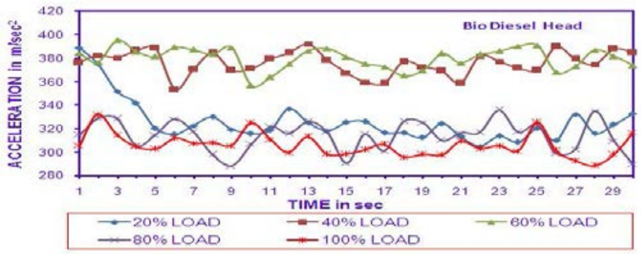

Fig.13 Time Vs Acceleration (Biodiesel Head)

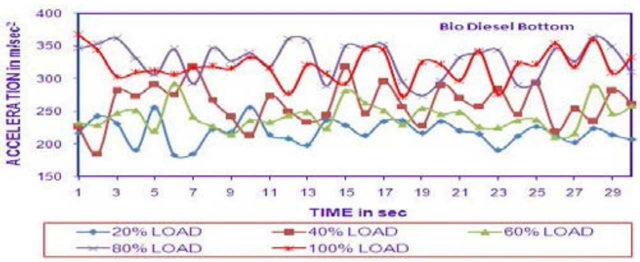

Fig.14 Time Vs Acceleration (Biodiesel Bottom)

From Fig.11 to Fig.14 shows the comparison of time and acceleration of time at various load condition with diesel and bio diesel. The acceleration is higher in bio diesel at head position, at the bottom is lowered compared with diesel. This is due to higher viscosity of biodiesel. Biodiesel always shows a lower peak pressure than mineral diesel. The start of combustion reflects the variation in ignition delay because the fuel pump and injector setting were kept identical for all fuels. Combustion starts later for biodiesel owing to the longer ignition delay. The ignition delay is longer the actual bring of the first few droplets gets accumulated in the chamber. Such a situation produces the extreme pressure differentials and violent gas vibrations known as knocking.

5. Conclusions

Experimental investigations are carried out on a single cylinder DI diesel engine to examine the suitability of Canola biodiesel as an alternative fuel. The performance, emission and combustion characteristics of blends are evaluated and compared with diesel and optimum blend is determined and also the vibration characteristics determined by vibro meter of diesel and biodiesel at head and bottom position. From the above investigations, the following conclusions are drawn.

- Specific fuel consumption increases as the concentration of canola biodiesel increases so we can observe that with 20% canola biodiesel blend almost matches with diesel fuel.
- Air fuel ratio for diesel is greater than canola biodiesel and its blends which is evident from the graph.
- Brake thermal efficiency of canola biodiesel at 20% blend has slightly higher efficiency than diesel Brake thermal efficiency is always found to be lower with increasing the bio diesel blends (B20, B40, B60) as compared with diesel.
- The exhaust emission temperature of all the biodiesel are higher than the diesel and It is observed that, at full load the exhaust gas temperature is maximum, due to chemically correct ratio of air and fuel.
- The B20 has lower average percentage of change in CO, and HC compared to Diesel. Yet, B20 is producing higher NOx emission. Nevertheless, the B20 is still the suitable biodiesel blend amongst all as the NOx emission can be reduced with the advanced technologies.
- The acceleration is higher in bio diesel at head position; the bottom is lowered compared with diesel. The maximum vibration amplitude is related to the rate of pressure rise and the maximum pressure in the cylinder during ignition. When the rate of pressure rise increases the vibration amplitude also increases.

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