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A Critical Performance Examination of Diesel Engine Fueled with Different Blends of Jatropha Bio-Diesel With Diesel Fuel in Varying Compression Ratios

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Abstract: The foremost intention of this present research work is to observe the consequence of various compression ratios on various performance parameters of direct injection compression ignition engine when it is fueled with different blends of Jatropha bio-diesel with diesel fuel. This study establishes the experimental investigations at different compression ratio (CR-18 and CR-16) to evaluate the performance of the engine using numerous blends of Jatropha bio-diesel and diesel fuel. The blend ratios used for the examination are 100D0JB (100% Diesel and 0% Jatropha Bio-Diesel), 90D10JB (90% Diesel and 10% Jatropha Bio-Diesel), 80D20JB (80% Diesel and 20% Jatropha Bio-Diesel), 70D30JB (70% Diesel and 30% Jatropha Bio-Diesel) and 60D40JB (60% Diesel and 40% Jatropha Bio-Diesel) in direct injection compression ignition engine under the different conditions of the load on the engine. The base line data was generated using 100D0JB, i.e. 100% pure diesel as a fuel in all the compression ratios and different performance parameters were obtained using different blends of Jatropha bio-diesel with diesel in respective compression ratios and compared with the base line data. In this experimental work, different performance characteristics like brake power, brake thermal efficiency, mechanical efficiency, specific fuel consumption and volumetric efficiency were calculated. Various graphs were prepared to demonstrate the precariousness of the different performance parameters in case of different blends of Jatropha bio-diesel with the variations of compression ratios.

Keywords* — *blend, break power, Compression Ratio, Jatropha Bio-diesel, mechanical efficiency, specific fuel consumption, thermal efficiency

I. Introduction

In current scenario, for the development of the country, the industrial revolution occurs and for that energy from the fossil fuels plays vital role. The fossil fuels comprise coal, oil and natural gas. The combustion of the fossil fuels discharges the CO_x, NO_x, particulates in the environment. This industrial revolution fetched wealth, prosperity, elevated living standards of the individual of the developed country but on the other side, industrial revolution made the ecological imbalance. The global environment is contaminated because of the often use of the fossil fuels. The increasing demand of the energy opened up the new horizon to discover the auxiliary of the fossil fuels. Many researches are done on the biofuels, which may be the substitute of the fossil fuels and the use of which is one step towards green revolution in the growing demand of energy.

The foremost intention of this line of investigation work is to estimate the usage of the Jatropha bio-diesel as an auxiliary fuel for the diesel fuel and in assorted compression ratios, using various blends of Jatropha bio-diesel with diesel, the performance parameters of the diesel engine was observed. The best combination of the blend of Jatropha bio-diesel with diesel fuel in optimum compression ratio was estimated through this experiment.

Section II introduces the work done in the domain of the presented work in the form of literature study. Section III gives the information about experimental setup prepared for presented research work. Section IV furnishes the experimental procedure and the methodology carried out in the presented work. Section V shows the results obtained

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and Section VI presents concluding remarks concerning the research work.

II. Literature Study

Patel P. R. et al, 2018, had explored the effect of Compression Ratio on Performance of CI Engine Fueled with Diesel – Palm Seed Oil Blends using Taguchi's DOE Approach [1]. The authors had performed the experiments by taking three different compression ratios i.e. 14, 16, 18 and performed experiments by taking L9 orthogonal array using Taguchi method for exhaust manifolds, compression ratio, blend and load.

Upadhyay B. D. et al., 2018, had experimented for the performance of single cylinder 4-stroke diesel engine using blower at exhaust in different compression ratios [2]. The authors concluded that the compression ratio affects the different parameters of the performance of the engine.

Patel S. N. et al, 2012, had revealed the effect of the variation of compression ratio on the performance of diesel engine using biofuel [3]. The authors investigated to improve the injection system as the biodiesel is viscous and hence the different blends become viscous than diesel fuel. Furthermore, the authors have concluded in their research that with increase in compression ratio, brake thermal efficiency increases but specific fuel consumption decreases.

