Experimental Investigation on Performance and Emission Characteristics of Four Stroke Diesel Engine Using Canola Biodiesel as a Fuel

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Abstract- **Day by day increasing of diesel price and exhaust emission from the vehicle using diesel as fuel faces economical and environmental problems. By considering these facts we need to search for some alternative and renewable fuel to avoid above problems. In this study, canola biodiesel was used as an alternative fuel for diesel engine. By taking canola oil as raw oil, biodiesel was prepared through transesterification process by using methanol and KOH as a catalyst. And prepared biodiesel were blended with diesel in proportion of 20% (B20), 40% (B40), 60% (B60) and 100% (B100) for analysis. The physical properties of biodiesel were observed. The effects of biodiesel and their blends on diesel engine performance and emission characteristics were studied under various loading conditions such as 25%, 50%, 75% and 100%. Finally the brake thermal efficiency (BTE) and brake specific fuel consumption (BSFC) were calculated from the observed data. From the emission tests, it is noted that Hydrocarbon and NOX pollutants are decreased along with the increasing percentage of blends of biodiesel.**

Keywords- ***Canola biodiesel, Transeterification, Diesel engine, Engine performance, Engine emission*.**

I. INTRODUCTION

By considering the petrol and diesel price the new way of finding some alternative fuel idea leads to get renewable energy source such as biodiesel for diesel engines. The biodiesel is one of the best alternative fuels which prepared from vegetable oil, animal fats, and recycled cooking oil. Biodiesel is renewable and environmental friendly alternative diesel fuel. The technical definition of biodiesel is mono alkyl esters of long fatty acids. The most important method to produce biodiesel is called transesterification. Through transesterification process separate the glycerin as a byproduct by using potassium hydroxide and methanol. Properties of biodiesel vary depending upon the plant source and fat source. That is basically related to the chemical composition as like number of carbon content and number of double bonds in hydrocarbon chain reaction. The biodiesel has produce 50 % less hydrocarbons as compared diesel fuel, during the exhaust emission the biodiesel has produce few amount of sulfur oxide as compared diesel [1]. On the other hand environment conversion and control of greenhouse gas (GHG) emissions have inspired for R&D on biofuels. The Biofuels such as alcohols and biodiesel have been proposed as alternatives for internal combustion engines [2]. Like canola oil, it can be directly used in diesel engines as they have a high cetane number and calorific value very close to diesel [3]. Canola oil is environment friendly and does not produce Volatile organic Compounds as atmospheric pollutants.

The aim of the study was to check the performance and the emission characteristics of four stroke direct injection diesel engine using canola biodiesel as fuel, for various proportions of biodiesel blends.

II. MATERIALS AND METHODS

Biodiesel Production:

Biodiesel was prepared in the chemical laboratory by using canola oil and methanol in presence of sodium hydroxide (NaOH) as a catalyst. The chemical reaction takes place while conversion of canola oil into biodiesel was transesterification reaction. The transesterification process is shown in figure.1. Here 2.0g of sodium hydroxide (NaOH) and 150ml of methanol were chosen and taken in a round conical flask, by another flask 600ml of canola oil was taken. And by using magnetic stirrer the methanol and sodium hydroxide (NaOH) were stirred together to form methoxide.

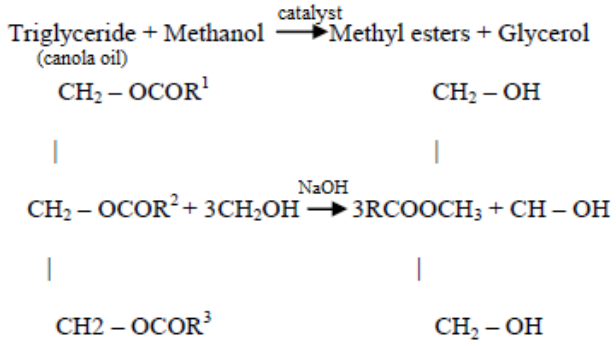

Fig .1 Transesterification Process

Now 600ml of canola oil was heated to 65°C and produced methoxide was poured into the heated canola oil. Again the

whole mixture was stirred till ester formation occurs, which means FAME (fatty acid methyl ester). Then it was allowed to cool for two to three hours in a flask itself without stirring. Finally two layers were formed inside a conical flask, on the bottom layer glycerol and top layer was ester (FAME). Biodiesel was separated from glycerol and kept in

