Experimental Examination of Performance Parameters of 4-S Single Cylinder DI-CI Engine Using Different Blends of Jatropha Bio-diesel with Diesel Fuel

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Abstract: The main objective of this present research work is to examine the effect of Jatropha bio-diesel on the various performance parameters of direct injection, water cooled diesel engine. This study demonstrates the experimental investigations at constant compression ratio (CR-18) 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 0/100, 10/90, 20/80, 30/70 and 40/60 in direct injection compression ignition engine under the different conditions of the load on the engine. The base line data was generated using pure diesel as a fuel and different performance parameters were obtained using different blends of Jatropha bio-diesel with diesel 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 measured. Various graphs were prepared to demonstrate the volatilities of the different performance parameters in case of different blends of Jatropha bio-diesel with diesel.

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

I. INTRODUCTION

Now a day, fossil fuels like, coal, oil and gas, are playing a vital and dominating role in global energy system. Energy from the fossil fuels is the essential driver for the industrial revolution of any country. The growing demand of energy, rushing oil rates, exhausting oil reservoirs and ecological contamination allied with the use of fossil energies have flashed new horizon to find out substitutes of fossil fuels. Peanut oil was used as a fuel by Rudolf Diesel, for the purpose of demo of new advanced CI engine in the first decade of 19th century. Assured edible and non-edible oils like cotton seed, rapeseed, Karanja, Putranjiva, sunflower, palm, Jatropha etc. can be used in diesel engines. For the better healthiness of the engine, these oils cannot be used directly, instead of that blending of such oils with diesel or some modifications can be done.

The foremost objective of this research work is to estimate the usage of the Jatropha bio-diesel as an auxiliary fuel for the diesel fuel and observe the performance parameters of the diesel engine using various blends of Jatropha bio-diesel with diesel.

II. LITERATURE STUDY

Haldar S. K. et al., 2009, conducted a study of performance and emission characteristics of a diesel engine using three different non-edible vegetable oils [1]. The authors used Putranjiva, Jatropha and Karanja non-edible oils to find out the most suitable alternative to diesel in diesel engine. During the study, Authors had observed that the non-edible oil of Jatropha gives the best result to the performance and emission at high loads.

Kadu S. P. et al., 2010, investigated through experiment, the use of pre-heated neat Karanja oil as a fuel in CI engine [2]. The study concerned with the performance parameters of 4-stroke single cylinder diesel engine using pre-heated neat Karanja oil from 30ºC to 100ºC. During this study the engine operated between speed ranges of 1500 to 4000 rpm under full load conditions. The authors concluded that the engine offers lower thermal efficiency when it is powered by pre-heated neat Karanja oil at higher speed of the engine.

Dwivedi G. et al., 2011, reviewed impact analysis of biodiesel on engine performance [3]. The objective of the review is to emphasis on the work completed in the range of different biodiesel and performance analysis of the engine.

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Pandey Anand Kumar et al., 2011, experimented with the effect of esterified Karanja biodiesel on the performance and emission of turbocharged direct injection diesel engine [4]. The authors had concluded in their study, the use of clean Karanja biodiesel can swap the diesel for running military CIDI diesel engine.

Rao P. V., 2011, investigated through experiments, the influence of the properties of Jatropha biodiesel on performance, combustion and emission characteristics of a DI-CI engine [5].In this study the performance and other parameters were compared using Jatropha biodiesel against those obtained using diesel. Also the possibility for reduction of NOx was investigated by using preheated Jatropha biodiesel.

Dwivedi G. et al., 2013, evaluated the performance of diesel engine using biodiesel from Pongamia oil [6]. The authors concluded that up to the use of 20 % Pongamia biodiesel with 80 % diesel fuel, the fuel properties like flash point, calorific value, density etc. remain same as diesel and hence diesel may be replaced with biodiesel very soon in near future. The detailed study incorporated the performance of the engine which shows the low efficiency of the engine may be because of the low volatility and slightly higher viscosity of biodiesel which affects the mixture formation and leads to slow combustion.

Pexa M. et al., 2014, performed an experiment to look at the impact of biofuel (Rapessed Methyl Ester) blended with diesel and technical condition of the engine in concern with the smoke [7].

Kumar Satish et al., 2013, examined the advancements in diesel – alcohol blends and their effect on the performance and emissions of the diesel engine [8]. The authors had concluded that the alcohols may decrease the contaminants as they have lesser carbon and sulphur matters and greater proportion of oxygen than in fossil oils and hence the dependency can be reduced on fossil fuels.