Mofijur M.et al., 2015, had discussed about the recent developments on internal combustion engine performance and emissions when the engine is fuelled with mixed blends of biodiesel, diesel and ethanol blends [4] through certain literature review and also noticed that the most of the researchers reported about adding the ethanol into biodiesel-diesel blends in diesel engine expressively reduce the exhaust particulars but up to some extent increase fuel consumption. The authors revealed that the different blends of the biodiesel-diesel-ethanol can be used as a replacement to reduce the enslavement on the fossil fuel and the exhaust emission of the engine as well.

Raheman H. et al., had exposed the performance of diesel engine with biodiesel with variation of compression ratio and ignition timing [5]. The authors had used biodiesel obtained from Mahua oil and blended with high speed diesel at different compression ratio, injection timing and loads on the engine on Ricardo E6 engine. The authors observed through their experiment that brake specific fuel consumption of biodiesel and its blends with high speed diesel reduced but at the same time brake thermal efficiency and exhaust gas temperature increased with increase in load.

Reddy A. G. et al., 2015 revealed through the experiment about the effect of compression ratio on the performance of diesel engine at different loads [6]. The authors concluded that as the compression ratio of the engine increased, the brake specific fuel consumption improves but lower compression ratio leads higher fuel consumption due to incomplete combustion of the fuel. The maximum fuel consumption was observed at compression ratio as 14. Moreover, the authors observed that the utmost brake thermal efficiency was attained at a compression ratio as 18 due to better combustion and well intermixing of the fuel. The lease brake thermal efficiency was found at a compression ratio as 14.

Umamaheswara Rao S. V. et al., 2016, had discussed in their research about the outcome of variable compression ratio on performance and emissions distinctiveness of I. C. engine [7]. The authors investigated the optimum compression ratio as 17.5 for which the best performance of the engine is possible. Also they derived through the experiments that the compression ratio lesser than 19 results significant drop in brake thermal efficiency and rise in specific fuel consumption.

Nagaraja S. et al., 2013, had experimented and derived the combustion and performance analysis of variable compression ratio engine fueled with preheated palm oil-diesel blends [8]. The authors investigated the sustainability of the palm oil as a substitute of the fossil fuel and analyzed that the blend of 20% preheated palm oil with 80% diesel was found best for the maximum thermal efficiency at higher compression ratio as 20 in their experiments.

Saravanapprabhu E. et Al., 2017, had analyzed the Effect of variable compression ratio in C.I. engine using turbocharger [9]. The authors used turbocharger in variable compression ratio engine and determined that the increase in the intake boost pressure improves considerably the brake thermal efficiency of the engine.

Kassaby M. El. et al., 2013, studied the effect of compression ratio on an engine fueled with waste oil produced biodiesel or diesel fuel [10]. The authors had used biodiesel from wasted cooking oil through transesterification and blended with diesel fuel in different proportions with variation of compression ratios in their experiments. The authors concluded during their study that with 20% use of biodiesel with diesel fuel gives almost same performance and emission as that with pure diesel fuel in all range of compression ratios.

Padmanabhan S. et al., 2017, investigated the performance and emission characteristics of the diesel engine fueled with various blends of Soapnut oil with diesel [11]. The authors had concluded that the Soapnut oil is a good auxiliary fuel which gives better engine performance and similar emission characteristics as diesel up to the blending of 30 % use of Soapnut oil with diesel fuel.

Sharma A. et. Al., 2015, also revealed the potential use of the tyre pyrolysis oil blending with the bio-diesel with

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different compression ratios of 16.5, 17.5 and 18.5 in diesel engine and discussed the performance parameters and exhaust particulars based on the results obtained.

III. Experimental Setup and Procedure

An experimental setup was prepared consisting of a four stroke, Single Cylinder, Compression ignition Engine coupled with water cooled, eddy current dynamometer and necessary arrangements for measurement of performance parameters. Figure.1 shows the experimental setup for the evaluation of performance of the engine by using various mixing blends of Jatropha Bio-diesel and diesel fuel with variation of compression ratios.

Figure 1: Experimental Setup

Figure 2 demonstrates the schematic layout of the test set up. Figure 3 shows the mechanism for the setting of the compression ratio in variable compression ratio engine. The variation of the compression ratios is to be done in the presented research work.

