PERFORMANCE AND EMISSION CHARACTERISTICS OF C.I. ENGINE USING JATROPHA BIODIESEL BLENDED WITH DIESEL

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ABSTRACT

Investigations are carried out to know the performance and emission characteristics of CI Engine using Jatropha bio-diesel and pure Diesel. Here performance and emission parameters like Brake Specific Fuel Consumption(BSFC), Brake Thermal Efficiency(BTE), Indicated Thermal Efficiency(ITE) and Mechanical Efficiency(ME), Exhaust Gas Temperature(EGT), HC, NOx, and CO are evaluated.. In this, fuels like pure diesel (PD100) and blends of Jatropha biodiesel JB15, JB25 are used and the engine was evaluated at 25%, 50%, 75% and 100% load conditions and at an injection pressure of 220bar and at an injection timing of 23^o b TDC. It was concluded that JB25D75 blend shows almost same fuel consumption, higher mechanical efficiency, higher brake and indicated thermal efficiencies with load variations than that of conventional diesel PD100. NOx emissions of the blends of Jatropha oil biodiesel JB15D85 and JB25D75 are higher than pure diesel while the emissions of HC, CO is lower than that of diesel PD100. The exhaust gas temperature of biodiesel was more compared to diesel.

Key words: Diesel Engine, Performance, Bio-diesel, Emission, Injection pressure.

1. INTRODUCTION

Many vegetable oils can be used in diesel engines, including peanut oil, linseed oil, rapeseed oil, and sunflower oil. When vegetable oils are burned, their chemical composition helps to reduce the emission of unwanted components. Vegetable oil has numerous advantages, including sustainability, reduced greenhouse gas emissions, regional development, and agricultural improvement. On various blends of vegetable oil and diesel fuel, the diesel engine would run successfully – without any modifications or damage to engine parts. The rapid depletion of petroleum fuels and consequent price hikes have made a serious impact on the power and transport sectors as well as on the international economy. Vegetable oils might provide a viable alternative to diesel since they are renewable in nature and environmentally friendly. Biodiesel can be used in unmodified diesel engines, either alone or blended with conventional diesel. The use of edible vegetable oils such as like sunflower oil, rapeseed oil and soybean oil for fuel purposes may directly affect the economy, i.e., it may cause an increase in the prices of cooking oils. In order to avoid that consequence, it is essential to use non-edible oils for biodiesel production. Rubber seed oil, Jatropha oil, Pongamia pinnata oil and linseed oil are examples of non edible oils. Jatropha oil-based biodiesel is one of the potential alternatives because of the relative ease of growing and producing this plant. In this study, the experimental analyses of Jatropha oil-based JB15D85 & JB25D75 biodiesel were performed and compared with conventional diesel.

1.1BIOFUELS

A biofuel is a source of fuel made from living organisms, most commonly plants or plant-derived materials. Due to their potential to reduce numerous environmental stresses caused by fossil fuel use, liquid biofuels are increasingly being considered alternatives to gasoline and diesel fuel as energy sources.

1.2 BIO-DIESEL

Biodiesel is an alternative fuel made from vegetable oil or animal fat that is designed specifically for diesel engines. Biodiesel is an environmentally friendly, clean-burning, nontoxic, biodegradable fuel that can be used in any compression ignition engine (diesel engine).
Many researchers have used Jatropha oil (neat or modified form) as a CI engine fuel and the government of India is promoting Jatropha oil as a source of biofuel for the partial substitution of diesel. Waste lands available in the country, like railway track sides and other non-food cultivation are proposed to be used for the plantation of Jatropha trees.

[1]Experimental investigations on Jatropha biodiesel and additive in diesel engine were conducted by **Y.V.Hanumantha Rao et.al. (2009)** to evaluate its performance and exhaust emissions. The brake thermal efficiency for biodiesel and its blends was found to be slightly higher than that of diesel fuel at tested load conditions and there was no difference between the biodiesel and its blended fuels efficiencies.

[2] G. Lakshmi Narayana Rao et al., (2007) have conducted the experiments to analyze combustion, performance and emission characteristics of a direct injection diesel engine fuelled with Jatropha methyl ester (JTME), diesel and their blends. From this work, it was concluded that ignition delay, maximum heat release rate and combustion duration are lower for JTME and its blends compared to diesel though JTME and its blends recorded lower Brake thermal efficiency.

[3] Performance and combustion investigations on single cylinder compression ignition (CI) genset engine were carried out by **C.Patel et.al. (2019)** using biodiesels derived from Waste cooking oil (WCO), Jatropha and Karanja oils. WCO biodiesel showed slightly higher heat release rate (HRR) than baseline mineral diesel, while it was slightly lower for Karanja and Jatropha biodiesels. Hydrocarbons (HC) and oxides of nitrogen (NO_X) emissions were lower, while carbon monoxide (CO) emission was relatively higher for biodiesels compared to baseline diesel.

[4] K.Pramanik et al., (2003) conducted experimental investigations on Diesel engine using various blends of Jatropha curcas oil and diesel, results are analyzed and compared. From this work, it was concluded that the specific fuel consumption and the exhaust gas temperature are reduced due to decrease in viscosity of the vegetable oil. Acceptable thermal efficiencies of the engine were obtained with blends containing up to 50% volume of Jatropha oil. From the properties and engine test results it has been established that 40–50% of Jatropha oil can be substituted for diesel without any engine modification.

[5] Performance and emission characteristics of single-cylinder direct-injection engine were carried out by **F.K.Forson et.al. (2004)** using diesel fuel, Jatropha oil, and blends of diesel and Jatropha oil in proportions of 97.4%/2.6%; 80%/20%; and 50%/50% by volume. The test showed that Jatropha oil could be conveniently used as a diesel substitute in a diesel engine. The test further showed increases in brake thermal efficiency, brake power and reduction of specific fuel consumption for Jatropha oil and its blends with diesel generally, but the most significant conclusion from the study is that the 97.4% diesel/2.6% Jatropha fuel blend produced maximum values of the brake power and brake thermal efficiency as well as minimum values of the specific fuel consumption.

[6] J.Narayana Reddy and A.Ramesh (2006) conducted parametric studies for improving the performance of a Jatropha oil-fuelled compression ignition engine. From this work, it was observed that the ignition delay with Jatropha oil is always higher than that of diesel under similar conditions. When the injection timing is retarded with enhanced injection rate, a significant improvement in performance and emissions was noticed. In this case emissions with Jatropha oil are even lower than diesel.