Fig .2 Biodiesel Produced from Canola oil

a clean conical flask for purification. Because separated biodiesel will contain some residues like soap and glycerol, it was removed by washing the biodiesel using distilled water. And cleaned biodiesel was taken to remove moisture content by drying in a incubator for 24 hours, followed by using sodium sulphate. The biodiesel obtained at various stages during preparation was shown in figure-2. And finalized biodiesel was taken for analyze the properties of it, like viscosity, density, flash point, fire point and calorific value. The properties obtained for prepared biodiesel was listed in Table 1. The experimentation was conducted for various loading condition in a diesel engine.

TABLE I
PROPERTIES OF BIODIESEL PREPARED

S.No	PROPERTIES	DIESEL	B20	B40	B60	B100
1.	Density at 15°C (Kg/m^3)	830	840	865	883	913
2.	Viscosity at 40 ^{o}C (cST)	2.70	3.15	3.32	4.59	6.47
3.	Flash point (^{o}C)	58	84	105	122	168
4.	Fire point (^{o}C)	77	89	131	156	193
5.	Calorific value (MJ/Kg)	43.09	42.56	40.83	38.04	37.65
6.	Pour point (^{o}C)	3.1	4.1	5.12	6.05	7.54
7.	Cloud point (^{o}C)	6.8	8.07	8.96	10.86	14.66

III. EXPERIMENTATION

Experimental Setup:

The four stroke single cylinder, direct injection diesel engine was used for the performance test. The complete specification of the test engine is shown in Table -2. No modification or alteration has been made in the diesel engine. Then the experimental setup consists of variable compression ratio engine which is coupled with an eddy current dynamometer. The experiments were carried out for various loading conditions such as 25%, 50%, 75% and 100% at 1500 rpm constant speed on engine.

TABLE II
ENGINE SPECIFICATION

Manufacturer	Kirloskar engine Ltd, pune, India.
Engine type	Single cylinder, four stroke, compression ignition engine
Rated power (KW)	5.2 @ 1500 rpm (constant)
Bore (mm)	87.5
Stroke (mm)	110
Swept volume (cc)	558
Compression ratio	17:5
Injection type	Direct injection
Dynamometer	Eddy current dynamometer
Cooling system	Water cooled type

The data acquisition system was used here to collect the data's from the system and stored that data's into a computer storage for evaluation of characteristics of engine. Then the pressure generated inside the engine cylinder was measured by piezoelectric pressure transducer, by the same crank angle also measured by using crank angle encoder. Load cell is connected to eddy current dynamometer for measuring loads applied on the engine.

Fig .3 Experimental Setup

And a K type thermocouple used here to measure the inlet air temperature and exhaust gas temperature. A burette with two infrared optical sensors adopted here to measure fuel flow rate and the air flow sensor was used here for measuring inlet air flow rate. AVL smoke meter allows to measure the smoke produce from the engine and AVL

DIGAS analyzer is used here to measure the exhaust gas constituents such as NO, CO and HC. All the experiments were conducted at constant compression ratio of 17:5 and the results are recorded.

In this study, the biodiesel used in the various proportions of 20% (B20), 40% (B40), 60% (B60) and 100% (B100) were used for conducting performance tests. The term B20 indicates 20% biodiesel and 80% pure diesel. First by using commercial diesel D100 analysis was made, after that by using various blend proportions of biodiesel the tests were carried as same loading condition taken for pure diesel D100. The experimental setup was shown in figure-3. Finally the parameters were measured based on above procedures are: performance and emission characteristics.