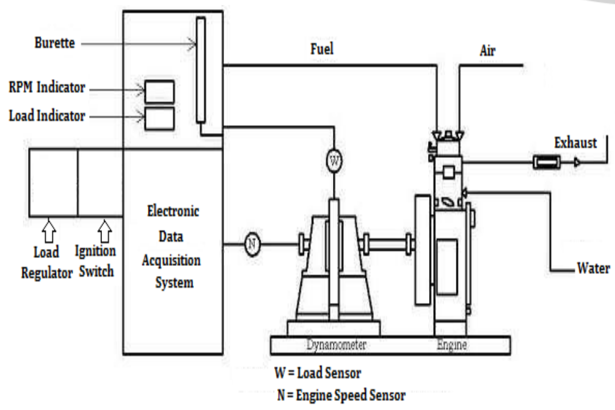

Figure 2: Schematic diagram of Test Setup

Figure 3: Variation of Compression Ratio using lock nut

The major specifications of the engine are presented in Table 1.

Table 1: Technical Specifications of Diesel Engine

Item	Specifications
Engine Make	Kirloskar
Engine power	3.50 kW
Engine speed	1500 rpm
No. of cylinders	1
No. of strokes	4
Type of cooling system	Water Cooled
Type of fuel used	Diesel
Direction of Rotation	Clockwise
Cylinder Bore	87.50 mm
Stroke Length	110.00 mm
Connecting Rod length	234.00 mm
Compression Ratio	18.00
Swept volume	661.45 (cc)
Peak Presure	77.5 kg/cm^2
Fuel timing	23° BTDC
Dynamometer Type	eddy current, water cooled, with loading unit
Overall Dimensions	617L × 504W × 877H
Weight	160 kg

IV. Experimental Work

The experimental work towards engine performance estimation was done in two phases. The two phases are as follows:

1. Base line data generation in all considered range of compression ratios
2. Performance evaluation under pure diesel and different blends of diesel with Jatropha bio-diesel in all range of compression ratios.

Initially, the engine was confirmed for all its setting parameters using diesel as a fuel by taking compression

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ratio as 16 and 18. The load on the engine was varied from no load to 2 Kg, 4 Kg, 6 Kg, 8 Kg, 10 kg & 12 Kg of rated load. The analysis was done for each load applied on the engine. Complete load range from no load to over load was investigated for different compression ratios and performance parameters were generated for analysis purpose.

In this segment of experimental work, the engine was operated on diesel fuel with different percentage of Jatropha bio-diesel by keeping the compression ratio as 16 in different load range on the engine. Methodology used was identical with that of high-speed diesel operation with respect to change of loads and calculated the performance characteristics like brake power, brake thermal efficiency, specific fuel consumption, Mechanical efficiency, volumetric efficiency and various temperatures. The same procedure was repeated for the compression ratio as 18.

Different experiments were conducted on various blends of Jatropha bio-diesel with diesel.

The different blends were tested on the engine with variation of compression ratio as shown in Table 2.

. Table 2: Blending details used in VCR Engine

Sr. No.	Compression Ratio	Diesel	Jatropha Bio-diesel	Blend term
1	16	90%	10%	90D10JB16CR
2	16	80%	20%	80D20JB16CR
3	16	70%	30%	70D30JB16CR
4	16	60%	40%	60D40JB16CR
5	18	90%	10%	90D10JB18CR
6	18	80%	20%	80D20JB18CR
7	18	70%	30%	70D30JB18CR
8	18	60%	40%	60D40JB18CR

V. Experimental Result

Based on the experimental results, the graphical representations are shown below to see the associations of the various blends of Jatropha bio-diesel with the diesel fuel with variation of the compression ratio in terms of the performance of the compression ignition engine.

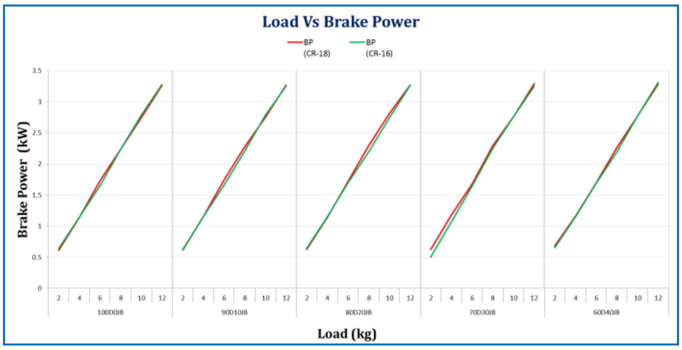

Figure 4: Load (kg) Vs Brake Power (kW)

It is observed from the graph (Figure 4) that at the compression ratio of 18, the brake power increases with the increase in load in almost all the blends of the Jatropha bio-diesel with diesel fuel as compared to the compression ratio of 16.