[7] Performance and emission characteristics of a compression ignition engine fuelled with dissimilar compositions of karanja biodiesel and its blend at 5%, 10%, 20%, 25%, 50%, 75% and 100% with mineral diesel were carried out by **K.Loganadhan et.al. (2015).** HC, CO, CO2 and smoke were measured, found lower with karanja biodiesel fuel. However, NOx emissions of karanja biodiesel and its blend were higher than diesel. Performance of the engine fuelled with karanja biodiesel and its blends with diesel fuel is by and large comparable with pure diesel.

[8] I. Vamsee et.al. (2015) conducted experimental investigations on performance and emission characteristics of compression ignition engine using duel bio-fuel methyl ester, diesel and different blends of methyl ester with diesel. The results showed that 20 % of blend gives better performance with reduced pollution.

[9] Experimental analysis of performance and pollutants of CI engine conducted by **L.Karikalan et.al. (2012)** using Jatropha bio-diesel with EGR. The result shows that emissions are reduced with bio-diesel as compared with diesel.

[10] P. Dubey and R. Gupta (2017) carried out extensive experimental work on a Kirloskar make the single cylinder, natural aspired diesel engine to examine combustion performance and emission characteristics using Jatropha methyl ester with turpentine oil blends and conventional diesel. Dual fuel blends are found to be the best substitute to conventional diesel fuel in all aspects such as performance and emissions. Further, BT 50 resulted at full load condition, reduction of 2.9%, 4.72%, 4.56%, 42.5% and 29.16% in the brake thermal efficiency, NO_x, HC, CO and smoke respectively while CO_2 emissions increase 10.7%.

[11] Combustion evaluation of Single Cylinder 4 Stroke CI Engine Fueled with Jatropha Biodiesel and Diesel Blend has been done by **Yashkumar A Lad & Tushar M Patel (2019)**. In this work, it identifies that at JB50, injection pressure 150 bar, engine water flow 400 lph, and engine load 11 kg is the optimum parameter setting for higher engine mechanical efficiency. Also peak pressure was decreased by about 1.66% and 3.06%, maximum fuel line pressure was reduced by 5.09% and 8.04%, and the net heat release was lowered by 10.70% and 21.41% for JB50 and JB100 respectively.

In this present work, performance and emission characteristics of diesel engine operating with pure diesel(D100) and blends of Jatropha biodiesel B15, B25 biodiesel at 25%, 50%, 75% and 100% load conditions are evaluated and compared at an injection pressure of 220bar and at an injection timing of 23^{o} b TDC.

OBJECTIVES OF THE PRESENT STUDY:

(1) To calculate performance parameters like brake specific fuel consumption, brake thermal efficiency, indicated thermal efficiency and mechanical efficiency for a vertical single cylinder 4 stroke diesel engine.

(2) To know the emission characteristics like exhaust gas temperature, hydrocarbons, oxides of Nitrogen and oxides of carbon for a vertical single cylinder 4 stroke diesel engine.

2. EXPERIMENTAL SETUP

The setup consists of single cylinder, four stroke, Diesel engine connected to eddy current type dynamometer for loading. It is provided with necessary instruments for combustion pressure and crank angle measurements. These signals are interfaced to computer through engine indicator for Pressure crank angle-PV diagrams. Provision is also made for interfacing airflow, fuel flow, temperatures and load measurement. The set up has stand alone panel box consisting of air box, fuel tank, manometer, fuel measuring unit, transmitters for air and fuel flow measurements, process indicator and engine indicator. Rota meters are provided for cooling water and calorimeter water flow measurement. The setup enables study of engine performance for brake power, indicated power, frictional power, BMEP, IMEP, brake thermal efficiency, indicated thermal efficiency, Mechanical efficiency, volumetric efficiency, specific fuel consumption, A/F ratio and heat balance. Line diagram of Experimental setup has been shown in Fig.2.1.

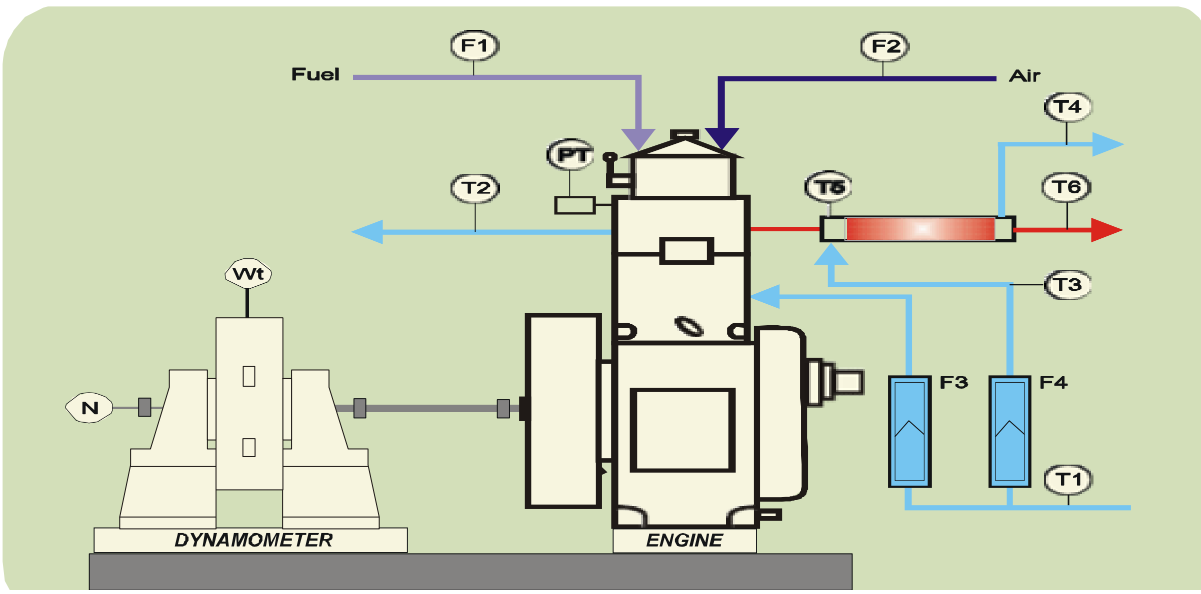

Fig. 2.1: Line diagram of Experimental setup

PT Pressure Transducer	**F2 Air flow**	**T2 Water outlet temperature**
N Rotary encoder	**F3 Jacket water flow**	**T3 Calorimeter water inlet temperature**
Wt Weight	**F4 Calorimeter water flow**	**T4 Calorimeter water outlet temperature**
F1 Fuel flow	**T1 water inlet Temperature**	**T5 Exhaust gas to calorimeter temperature**
		T6 Exhaust gas from calorimeter temp.