Padmanabhan S. et al., 2017, investigated the performance and emission characteristics of the diesel engine fueled with various blends of Soapnut oil with diesel [9]. The authors had concluded that the Soapnut oil is an admirable substitute which gives better engine performance and similar emission characteristics as diesel up to the blending of 30 % use of Soapnut oil with diesel fuel.

Baghel et al., 2015, revealed the Combine effect of Injection pressure and increasing inlet air pressure on the performance & emission of CI engine using Mahua oil blended with diesel [11].

Sani F. M. et al, 2013, looked over the use of biodiesel in compression ignition engine and discussed the performance parameters and emission characteristics after the deep study of different research papers related to the use of biodiesel in CI engine [12].

Pradip kumar M. et al., 2017, carried out the experimental research of performance and emission characteristics using bio-diesel with oxygenated additives and concluded that the performance of the engine increases and fuel consumption decreases considerably using biodiesel. Moreover, use of oxygenated additive, leads the improvement in the exhaust and the emitting pollutants decreases [13].

III. Experimental Setup and Procedure

An experimental setup was prepared consisting of a 4-S, 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 an engine by using various blends of Jatropha Bio-diesel with diesel fuel.

Figure 1: Experimental Setup

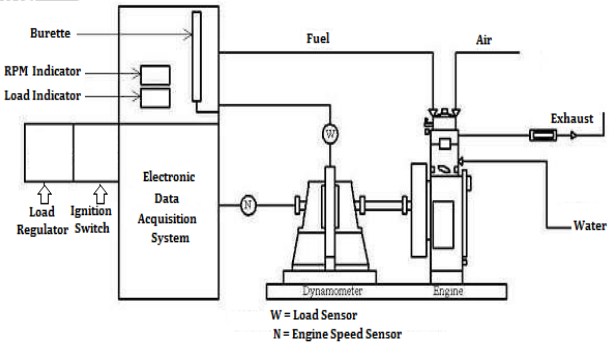

Figure 2: Schematic diagram of Experimental Setup

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

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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	23º 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
2. Performance evaluation under pure diesel and different blends of diesel with Jatropha bio-diesel.

Initially, the engine was confirmed for all its setting parameters using diesel as a fuel. 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 performance parameters and base line statistics 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. 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.

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

The following different blends were tested on the engine.
90% diesel and 10% Jatropha bio-diesel.
80% diesel and 20% Jatropha bio-diesel.
70% diesel and 30% Jatropha bio-diesel.
60% diesel and 40% Jatropha bio-diesel.

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 in terms of the performance of the compression ignition engine.

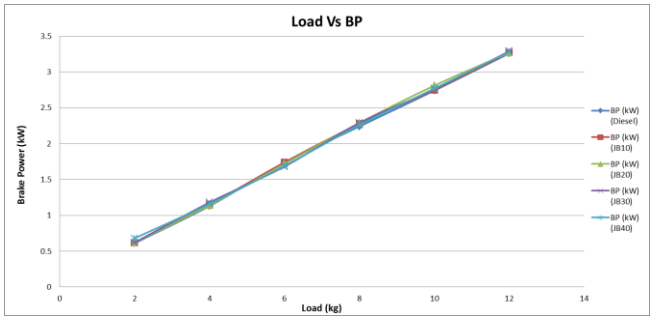

Figure 3: Load (kg) Vs Brake Power (kW)

The above figure 3 shows the graphical representation of the load on the CI engine Vs. Brake power. From the analysis, it is observed that the brake power increased with the increased proportion of Jatropha bio-diesel in blends with diesel.

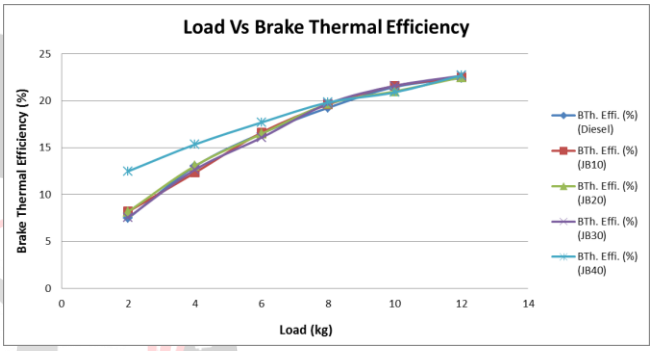

Figure 4: Load (kg) Vs Brake Thermal Efficiency (%)

The above figure 4 shows the graphical representation of the load on the CI engine Vs. Brake thermal efficiency. The brake thermal efficiency increases with rise in load with almost all the blends of Jatropha bio-diesel with diesel.