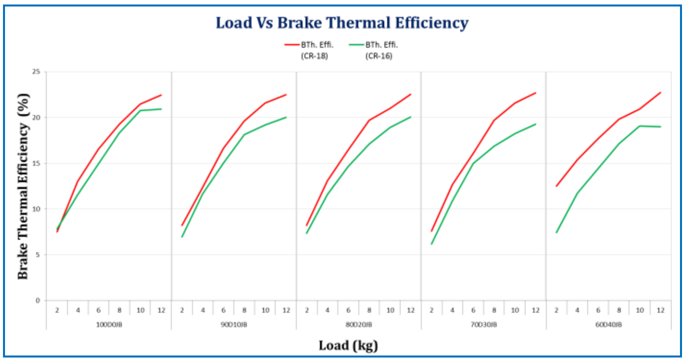

Figure 5: Load (kg) Vs Brake Thermal Efficiency (%)

It is observed from the graph (Figure 5) that at the compression ratio of 18, the brake thermal efficiency increases with the increase in load in the blend of 60D40JB18CR (60% diesel and 40% Jatropha bio-diesel) as compared to the compression ratio of 16. Furthermore, it is also observed that, in case of the compression ratio of 16, the performance of the engine is better when it is fueled with pure diesel than the use of the different blends of the Jatropha bio-diesel.

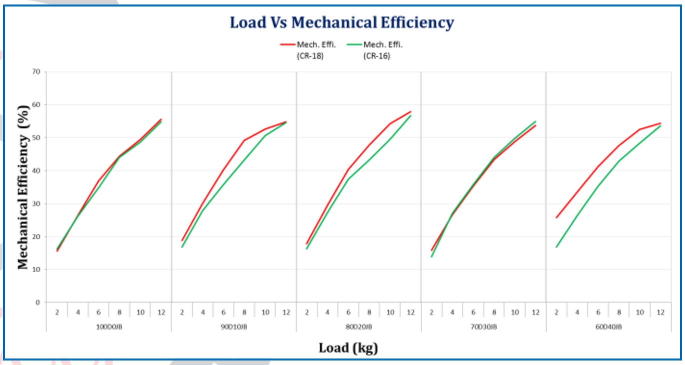

Figure 6: Load (kg) Vs Mechanical Efficiency (%)

It is observed from the graph (Figure 6) that at the compression ratio of 18, the mechanical efficiency increases with low range of the load in the blend of 60D40JB18CR (60% diesel and 40% Jatropha bio-diesel) and at higher load, the mechanical efficiency increases in the blend of 80D20JB18CR (80% diesel and 20% Jatropha bio-diesel). Moreover, it is also observed that, in case of the compression ratio of 16, the performance of the engine is better when it is fueled with different blends of the Jatropha bio-diesel with diesel than fueled with pure diesel but less than the performance of the engine in case of the compression ratio as 18.

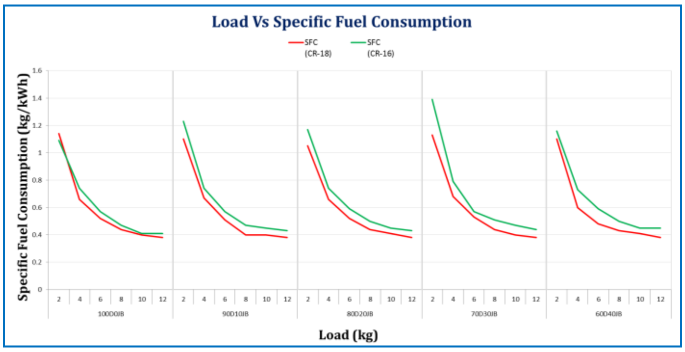

Figure 7: Load (kg) Vs Specific Fuel Consumption (kg/kWh)

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It is observed from the graph (Figure 7) that at the compression ratio of 16, the specific fuel consumption increases with the increase in load in almost all the blends of the Jatropha bio-diesel with diesel fuel as compared to the compression ratio of 18.

