EXPERIMENTAL INVESTIGATION OF PERFORMANCE AND EMISSION CHARACTERSTICS OF VARIABLE COMPRESSION RATIO DI DIESEL ENGINE OPERATING ON JATROPHA BIODIESEL AND DIESEL FUEL

Asst Prop. Harish. S. Naik[1], Ajey S. Udoshi[2], Nagaraj B. Kotagi[3], Lagamanna B. Kankanawadi[4], Akash B. Pattar[5]

[1, 2, 3, 4, 5]Mechanical engineering, Hirasugar Institute of Technology Nidasoshi, (India)

ABSTRACT

In the present investigation experimental work has been carried out to estimate the performance, emission characteristics of a single cylinder, four stroke variable compression ratio multi fuel engine fueled with Jatropha biodiesel blended with standard diesel. Tests has been conducted using the biodiesel blends of 10%, 20%, 30%, 40% of biodiesel with standard diesel, with compression ratio 15:1, 17:1, 18:1 and an engine speed of 1500 rpm at different loading conditions. Present paper deals with effects of engine fueled with diesel, blends of diesel with biodiesel with a view to provide a platform for comparison of performance and emission parameters. The performance parameter includes brake thermal efficiency (BTHE), indicated thermal efficiency (ITHE), mechanical efficiency, air-fuel ratio, brake specific fuel consumption (BSFC). The exhaust gas emission is found to contain carbon monoxide (CO), unburnt hydrocarbon (HC), oxides of nitrogen (NOx) and carbon dioxide (CO2).

Keywords: Biodiesel, Combustion, Emission, Jatropha biodiesel, Performance

I INTRODUCTION

Today in this fast developing world the need of various transportation system is increasing day by day, in the result of this number of vehicles and engine are increasing, but the conventional fuel used in the vehicles (like diesel and petrol) are limited and decreasing gradually with time. So there is a requirement of various means to drive these vehicles without a heavy modification in the engine of these vehicles. This situation leads to requirement of alternative fuels for engines. Biodiesel is the best substitute of the diesel in the diesel Engine. Vegetables oil is the best alternative fuel[1]. The main advantage of vegetable oil over the conventional fuel (as diesel in the diesel engine) is to reduce net CO_2 and CO emissions to atmosphere due to their agricultural origin. In this paper we investigate the properties of Jatropha oil to use as a bio-fuel in the conventional diesel engine. Jatropha oil is derived from Jatropha curcas plant which has been considered as a sustainable alternate fuel for diesel engine and also Jatropha curcas plant is renewable and non-edible[2]. However several durable and operational problems of using straight vegetable oils in the diesel engine are reported in literature, due to their higher viscosity and low volatility as compare to mineral diesel fuel. Hence vegetable oil does not give the better performance without proper modification[3].

In this experimental work, performance of diesel engine operating on Jatropha oil was evaluated and compared with diesel operation. The performance parameters considered for comparing are brake specific fuel consumption, thermal efficiency, volumetric efficiency, air fuel ratio, etc. and emission parameters considered for comparing are CO, CO_2, UBHC and NOx emissions[4].

II ABOUT JATROPHA

- It is a hardy, drought and pest-resistant plant.
- It produces seeds containing up to 40% oil.
- Botanical features:
    - Large green to pale-green leaves
    - Flowering plant
    - Fruits are produced in winter or throughout the year depending on temperature and soil moisture.
    - Seeds become mature when the capsules change from green to yellow[5].
- Grows almost anywhere including wastelands, gravelly, sandy, and saline soils. It can thrive on even some of the poorest stony soil and will grow in crevices of rocks.
- Complete germination is achieved within 9 days.
- Survives and thrives on a mere 250 mm (10 inches) of rain a year.
- Ploughing and planting are not needed regularly since the shrub will continue to grow for about forty years.
- The plant responds negatively to organic fertilizers like manure during germination.
- The uses of pesticides are not necessary due the pesticidal, poisonous, and fungicidal properties of the plant.
- Begins yielding after 9-12 months. However, effective yield comes only after 2-3 years[6].

III LITERATURE SURVEY

K. Pramanik et al. (2010) Conducted the experiment on “properties and use of Jatropha curcas oil and diesel fuel blends in compression ignition engine”. The main of present investigation was to reduce viscosity of Jatropha curcus oil close to that conventional fuel to make it suitable for use in a C.I. Engine and to evaluate the performance of the engine with the modified oils. Significant reduction in viscosity was achieved by dilution of vegetable oil with diesel in varying proportions. However, the properties of blends may be further improved to make use of higher percentage of Jatropha oil in the blends using Jatropha oil of purer grade which may be obtained by pretreatment of the oil. Moreover, the long term durability of the engine using biodiesel as fuel

Saurabh Sharma et al. (2014) Studied the "performance and emission analysis of diesel engine using biodiesel and preheating Jatropha oil". The experimental work carried out in this study was analyzed and the results were discussed as above and the major findings are listed in this. The main objective of the experiment is to analyze the performance and emission characteristics of Jatropha oil in variable compression ratio engine. The Jatropha oil has viscosity higher than that of diesel so viscosity is reduced by blending the Jatropha biodiesel with diesel or preheating the Jatropha oil, viscosity of Jatropha blends up to the D40 is found close to that of diesel. The results shows that engine performance when fueled with the biodiesel are comparable to that when fueled with petroleum diesel. CO, CO_2.and HC emission for the biodiesel blends and preheated biodiesel is lower than that of the diesel fuel, this is due to that biodiesel is green fuel and contain less carbon molecules. O_2 emission for the blends of the biodiesel is higher than that of diesel, this shows that biodiesel is an oxygenated fuel and it contains oxygen of about 11% by weight.