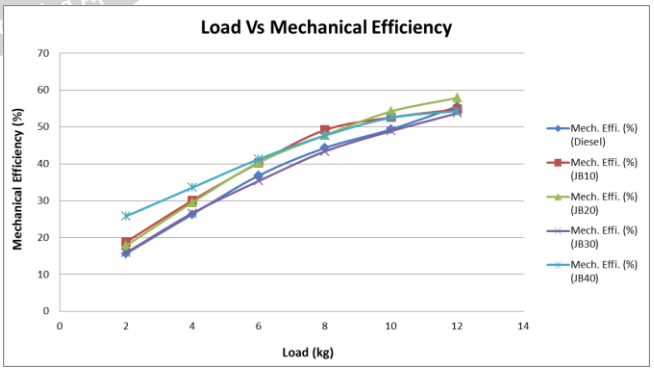

Figure 5: Load (kg) Vs Mechanical Efficiency (%)

The above figure 5 shows the graphical representation of the load on the CI engine Vs. Mechanical efficiency. Mechanical efficiency increases with increase in load with nearly all the blends of Jatropha bio-diesel with diesel.

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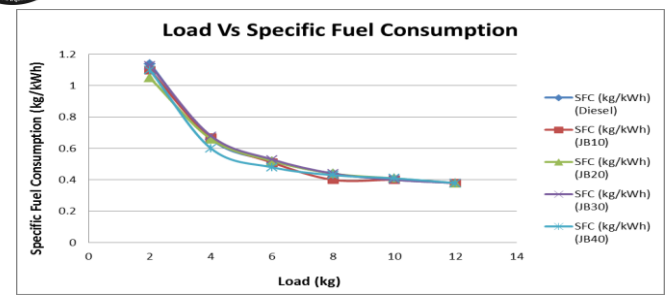

Figure 6: Load (kg) Vs Specific Fuel Consumption (kg/kWh)

The above figure 6 shows the graphical representation of the load on the CI engine Vs. specific fuel consumption. Slight higher brake specific fuel consumption is obtained in the case of Jatropha bio-diesel.

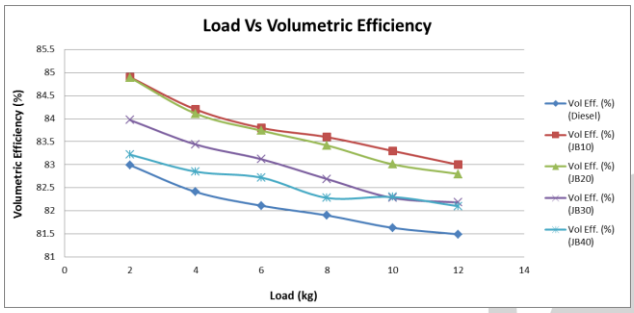

Figure 7: Load (kg) Vs Volumetric Efficiency (%)

The above figure 7 shows the graphical representation of the load on the CI engine Vs. volumetric efficiency. The volumetric efficiency increased in all the range of load with blend of 10% Jatropha bio-diesel with diesel.

VI. CONCLUSION

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

1. It is observed from the experiment that the brake power increased with the increased proportion of Jatropha bio-diesel in blends with diesel. In case blend of 30% Jatropha bio-diesel, 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 3.
2. The brake thermal efficiency was improved with rise in load with all the blends of Jatropha bio-diesel with diesel. In case of blend of 40% Jatropha bio-diesel, maximum brake thermal efficiency is achieved from all the blends of Jatropha bio-diesel. This is shown in Figure 4.
3. The mechanical efficiency was increased with rise in load in almost all blends of Jatropha bio-diesel. In case blend of 20% Jatropha bio-diesel, with increase in load subsequently the mechanical efficiency increases whereas in case of blend of 40% Jatropha bio-diesel, lower load attracts higher mechanical efficiency. This is shown in Figure 5.
4. Minute higher brake specific fuel consumption is obtained in the case of Jatropha bio-diesel but in case of the blend of 10% Jatropha bio-diesel with 90% diesel at higher load the brake specific fuel consumption reduces little than diesel and this is because of at higher temperature the viscosity of Jatropha bio-diesel and ultimately the viscosity of the bland decreases. This is shown in Figure 6.
5. It is perceived that the volumetric efficiency increased in all the range of load with blend of 10% Jatropha bio-diesel with diesel. This is shown in Figure 7.
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.

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