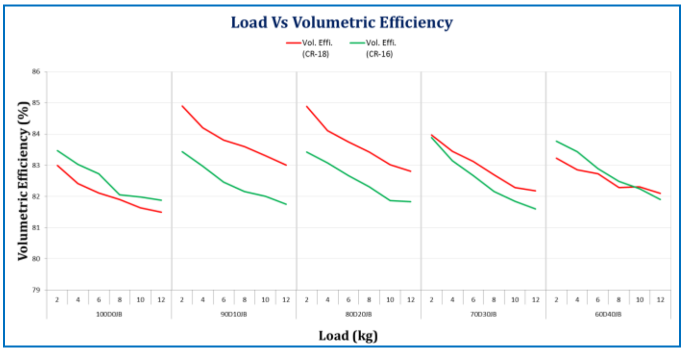

Figure 8: Load (kg) Vs Volumetric Efficiency (%)

It is observed from the graph (Figure 8) that at the compression ratio of 18, the volumetric efficiency increases with the decrease in load in the blend of 90D10JB18CR (90% diesel and 10% Jatropha bio-diesel) as compared to the compression ratio of 16. Furthermore, it is also observed that, in case of the compression ratio of 16, the performance of the engine in terms of volumetric efficiency is better when it is fueled with the blend of 60D40JB16CR (60% diesel and 40% Jatropha bio-diesel) than fueled with pure diesel.

VI. Conclusion

The following conclusions can be drawn based on the results and discussions:

1. It is observed from the experiment that, with the proviso of the compression ratio of 18, the brake power increases with the increase in load in almost all the blends of the Jatropha bio-diesel with diesel fuel as compared to the compression ratio of 16. Furthermore, in case blend of 30% Jatropha bio-diesel at compression ratio as 18, with increase in load subsequently the brake power increases whereas in case of blend of 40% Jatropha bio-diesel, lower load attracts higher brake power. This is shown in Figure 4.
2. Based on the experimental results, it is well-said that, at the compression ratio of 18, the brake thermal efficiency increases with the increase in load in the blend of 60D40JB18CR (60% diesel and 40% Jatropha bio-diesel) as compared to the compression ratio of 16. Furthermore, it is also observed that, with the proviso of the compression ratio of 16, the performance of the engine is better when it is fueled with pure diesel than the use of the different blends of the Jatropha bio-diesel. This is shown in Figure 5.
3. It is observed from the experiment that, at the compression ratio of 18, the mechanical efficiency increases with low range of the load in the blend of 60D40JB18CR (60% diesel and 40% Jatropha bio-diesel) and at higher load, the mechanical efficiency increases in the blend of 80D20JB18CR (80% diesel and 20% Jatropha bio-diesel). Moreover, it is also observed that, with the proviso of the compression ratio of 16, the performance of the engine is better when it is fueled with different blends of the Jatropha bio-diesel with diesel than fueled with pure diesel but less than the performance of the engine in case of the compression ratio as 18. This is shown in Figure 6.
4. Based on the experimental results, it is observed that at the compression ratio of 16, the specific fuel consumption increases with the increase in load in almost all the blends of the Jatropha bio-diesel with diesel fuel as compared to the compression ratio of 18. This is because of the reason that, at higher temperature, the viscosity of Jatropha bio-diesel and ultimately the viscosity of the bland decreases. This is shown in Figure 7.
5. It is observed from the experimental results that at the compression ratio of 18, the volumetric efficiency increases with the decrease in load in the blend of 90D10JB18CR (90% diesel and 10% Jatropha bio-diesel) as compared to the compression ratio of 16. Furthermore, it is also observed that, with the proviso of the compression ratio of 16, the performance of the engine in terms of volumetric efficiency is better when it is fueled with the blend of 60D40JB16CR (60% diesel and 40% Jatropha bio-diesel) than fueled with pure diesel. This is shown in Figure 8.
6. It is also derived that the temperature of exhaust gas is also minute high in case of the almost all blends of Jatropha bio-diesel with diesel in both the case of the compression ratios.

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