Water supply

Continuous, clean and soft water supply @ 1000 LPH, at 10 m. head. Provide tap with 1” BSP size connection

2.1 ENGINE DETAILS:

The complete details of Engine Test rig have been mentioned in the figures Fig. No 2.2 and Fig. No 2.3. The experiments were carried out for four different loads for the different blends at constant speed of 1500 rpm. The fuel samples used were **Diesel, JB15D85, and JB25D75.**

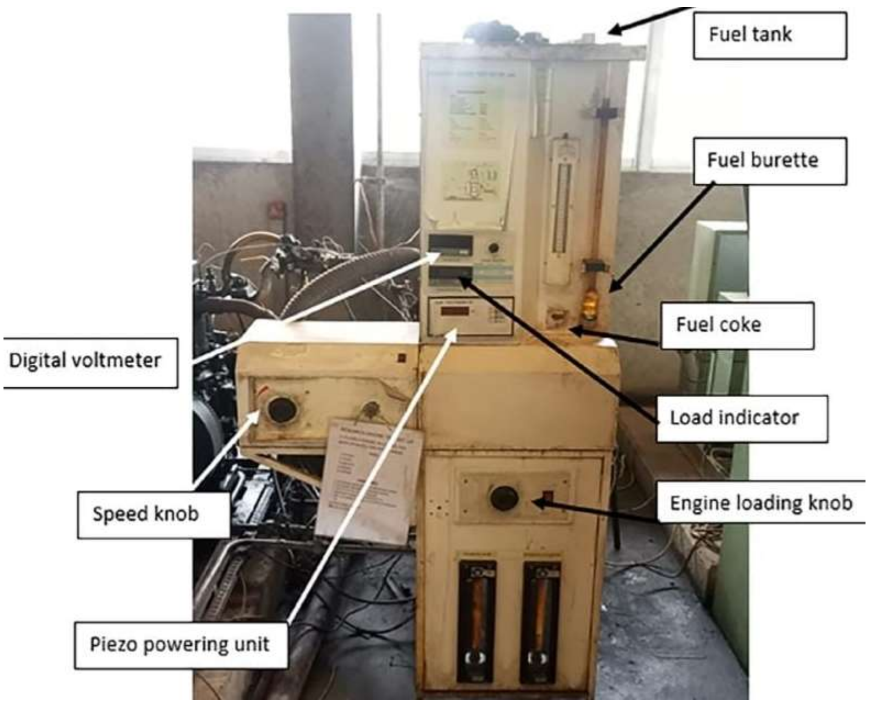

Fig. 2.2: Diesel testing engine

Fig. 2.3: Diesel engine with Dynamometer

2.1.1: Engine Specifications

The engine specifications that were used to carry out the various tests are mentioned in the table 2.1.1.

2.1.1: Engine Specifications

S.NO	ITEM	SPECIFICATIONS
1.	Type of cooling	Water- cooled engine
2.	Type of engine	Single cylinder, 4 stroke, vertical diesel engine
3.	Fuel	Diesel
4.	Rated speed (rpm)	1500
5.	Rated power	3.5Kw
6.	Bore	87.5 mm
7.	Compression ratio	18.00
8.	Stroke length	110 mm
9.	Connecting rod length	234 mm
10.	Type of loading	Eddy current dynamometer
11.	Swept volume	661.45 (cc)

2.1.2 SMOKE METER AND GAS ANALYZER:

Fig.2.4: Smoke meter and gas analyzer

The Fig. 2.4 shows a gas analyzer and a smoke meter. The diesel exhaust smoke meters are also known as opacity meters which identify and measure the amount of light blocked in a sample of smoke given out by diesel engines. The smoke meter displays the smoke density giving the rate of the efficiency of the combustion.

The smoke meter consists of an optical unit mounted inside a measuring head which also has a separate electrical control unit. The gas analyzers are of the principle that the absorption of light by the gas under test.

The analyzer only needs to shine a beam of light via the unheated chamber then it is measured to understand how much, the specific wavelength was observed by the sample.

The analyzer consists of an optical filter that cancels out all light leaving the wavelength that the selected gas molecule can observe.

Other gas molecules will not absorb light at this particular wavelength, and they don’t even affect the amount of light reaching the detector.

2.2 ENGINE PERFORMANCE CHARACTERISTICS:

Engine performance is indicated by the term efficiency.

Various types of efficiencies are

1. **Indicated thermal efficiency**: - It is a ratio of energy in the indicated horse power to the fuel energy.

$$ITE = \frac{\text{Indicated power (kw)} * 3600}{\text{Fuel consumption (kg/h)} * \text{calorific value (kJ/kg)}}$$

2. **Mechanical efficiency; -** It is ration of brake horse power to the indicated horse power.

$$\text{Mechanical efficiency } [\eta_{mech}] = \frac{\text{brake power} \times 100}{\text{Indicated power}}$$

3. **Brake thermal efficiency: -** It is the ratio of energy in the brake horse power to the fuel energy.

$$BTE = \frac{(\text{Brake power (Kw)} * 3600)}{\text{Fuel consumption} * \text{calorific value (kJ/kg)}}$$

4. **Volumetric efficiency: -** Volumetric efficiency is defined as the ration of air actually induced at ambient conditions to the swept volume of the engine.

5. **Specific fuel consumption: -** It is a ratio of fuel consumption per hour to the horse power.

6. **Indicated Horse power:-**It is the power produced inside the cylinder.

7. **Brake Horse Power: -** It is the power available at the crankshaft.

2.3 PREPARATION OF FUEL BLENDS:

- **Pure Diesel:** It is the base value for comparison purpose.
- **JB15D85:** The prepared Jatropha biodiesel is blended with diesel in the ratio 15% of Jatropha biodiesel and 85% of Diesel.
- **JB25D75:** The prepared Jatropha biodiesel is blended with diesel in the ratio 25% of Jatropha biodiesel and 75% of diesel.

The above 3 samples of diesel and biodiesel are tested in the engine mentioned at different loads of 25%, 50%, 75%, and 100% and observed for different performance parameters. Exhaust emissions are also noted with gas analyzer and smoke meter using probe.

3. EXPERIMENTAL ANALYSIS

In this analysis engine is operating at constant injection pressure 220 bar and injection timing of 23°btdc and at a loads of 25%, 50 %, 75%and 100% by using different blends with diesel.

3.1 BLENDS USED

- **PD100- pure diesel**
- **JB15D85 - mixture of 15% Jatropha oil biodiesel and 85% Diesel of total 100% volume**
- **JB25D75 - mixture of 25% Jatropha oil biodiesel and 75% Diesel of total 100% volume**

3.2 PERFORMANCE PARAMETERS

3.2.1 Brake specific fuel consumption:

Brake specific fuel consumption is the ratio of a mass flow rate of the fuel supplied to the engine to the brake power obtained at a crankshaft and it indicates how efficiently the fuel is used to produce brake power.