IV. RESULTS AND DISCUSSION

Performance Characteristics:

Brake Thermal Efficiency (BTE)

In an engine the chemical energy input in the form of fuel is converted into useful work is denoted by parameter called Brake thermal efficiency. In this study, BTE of the diesel engine is measured for different blends of biodiesel and pure diesel. Figure-4 clearly demonstrates the variation of BTE at different load condition. It tells that BTE increase with increasing loads on engine, when the load reaches 75% and above it almost shows constant value. The brake thermal efficiency of diesel (D100) is 97% same by comparing with pure biodiesel (B100), which is also shown in figure-4.

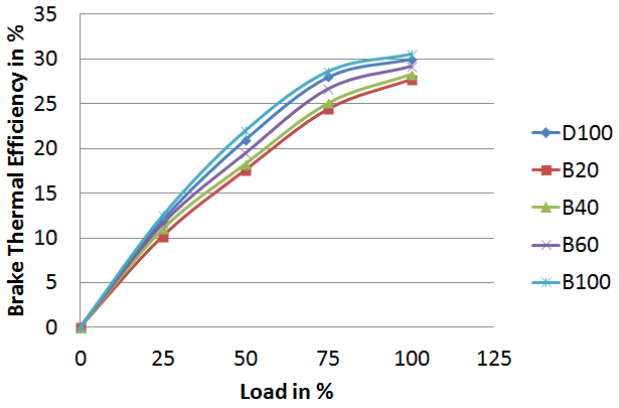

Fig .4 Load Vs Break Thermal Efficiency (BTE) for different blends of biodiesel and diesel

Brake Specific Fuel Consumption (BSFC)

Brake specific fuel consumption is the ratio between mass fuel consumption and brake power. The variation of BSFC at different loading conditions for various blend combinations have been shown in figure-5. By the graph itself it is clearly known that BSFC is decreases with increasing the load on engine. And also when compared to the diesel (D100) fuel, the BSFC of blended biodiesel's (B20, B40, B60 and B100) was lower. The BSFC of biodiesel (B100) is 93% higher than that of pure diesel (D100).

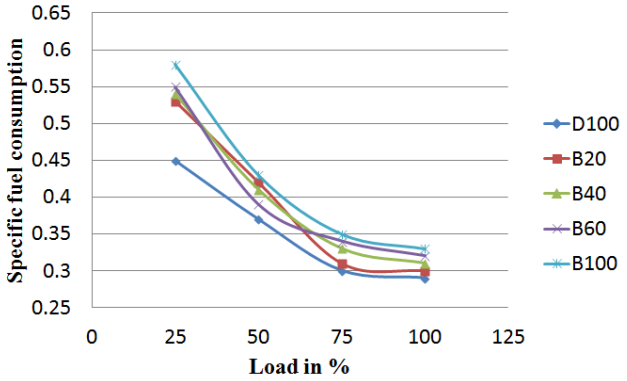

Fig .5 Load Vs Break Specific Fuel Consumption (BSFC) for different blends of biodiesel and diesel

Exhaust Gas Temperature (EGT)

It is observed that, when the load increases on engine by the way exhaust gas temperature (EGT) also increased. It is clearly shown in figure-6. And from the figure it is denoted that the EGT of biodiesel is lower than that of pure diesel.

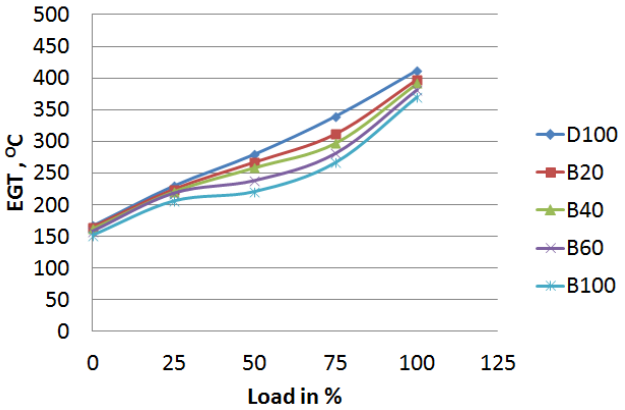

Fig .6 Load Vs Exhaust Gas Temperature (EGT) for different blends of biodiesel and diesel

