Effect of Compression Ratio on Exhaust Emission of Diesel Engine Fuelled With Diesel and Biodiesel (B100)

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Abstract— The performance and emission characteristics of a constant speed single cylinder four stroke diesel engine fuelled with biodiesel (B100) are studied and compared with base diesel. The biodiesel is produced from Karanja oil by transesterification process has been used in this study. Experiments has been conducted at 100% load and at compression ratios of 18:1, 19:1 and 20:1. The impact of compression ratio on performance and exhaust gas emissions has been studied and presented. Best compression ratio which gives better performance and less emission has been identified. The results indicate higher brake thermal efficiency, lower fuel consumption and increasing trend in NOx emission.

Key words: Diesel Engine, Diesel and Biodiesel (B100)

I. INTRODUCTION

Diesel engines are mainly used in mass transportation, passenger transportation and decentralized power generation due to high fuel economy as these engines operate at higher compression ratio as compared to spark ignition engine. In addition to this, torque is also higher due to higher volumetric efficiency [1]. Diminishing petroleum reserves, rising petroleum prices and different types of pollutants emitted from diesel engines depends on many factors including design parameters, types of fuel used, operating conditions and exhaust emission after treatment device [2]. In order to overcome these problems wide research works were carried out in the last two decades. Many researchers advised that the use of liquid biofuels with the base diesel fuel or as a single fuel without any major modification would surely help to solve many problems mainly CO, HC, PM or smoke [3]. Number of researchers have conducted experiments to study the performance and emission characteristics of diesel engine with biodiesel and diesel biodiesel blends and it has been found to be economical and competitive compared to standard diesel [4].

Raheman and Ghadge [5] conducted an experiments on single cylinder constant speed engine using biodiesel and its blends with diesel at varying compression ratio (18, 19 and 20:1) and they observed that BSFC decreased, whereas BTE and exhaust gas temperature increased with the increase in the CR.

Gnanamoorthi and Devaradjane [6] studied the performance and emissions of a CI diesel engine, using neat apricot seed kernel oil methyl ester and its blends with diesel fuel and found that lower concentration of apricot seed kernel oil methyl ester in blends give a better improvement in the engine performance and exhaust emissions.

Raheman and Ghadge [7] conducted an experiments in Ricardo E6 engine using bio diesel derived from mahua oil (B100) and its blend with base diesel at different compression ratio and engine loads. He reported that the brake specific fuel consumption (BSFC) and exhaust gas temperature increased, whereas brake thermal efficiency (BTE) decreased with increase in the proportion of bio diesel in the blends for all compression ratios (18:1–20:1).

Mohammed et al. [8] conducted experiments on single cylinder diesel engine and investigated the engine performance of Castor Methyl Ester (CME) variable compression ratio and concluded that the lower blends of bio diesel increased the break thermal efficiency and decrease the fuel consumption. The exhaust gas temperature increased with increasing bio diesel concentration.

Jindal et al. [9] conducted an experiments in a single cylinder diesel engine and studied the effects of compression ratio and the performance parameters such as fuel consumption, brake thermal efficiency, emissions of CO, CO_2, HC, NOx, and smoke opacity with Jatropha methyl ester as fuel and reported that the combined in compression ratio increases the brake thermal efficiency and decrease the brake specific fuel consumption while dropping the emissions.

The aim of this research is, therefore, to study the effect of different compression ratio on performance and emissions characteristics of a single cylinder constant engine with base diesel and plane biodiesel at 100% load.

II. EXPERIMENTAL SETUP

An experimental setup was developed to conduct tests as shown in Figure 1. It consists of a four stroke naturally aspirated diesel engine coupled with alternator, intake air system (air filter, air flow meter, and surge tank) and NDIR principal based AVL Di-gas analyzer for measuring the exhaust gas emissions such as CO, HC, CO_2 and NOx. Test engine specifications are given in Table1.

The properties of fuels (Diesel and B100) are given in Table 2. Experimental tests were carried out on the engine with diesel and plain biodiesel (B100). At constant engine speed at 100% load.