Table 3.1 BSFC values with respect to loads of 25%, 50%, 75% and 100% for fuels PD100, JB15D85 and JB25D75

LOAD (kg)	PD100	JB15D85	JB25D75
3	0.6445	0.6924	0.7031
6	0.5148	0.5231	0.5376
9	0.4446	0.4515	0.5088
12	0.4310	0.4450	0.4812

3.2.2 Brake thermal efficiency:

Table 3.2 brake thermal efficiency values with respect to loads of 25%, 50%, 75% and 100% for fuels PD100, JB15D85 and JB25D75

LOAD	PD100	JB15D85	JB25D75
3	11.37	12.60	13.37
6	16.45	16.68	17.96
9	19.05	19.33	20.46
12	19.65	20.06	22.03

3.2.3 Indicated Thermal Efficiency:

Table 3.3Indicated Thermal efficiency with respect to loads of 25%, 50%, 75% and 100% for fuels PD100, JB15D85 and JB25D75

Load	PD100	JB15D85	JB25D75
3	46.17	48.39	50.87
6	43.47	44.70	46.54
9	42.08	43.85	44.56
12	39.91	40.47	42.40

3.2.4 Mechanical Efficiency:

Table 3.4 Mechanical efficiency with respect to loads of 25%, 50%, 75% and 100% for fuels PD100, JB15D85 and JB25D75

LOAD	PD100	JB15D85	JB25D75
3	24.6451	26.0509	27.9324
6	37.8462	39.6856	41.5896
9	45.2664	46.0915	48.5213
12	49.2315	50.3332	55.0884

3.3 EMISSION PARAMETERS

3.3.1 Hydrocarbons HC in ppm:

Table 3.5 HC emissions with respect to loads of 25%, 50%, 75% and 100% for fuels PD100, J15BD85 and JB25D75

LOAD	25%	50%	75%	100%
PD100	139	131	127	122
JB15D85	131	125	122	117
JB25D75	126	120	117	111

3.3.2 Carbon monoxide:

Table 3.6 CO emissions with respect to loads of 25%, 50%, 75% and 100% for fuels PD100, JB15D85 and JB25D75

LOADS	PD100	JB15D85	JB25D75
25%	0.024	0.019	0.014
50%	0.027	0.023	0.015
75%	0.033	0.027	0.021
100%	0.037	0.032	0.028

Oxides of nitrogen:

Table 3.7 NOx emissions with respect to loads of 25%, 50%, 75% and 100% for fuels PD100, JB15D85 and JB25D75

LOADS	25%	50%	75%	100%
PD100	421	654	675	720
JB15D85	446	660	681	728
JB25D75	469	694	706	740

Exhaust gas temperature:

Table 3.8 Exhaust gas temperature with respect to loads of 25%, 50%, 75% and 100% for fuels PD100, JB15D85 and JB25D75

EGT(°c)	25%	50%	75%	100%
PD100	165.98	190.35	244.65	298.74
JB15D85	174.32	195.25	260.25	308.65
JB25D75	181.11	224.52	264.26	325.98

4. RESULTS AND DISCUSSION

4.1 PERFORMANCE CHARACTERISTICS:

4.1.1 Brake specific fuel consumption: The variation in the brake specific fuel consumption (BSFC) with increasing load on the engine for the various fuels PD100,JB15D85 and JB25D75 at 220 bar injection pressure and 23°bTDC of injection timing at rated engine speed 1500 rpm was presented in the Fig.4.1.

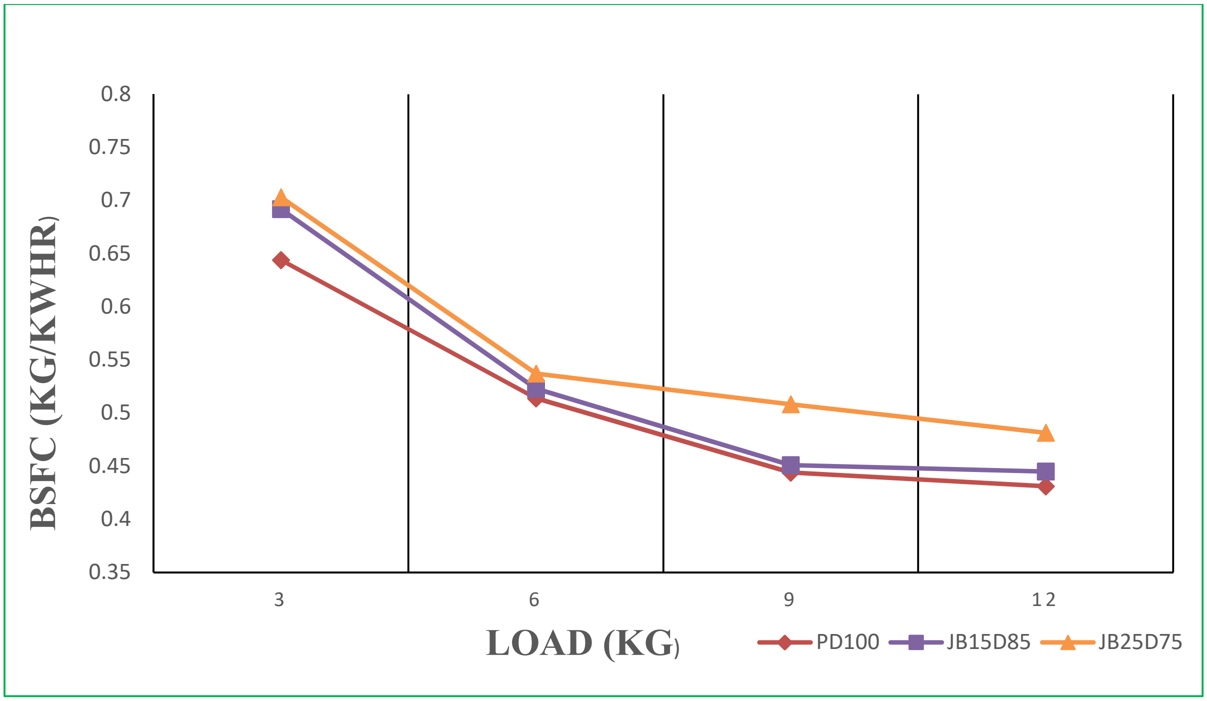

Fig.4.1: LOAD Vs Brake specific fuel consumption

For all the fuels, the specific fuel consumption decreases with an increase in load. The increase in percentage of Jatropha biofuel in the blend increases the specific fuel consumption because of the lower heating value of blend as compared to the pure diesel.