Emission Characteristics:

Figure 7 and 8 illustrates the emission of HC and Nox. Figure-7 illustrates HC emission at different loads for various blend proportions of biodiesel. From the figure-4, it is concluded that the HC emissions are gradually decreased by increasing blends of biodiesel from B20 to B100. But there is no any changes observed in blend B40. This is because of an even mixture of diesel and biodiesel. By increasing the load HC emission was decreased for all

blends of biodiesel except diesel (D100) fuel, is observed. Figure-8 demonstrates Nox emission at different loading conditions for various biodiesel blends. When comparing to the diesel (D100) fuel, Nox emissions of various blends of biodiesel were higher. And by the same Nox emissions were

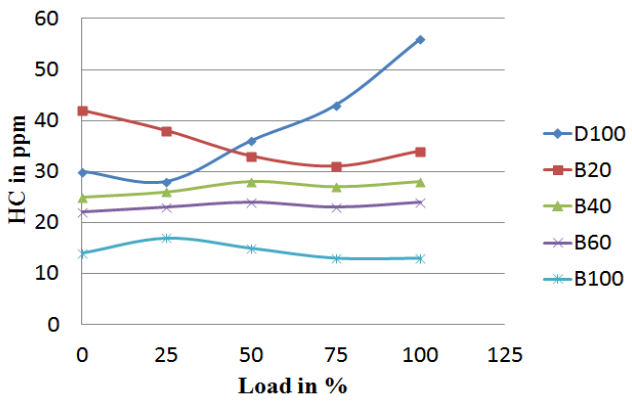

Fig .7 Load Vs Hydro Carbon Emissions (HC) for different blends of biodiesel and diesel

increased by increasing the loads for various blended fuel. However higher Nox emissions are observed with higher percentage of biodiesel blends.

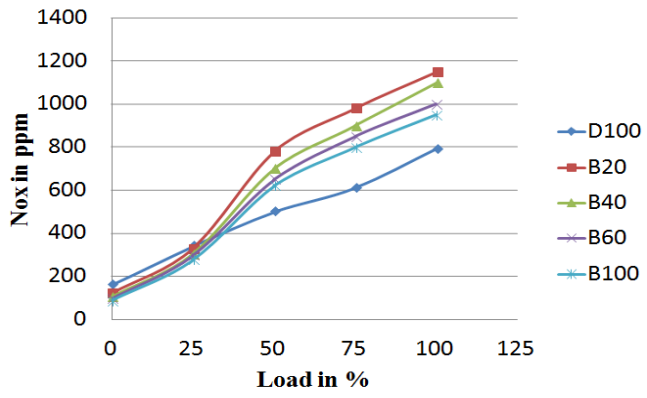

Fig .8 Load Vs Nox Emission for different blends of biodiesel and diesel

V. CONCLUSION

Biodiesel by using canola oil was prepared at various proportions and their fuel characteristics have been investigated. An experimental investigation has been conducted to evaluate a performance and emission characteristics of an engine with biodiesel fuelled. The result obtained from the various investigation parameters are listed below as a conclusions:

1) The prepared biodiesel properties were slightly varied from commercial diesel (D100).
2) Brake Thermal Efficiency (BTE) of canola biodiesel was lower when compared to commercial diesel fuel.
3) Brake Specific Fuel Consumption (BSFC) and Exhaust Gas Temperature (EGT) of biodiesel blends are higher than that of diesel fuel.
4) HC emissions are decreased by increasing the loads and increasing the percentage of biodiesel blends such as proportions of biodiesel.
5) Nox emission are reduced while increasing the blend proportions up to 20% such as (B20) evenly and also by increasing the load. Hence B20 blended biodiesel were shows 15 to 25 % of Nox increases at different loading conditions. However the Nox emissions decreased with increasing blends of biodiesel were observed.

Hence the use of canola biodiesel as a fuel for engines can be allowable without any modification of engines.

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