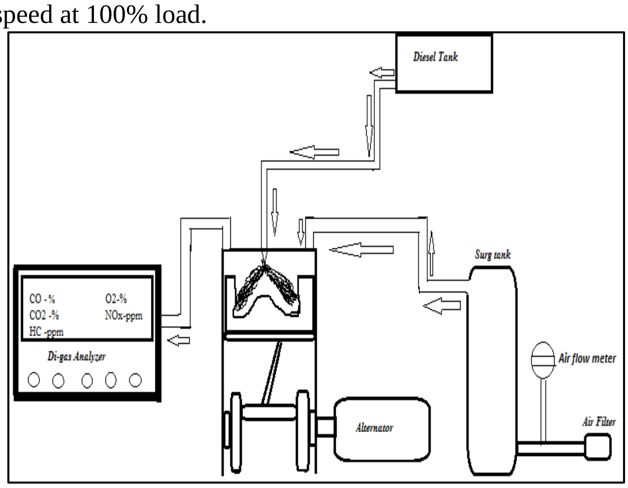

Fig. 1: Experimental Setup

S.No.	Description	Parameter values
1	Make, Model	Kirlosker, EA10
2	No. of cylinders	1
3	Displacement Volume (cc)	947.3
4	Rated output (kW)	7.4
5	Rated Speed (rpm)	1500
6	Bore x Stroke (mm)	102 x 116
7	Compression ratio	19.5:1
8	Connecting rod length	232.6 mm
9	Intake valve opening and closing	43^{0}BTDC and 67^{0}ABDC
10	Exhaust valve opening and closing	87^{0}BBDC and 39^{0}ATDC

Table 1: Test engine specifications

S.No	Parameter	Biodiesel (B100)	Diesel
1.	Density (kg/m3)	883	850
2.	CV (MJ/kg)	40.98	43.97
3.	Viscosity at 40 ^{0}C (cSt)	4.37	2.87
4.	Flash point(^{0}C)	163	76
5.	Cloud point(^{0}C)	14.6	6.5

Table 2: Properties of base diesel and biodiesel (B100)

III. Results and Discussion

A. *Brake Thermal Efficiency*

The figure 2 shows the variation of brake thermal efficiency for different compression ratios at 100% load for both the fuels diesel and biodiesel from the figure it is clear that BTE is increasing with the increasing compression ratio but when we compare the BTE of particular compression ratio with biodiesel the efficiency is less than the diesel fuel. This is due to increase in compression ratio confirms more complete combustion. However, the efficiency of B100 is less because its fuel consumption is more than the diesel and its calorific value is also lower than base diesel that why the BTE of biodiesel is less than the diesel.

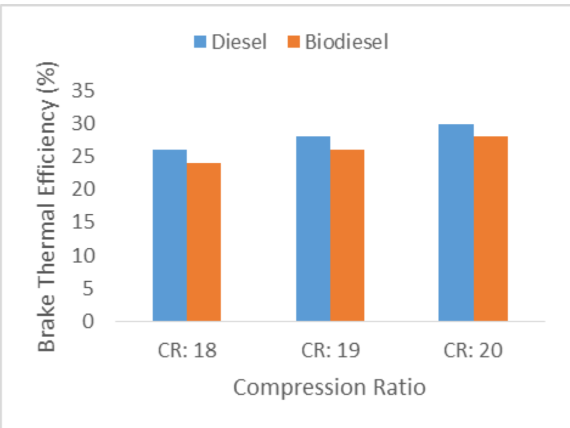

Fig. 2: Variation of brake thermal efficiency with different CR

B. *Brake Specific Fuel Consumption*

The figure 3 shows the variation of brake specific fuel consumption for different compression ratios at 100% load for both the fuels diesel and biodiesel from the figure it is clear that brake specific fuel consumption is decreasing with the increasing compression ratio but when we compare the brake specific fuel consumption of particular compression ratio with biodiesel the fuel consumption is higher than the diesel fuel because its calorific value is lower than base diesel. So its need more fuel to consume for the same power output.