4.1.2 Brake thermal efficiency: Fig.4.2 shows the comparison of brake thermal efficiency of various fuels PD100, JB15D85 and JB25D75 at 220bar injection pressure and 23°bTDC of injection timing at rated engine speed 1500 rpm at various loads. The brake thermal efficiency increases with an increase in load for all the fuels.

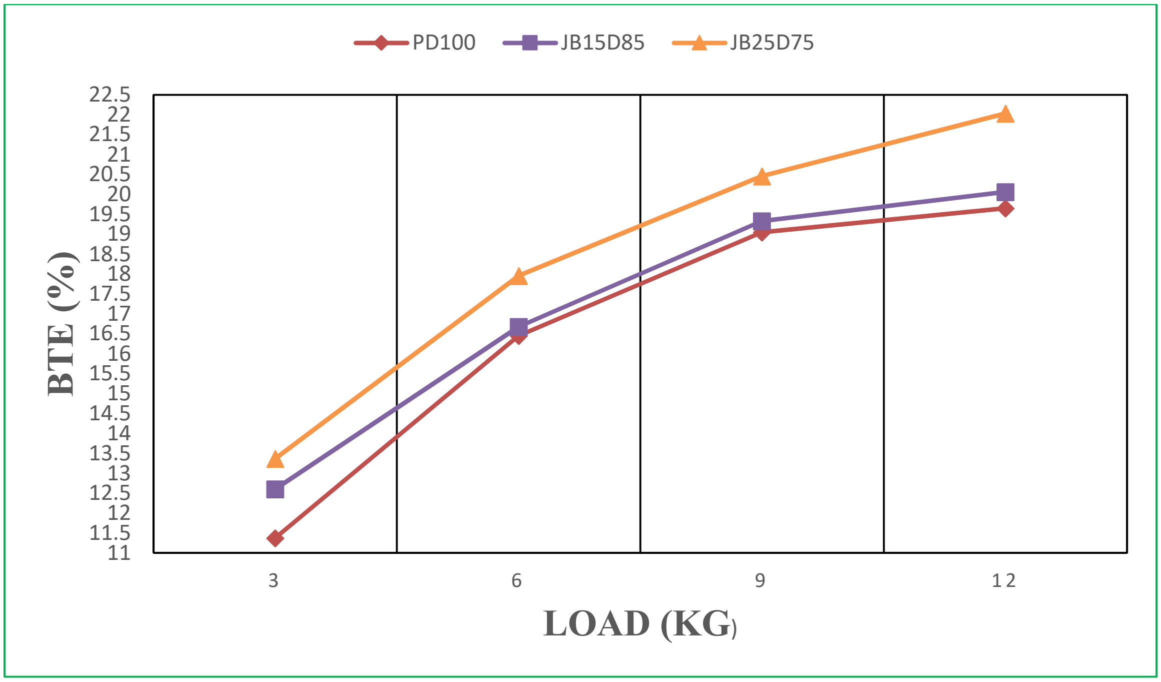

Fig.4.2: Load Vs Brake thermal efficiency

It was observed that the brake thermal efficiencies of JB15D85 and JB25D75 are 20.06%, and 22.03% when compared to diesel brake thermal efficiency 19.65% at 12kg engine load. Brake thermal efficiencies of Jatropha biofuels were higher than that of pure diesel at all loads.

4.1.3 Indicated Thermal Efficiency:

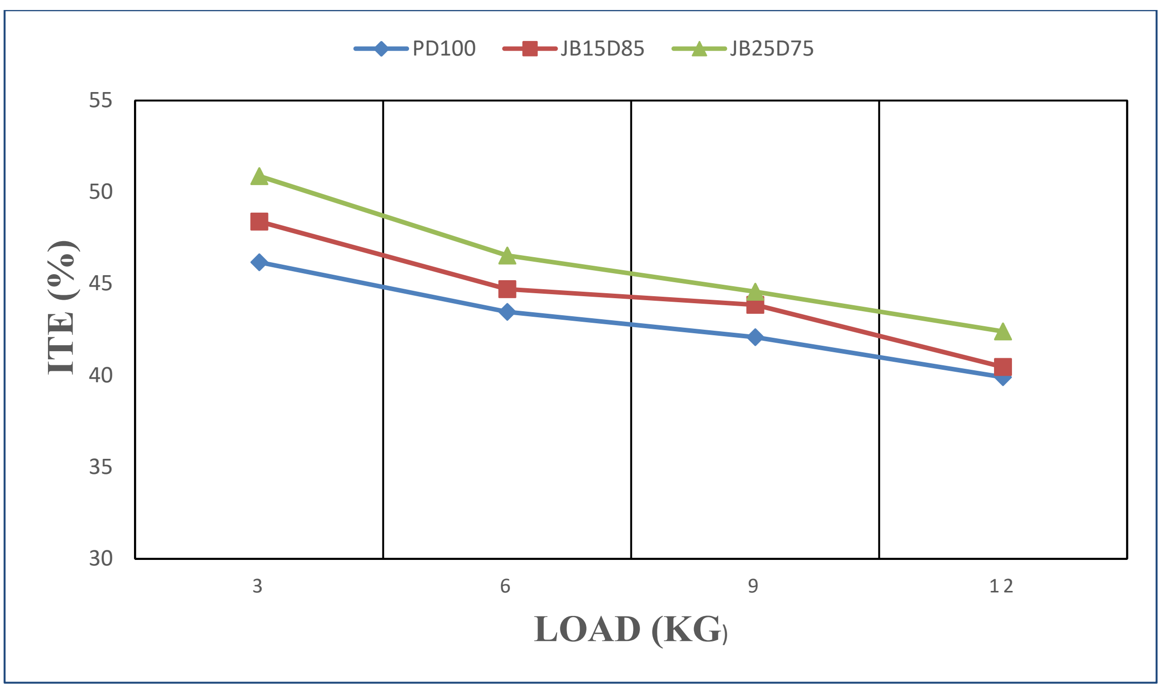

Fig.4.3: Load Vs Indicated thermal efficiency

The Fig.4.3 shows the variation of Indicated thermal efficiencies with varying loads of different blends JB15D85 and JB25D75 in comparison with diesel. It was observed that values of Indicated thermal efficiency decreases with increase in load. It is seen that the indicated thermal efficiencies of biodiesel blends are higher when compared to the diesel. Biodiesel and its blends have a higher indicated thermal efficiency than pure diesel since biodiesel has more oxygen content than diesel which aids in combustion.