Pradeep et al. (2007) have experimented the use of hot EGR for NOx control in a single cylinder compression ignition engine fueled with bio-diesel from Jatropha oil (JBD). The NOx has been reduced when the engine was operated under HOT EGR levels of 5.25%. However, EGR level has been optimized as 15% based on adequate reduction in NO emissions, minimum possible smoke, CO, HC emissions and reasonable brake thermal efficiency. Smoke emissions of JBD in the higher load region have been lower than diesel, irrespective of the EGR levels. However, smoke emission is higher in the lower load region. CO and HC emissions have been found to be lower for JBD irrespective of EGR levels.

Reddy et al. (2006) have carried out parametric study on a single cylinder, constant speed, direct injection diesel engine which is operated on neat Jatropha oil. Injection timing, injector opening pressure, injection rate and air swirl level are changed to study their influence on performance, emissions and combustion. It is found that the ignition delay with Jatropha oil is always higher than that of diesel under similar conditions, advancing the injection timing from the base diesel value and increasing the injector opening pressure increases the brake thermal efficiency from 25.7% to 27.3% and reduces HC and smoke emissions level from 3.9 BSU to 3.3 BSU. The significant increase in NOx level is also observed. When the injection timing is retarded, though the thermal efficiency is still lower than diesel with enhanced injection rate, a significant improvement in performance and emissions has been noticed. Enhancing the swirl has only a small effect on emissions.

Sahoo& Das et.al (2009) have carried out combustion analysis of Jatropha, Karanja and Polanga based biodiesel as fuel in a diesel engine. The major objective of the present investigations is to experimentally access the practical applications of biodiesel in a single cylinder diesel engine used in generating sets and the agricultural applications in India. Diesel, neat biodiesel from Jatropha, Karanja and Polanga and their blends (20 and 50% by volume) have been used for conducting combustion tests at varying loads (0, 50 and 100%). The engine combustion parameters such as peak pressure, time of occurrence of peak pressure, heat release rate and ignition delay have been computed. Combustion analysis has revealed that neat Polanga biodiesel results in maximum peak cylinder pressure has been the optimum fuel blend as far as the peak cylinder pressure is concerned. The ignition delays have been consistently shorter for neat Jatropha biodiesel, varying between 5.9° and 4.2° crank angles lower than diesel with the difference increasing with the load. Similarly, ignition delays are found to be shorter for neat Karanja and Polanga biodiesel when compared with diesel.

IV OBJECTIVES

By studying various literatures we conducted experiments on VCR diesel engine by diesel and JATROPHA biodiesel blends. So we estimated to achieve the following objectives.

- Investigation of the properties of Jatropha biodiesel and diesel: Finding the properties of different blends which will helps to calculate the performance parameters.
- Experimental investigation of performance characteristics of VCR engine: To obtain biodiesel blend, which will gives the more efficiency.
- Experimental investigation of emission characteristics of VCR engine. To obtain biodiesel blend, which will gives less emissions.
- Comparison of VCR engine parameters for Jatropha biodiesel and diesel.

V EXEPERIMENTAL SETUP

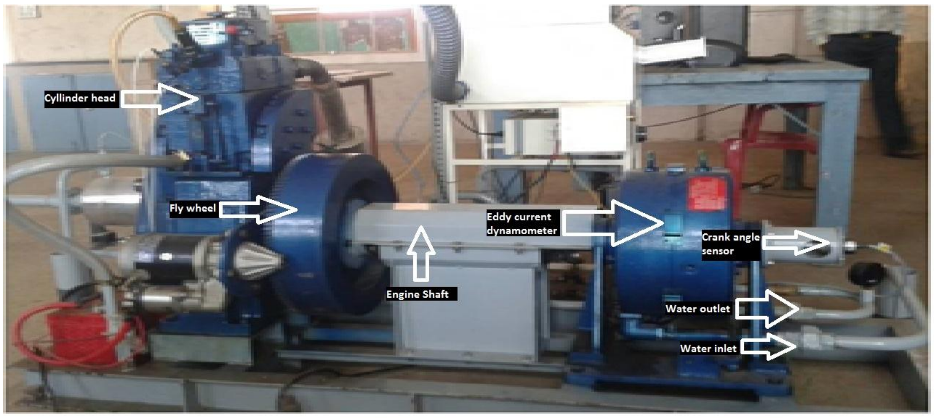

Fig 1- Experimental Setup

Table 1 Technical specification of experimental test rig

Engine	Type - single cylinder, four stroke Diesel, water cooled, rated power 3.5 kW at 1500 rpm, stroke 110 mm, bore 87.5 mm. 661 cc, CR 17.5, Modified to VCR engine CR range 12 to 18
Dynamometer	Type eddy current, water cooled, with loading