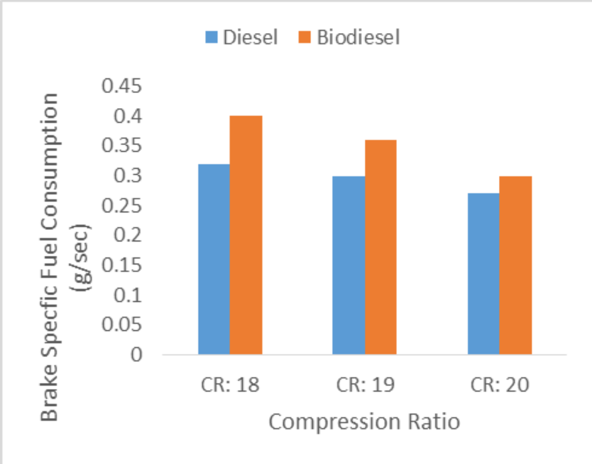

Fig. 3: Variation of bsfc with different CR

C. *CO Emission*

The figure 4 shows the variation of CO emission for different compression ratios at 100% load for both the fuels diesel and biodiesel from the figure it is clear that CO emission is decreasing with the increasing compression ratio but when we compare the CO emission of particular compression ratio with biodiesel the CO emission is less than the diesel fuel. This may due to the increased compression ratio actually increases the air temperature inside the cylinder consequently reducing the delay period causing better and more complete burning of the fuel and so lower CO emission.

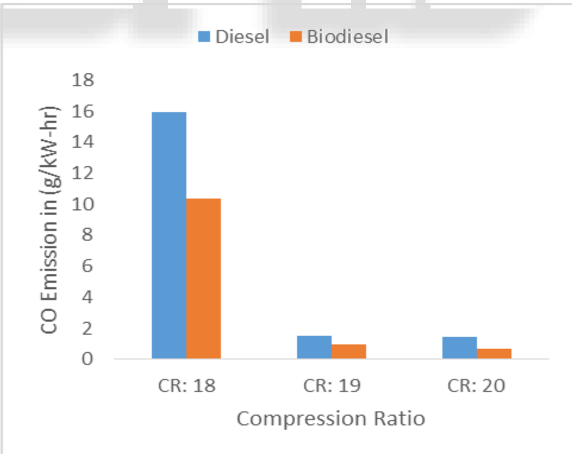

Fig. 4: Variation of CO emission with different CR

D. *HC Emission*

The figure 5 shows the variation of HC emission for different compression ratios at 100% load for both the fuels diesel and biodiesel from the figure it is clear that HC emission is decreasing with the increasing compression ratio but when we compare the HC emission of particular compression ratio with biodiesel the HC emission is less than the diesel fuel. This may due to the higher oxygen contain in biodiesel which helps in better combustion of biodiesel inside the combustion chamber.

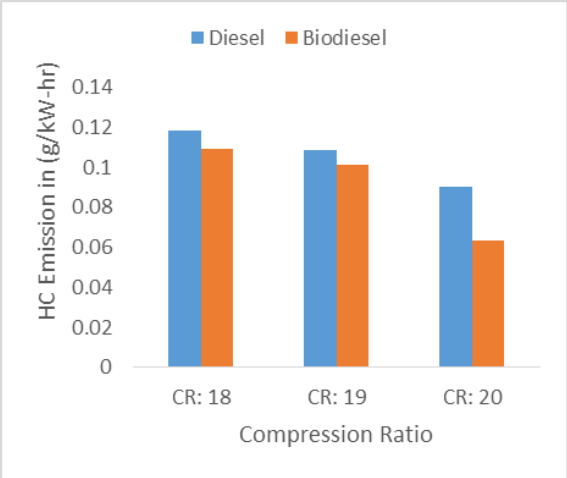

Fig. 5: Variation of HC emission with different CR

E. CO_2 Emission

The figure 6 shows the variation of CO_2 emission for different compression ratios at 100% load for both the fuels diesel and biodiesel from the figure it is clear that CO_2 emission is decreasing with the increasing compression ratio but when we compare the CO_2 emission of particular compression ratio with biodiesel the CO_2 emission is higher than the diesel fuel. This may due to the higher oxygen contain in biodiesel which helps in better combustion of biodiesel inside the combustion chamber and increase the reaction of CO to CO_2 conversion.