4.1.4 Mechanical Efficiency:

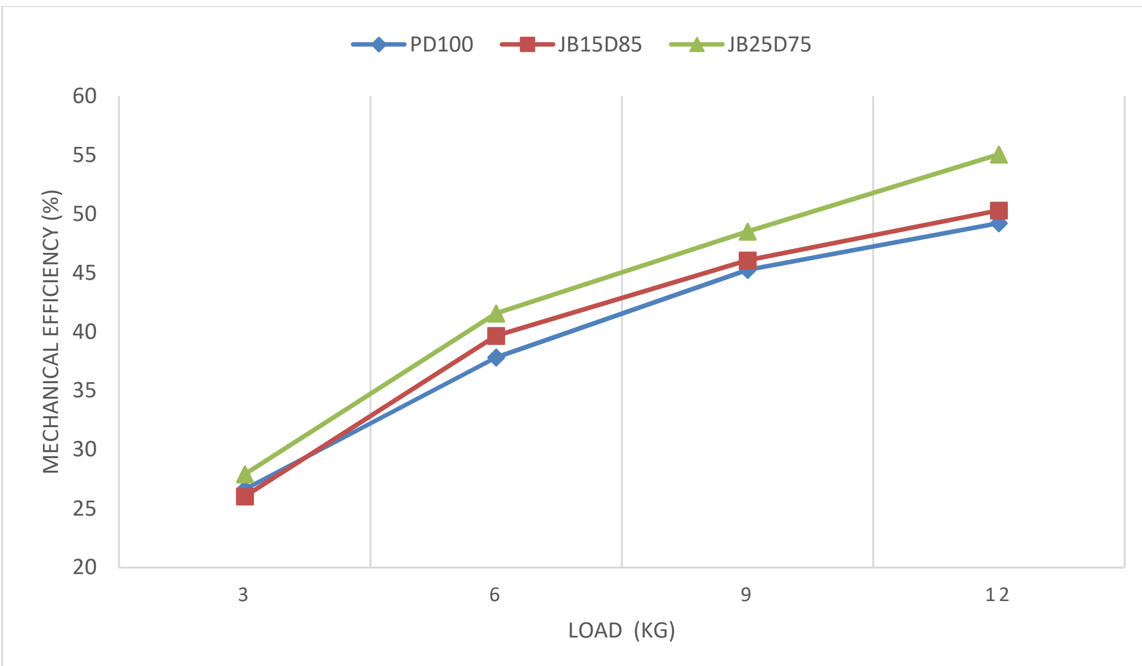

Fig.4.4: Load Vs Mechanical efficiency

The variation of Mechanical efficiency with respect to load is shown in the Fig.4.4. It was observed that mechanical efficiency increases when the load increases for all operations of diesel and biodiesel blends. This is due to increase in power with increase in load and frictional power remains constant as engine was running at constant speed of 1500 r.p.m as the frictional power depends on the speed of the engine. It is also observed that mechanical efficiency was better when JB15D85 and JB25D75 are used. This is due to the viscosity of blends increases which reduces the friction on account of its lubricity.

4.2 EMISSIONS:

4.2.1 Hydrocarbon (HC) emissions- Fig.4.5 shows the variation of UBHC emissions for different fuels with load. It was observed that HC emissions decrease as the load increases for all the fuels. Adding Jatropha biodiesel blends enhances the air fuel mixture in the fuel injection which increases the combustion efficiency, Biodiesel contains oxygen molecules, which helps reduces the amount of HCs compared to diesel.

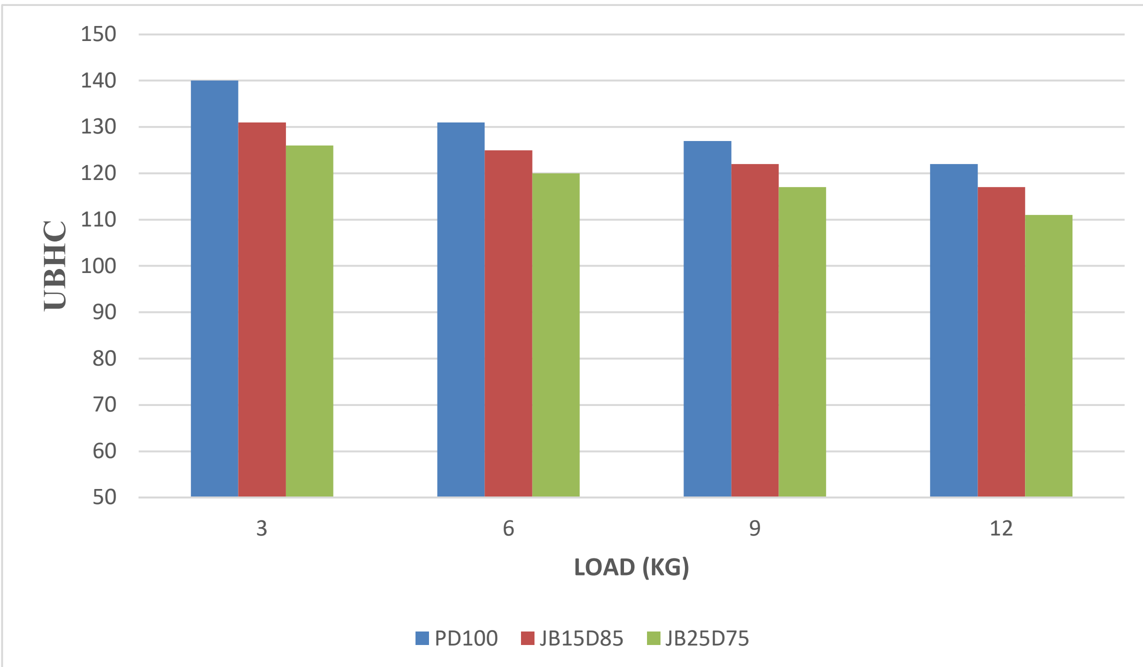

Fig.4.5: Load Vs Hydrocarbons

4.2.2 Carbon monoxide (CO) emissions- Fig.4.6 reveals higher CO emission for diesel oil compared to JOBD and its blends. CO emission increases sharply after 50% of the rated load due to incomplete combustion as more fuel is injected at higher loads. CO emission decreases with an increase in JOBD in the blends due to presence of oxygen in biodiesel and its higher combustion temperature.

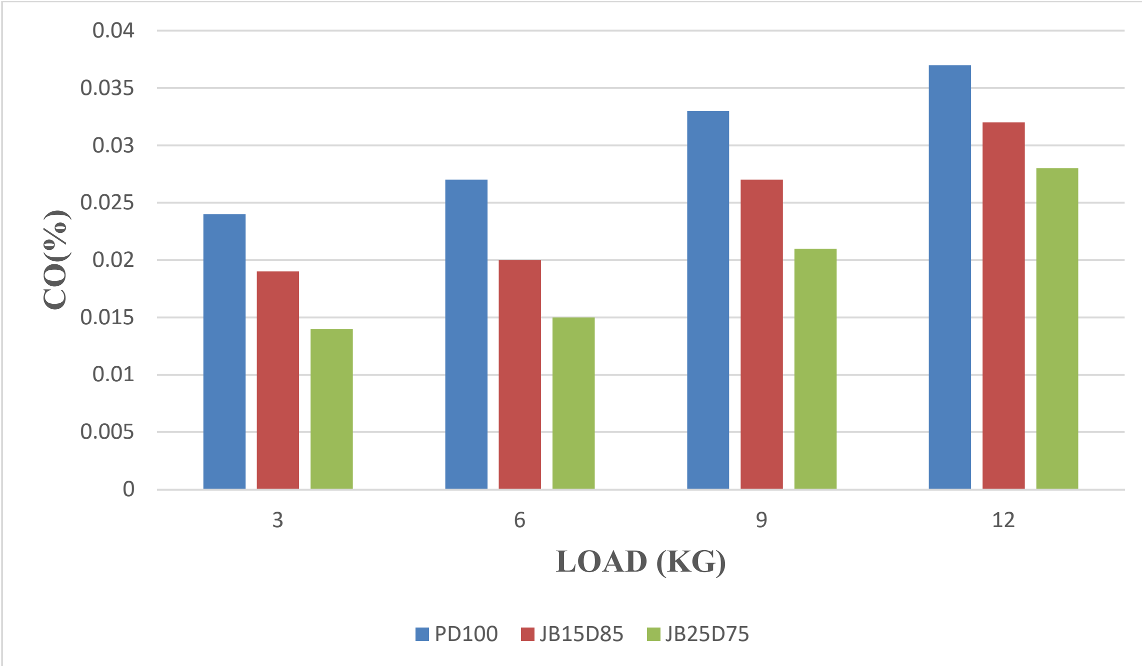

Fig.4.6: Load Vs CO emissions

4.2.3 Nitrogen oxide (NOx) emissions- Fig.4.7 shows the comparison of NOx emissions of diesel fuel with various blends of JOBD at various loads. It was observed that the NOx emissions increase with an increase in load for all the fuels. This is due to an increase in the amount of fuel burned with load that results in an increase in combustion temperature.

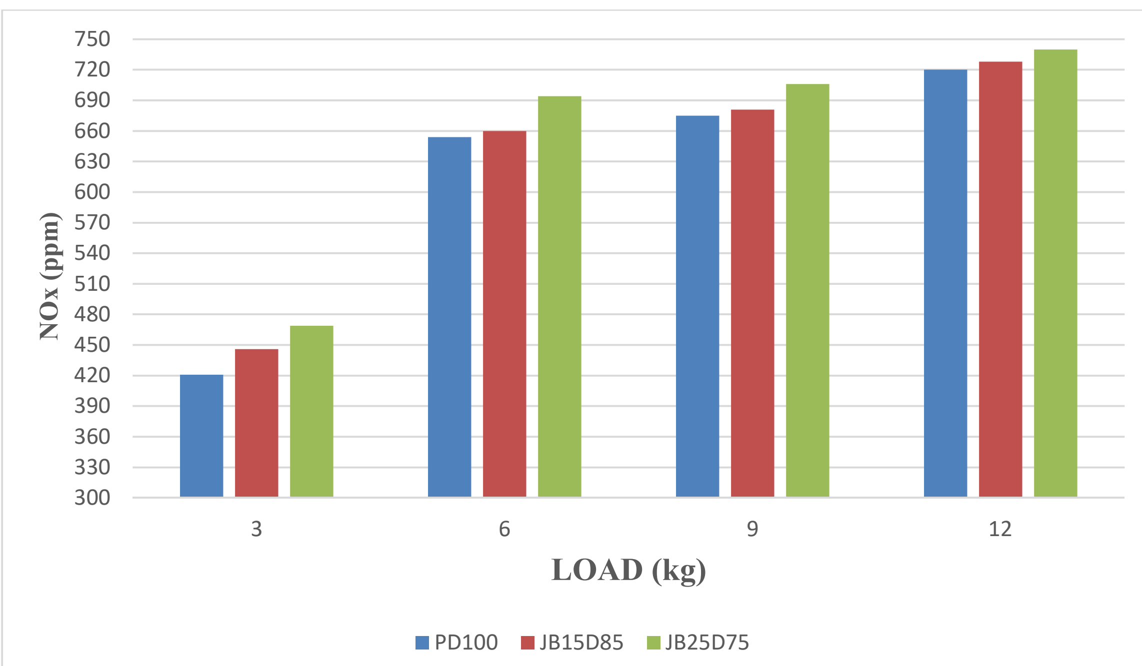

Fig.4.7: Load Vs NOx emissions

It is also observed that the NOx emissions increase with an increase in the amount of JOBD in the blend. This increase may be due to the fact that JOBD is an oxygenated fuel that leads to better combustion and hence higher combustion temperature is attained. This higher temperature promotes NOx formation. It is seen that the NOX emission of biodiesel blends is higher when compared to the diesel.

4.2.4 Exhaust gas temperature-Fig.4.8 shows the exhaust gas temperature variations for different fuels with load. It was observed that the exhaust gas temperature increases with load because more fuel is burnt at higher loads to meet the power requirement.