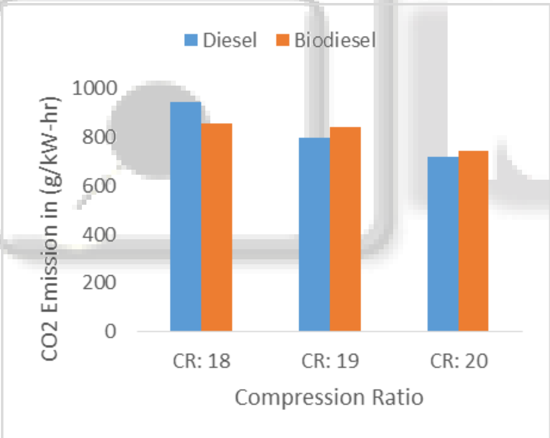

Fig. 6: Variation of CO_2 emission with different CR

F. NOx Emission

The figure 7 shows the variation of NOx emission for different compression ratios at 100% load for both the fuels diesel and biodiesel from the figure it is clear that NOx emission is increasing with the increasing compression ratio but when we compare the NOx emission of particular compression ratio with biodiesel the NOx emission is higher than the diesel fuel. This may due to the higher oxygen contain in biodiesel which helps in better combustion of biodiesel inside the combustion chamber and increase the in-cylinder temperature as we know that the NOx is a strong function of temperature.

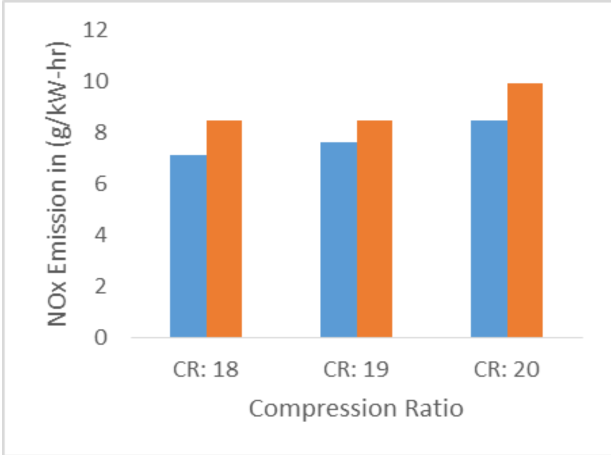

Fig. 7: Variation of NOx emission with different CR

G. Smoke Opacity

The figure shows the variation of smoke opacity for different compression ratios at 100% load for both the fuels diesel and biodiesel from the figure it is clear that smoke opacity is decreasing with the increasing compression ratio but when we compare the smoke opacity of particular compression ratio with biodiesel the smoke opacity is lower than the diesel fuel. This may due to the higher oxygen contain in biodiesel which helps in better combustion of biodiesel inside the combustion chamber and biodiesel having lower H/C ratio.

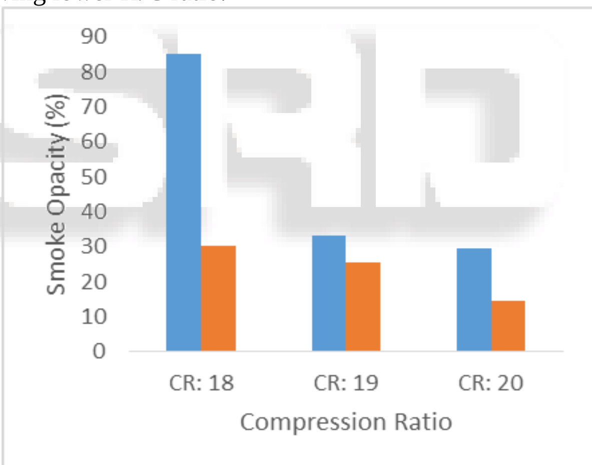

Fig. 8: Variation of smoke opacity with different CR

IV. CONCLUSIONS

The impact of compression ratios on the performance and emission characteristics was clearly examined in this study. The following opinions were noted.

The BTE of the diesel engine operated using B100 are very close to that of diesel oil at 100%load and the highest CR.

The BSFC is higher for B100 this is mainly due to lower calorific value and higher viscosity of biodiesels as compared to diesel.

CO, HC and Smoke Opacity are significantly less as compared to that with diesel fuel. However, formation of oxides of nitrogen and CO_2 is more with biodiesels as compared to that of diesel fuel at 100% load.

It can be concluded that engine operated with B100 is a better choice from both performance and emission point of view.

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