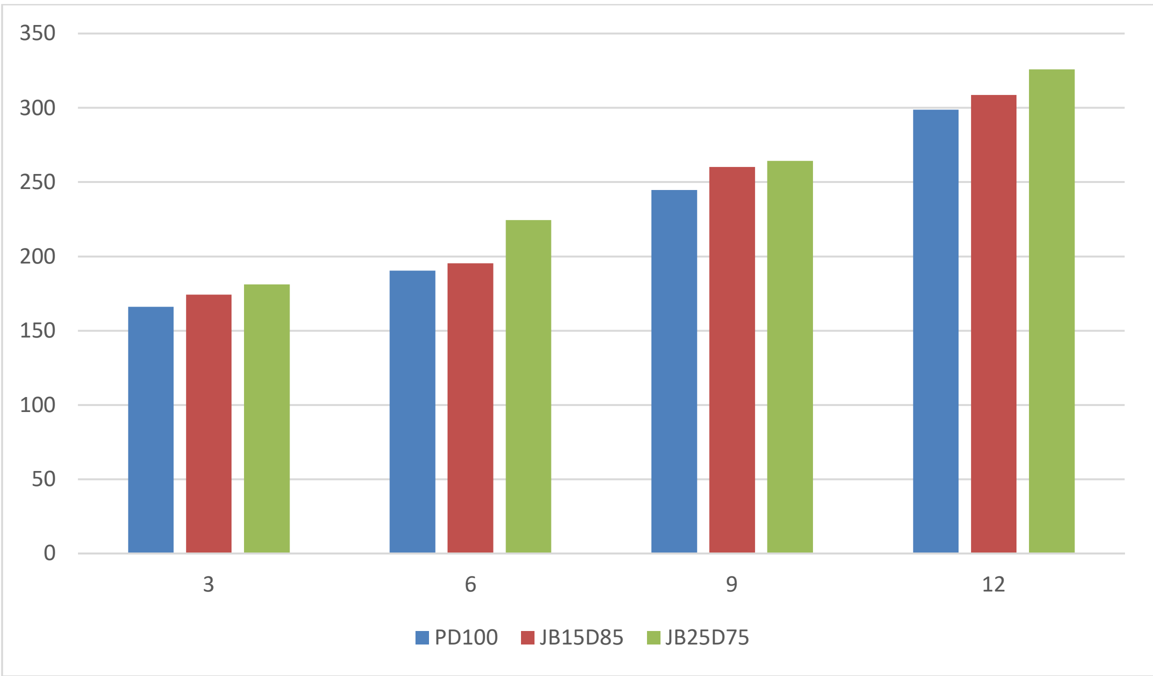

Fig.4.8: Load Vs Exhaust gas temperature

It is also observed that the exhaust gas temperature increases with the percentage of JOBD in the test fuels for all the loads. This may be due to the oxygen content of the JOBD, which improves combustion and thus may increase the exhaust gas temperature.

5. CONCLUSIONS

The performance and emission characteristics of a single cylinder four stroke diesel engines fueled with diesel PD100 and blends of Jatropha oil biodiesel JB15D85 and JB25D75 at an injection pressure of 220bar and at constant injection timing of 23°bTDC at engine rated speed of 1500rpm are investigated for different loads of 25%, 50%, 75% and 100%. The following conclusions were drawn from this study.

1. For all the fuels, the specific fuel consumption decreases with an increase in load. The increase in percentage of Jatropha biofuel in the blend increases the specific fuel consumption because of the lower heating value of blend as compared to the pure diesel.

2. It was observed that the brake thermal efficiencies of JB15D85 and JB25D75 are 20.06%, and 22.03% when compared to diesel brake thermal efficiency 19.65% at 12kg engine load. Brake thermal efficiencies of Jatropha biofuels were slightly higher than that of pure diesel at all loads due to the early start of combustion of Jatropha oil biodiesel and its blends.

3. Biodiesel and its blends have a higher indicated thermal efficiency than pure diesel since biodiesel has more oxygen content than diesel which aids in combustion.

4. It was observed that mechanical efficiency increases when the load increases for all operations of diesel and biodiesel blends. It was also observed that mechanical efficiency was better when JB15D85 and JB25D75 are used.

5. NOx emissions of the blends of Jatropha oil biodiesel JB15D85 and JB25D75 are generally higher than pure diesel while the emissions of HC, CO are lower than that of diesel PD100. From this analysis it can be concluded that Jatropha and its blends are a potential substitute for diesel.

6. It was concluded that JB25D75 blend shows almost same fuel consumption, higher mechanical efficiency, higher brake and indicated thermal efficiencies with load variations than that of conventional diesel PD100.

7. The specific fuel consumption was found to be more for Jatropha biodiesel when compared to diesel due to the lower Calorific Value of biodiesel.

8. The exhaust gas temperature of biodiesel was more compared to diesel due to the complete combustion which increases the combustion chamber temperature.

9. The CO and HC emission are lower for Jatropha biodiesel when compared to diesel; this may be due to the fact that biodiesel contains more oxygen.

10. The NOx emission is seen continuously increasing when load on engine is increased, which may be due to increase in cylinder temperature and due to increase in blend percentage.

REFERENCES

1. Y.V.Hanumantha rao, Ram Sudheer Voleti, A.V.Sitarama Raju, Pereddy Nageswara Reddy, Experimental investigations on Jatropha biodiesel and additive in diesel engine, Indian Journal of Science and Technology,Vol2,Issue4,2009.
5. G. Lakshmi Narayana Rao., B. Durga Prasad., S. Sampath., K. Rajagopal.,Combustion Analysis of Diesel Engine Fueled with Jatropha Oil Methyl Ester- Diesel Blends , International Journal of Green energy, Volume 4,Issue 6,2007.
6. Patel C, Chandra K, Hwang J, Agarwal RA, Gupta N, Bae C, Gupta T, Agarwal AK. Comparative compression ignition engine performance, combustion, and emission characteristics, and trace metals in particulates from Waste cooking oil. Jatropha and Karanja oil derived biodiesels, Fuel2019 Vol 236 Issue 15, pp 1366-1376.
7. Pramanik, K. (2003). Properties and use of Jatropha curcas oil and diesel fuel blends in compression ignition engine, Renewable Energy Vol 28,Issue 2,pp239–248.
8. Forson, F.K., Oduro, E.D., Hammond-Donkoh, E. (2004). Performance of Jatropha oil blends in a diesel engine, Renewable Energy, Vol 29, Issue 7, pp1135–1145.
9. Reddy, J.N., Ramesh, A. (2006). Parametric studies for improving the performance of Jatropha oil- fuelled compression ignition engine. Renewable Energy, Vol 31, Issue12, pp1994–2016.
10. L. Karikalan and M. Chandrasekaran. 2015. Karanja oil biodiesel: A potential substitution for diesel fuel in diesel engine without alteration, ARPN J. Engg. and Applied Sci., Vol 10, Issue 1, pp152-163.
11. I. Vamsi, C.S. Rao and M.I. Reddy. 2015. Experimental investigations on the engine performance and characteristics of compression ignition (CI) engine using dual bio-fuel methyl ester as alternate fuel with exhaust gas recirculation, Int. J. Engg. Research and Applications, Vol 5, Issue 5, pp53-58.
12. Karikalan Loganathan, Sathish Venugopal, S. Ramasubramanian and S. Jacob.,(2019) Experimental Analysis of Performance and Pollutants of CI Engine using Jatropha Biodiesel with Exhaust Gas RecirculationInt.Journal of Vehicle structures and systems, Vol 11,Issue 2,pp176-179.
13. P. Dubey and R. Gupta.,(2017) "Effects of dual bio-fuel (Jatropha biodiesel and turpentine oil) on a single cylinder naturally aspirated diesel engine without EGR," Appl. Therm. Eng., vol. 115,Issue 25, pp 1137–1147.
14. A.Yashkumar and Tushar M Patel., (2019) "Combustion Evaluation of Single Cylinder 4 Stroke CI Engine Fueled with Jatropha Biodiesel and Diesel Blend," SSRG International Journal of mech.engg. vol. 6, Issue 4, pp 1–7.