	unit
Load indicator	Digital, Range 0-50 Kg, Supply 230VAC
Software	"Enginesoft LV" Engine performance analysis software
Load sensor	Load cell, type strain gauge, range 0-50 Kg
Rotameter	Engine cooling 40-400 LPH; Calorimeter 25-250 LPH
Exhaust gas analyser	Make – Indus Scientific, Five gas analyser

Exhaust Gas Analyzer

An instrument used to analyze the chemical composition of the exhaust gas released by a engine is called exhaust gas analyzer. An image of the exhaust gas analyzer used in this study. The instrument measures the concentrations of Carbon monoxide (CO in % & ppm), Carbon Dioxide (CO_2) and Oxygen (O_2) in percentage, Hydrocarbons (HC), Oxides of Nitrogen (NOx) in ppm in the engine exhaust gas. The technical specifications of the exhaust gas analyzer[7].

Table .2 Technical Specifications of Exhaust Gas Analyzer

Non-Dispersive Infrared Sensors for CO, CO_2, HC
Electrochemical sensors for O_2, NOx and SOx

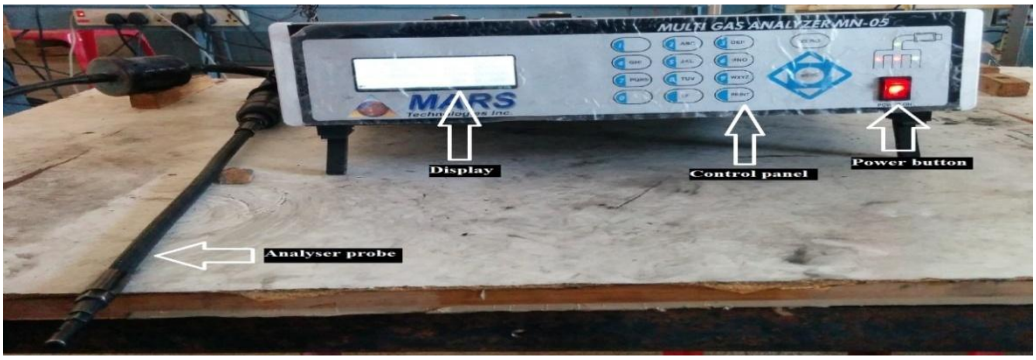

Fig.2.Exhaust Gas Analyzer

When the probe is inserted into the exhaust pipe of the engine the exhaust gas is passed through a metal mesh screen. The screen filters the soot and dust particles after which it is allowed to pass through a fine fiber element which filters the entire gas for any foreign particles. After this, the clean and cool sample gas enters the direct sensor measurement through a filter arrangement and the readings are displayed on the screen and are recorded. The emission measurements are carried out on dry basis.

VI METHODOLOGY

1) As we are conducting the experiment on the bio-fuel, collecting of sufficient quantity of bio fuel of Jatropha from the available place.
2) Preparing the different proportions blends as follows
   - B10=10% of Jatropha oil +90% of diesel
   - B20=20% of Jatropha oil +80% of diesel
   - B30=30% of Jatropha oil +70% of diesel
   - B40=40% of Jatropha oil +60% of diesel
3) Connect the computerized data acquisition system with engine and gas analyser.
4) Fill the tank with different blends and start the engine with electrical starter.
5) Wait for 2 to 3 min and apply load.
6) Experiments will repeated for above said different blends at different load conditions.
7) Based on the experimental results collected from the software and drawings of necessary graphs to identify the optimized bio-diesel with minimum emissions and better performance.
8) Finally come to the conclusion to suggest the optimized bio-diesel with highest thermal efficiency.

VII DIESEL, BIODIESEL and BLENDS

Fig.3: Diesel and blends of biodiesel

Table.3: Properties of diesel and blends of biodiesel

Sl. no	Properties	Diesel	Jatropha biodiesel	J10-D90	J20-D80	J30-D70	J40-D60	Method used
1)	Density (kg/m^3)	825	876	830	835	840	845	Mass/Volume
2)	Kinematic viscosity (cSt)	2.52	8.44	3.112	3.704	4.296	4.888	Redwood viscometer

3)	Calorific value (kJ/kg)	45843	39340	4519 2.7	44542. 4	43892. 1	43241 .8	Bomb calorimeter
4)	Flash point (°C)	55	176	67.1	79.2	91.3	103.4	Cleveland apparatus
6)	Fire point (°C)	58	190	71.2	84.4	97.6	110.8	Cleveland apparatus

VIII RESULTS AND DISCUSSION

8.1 Brake thermal efficiency for fuels

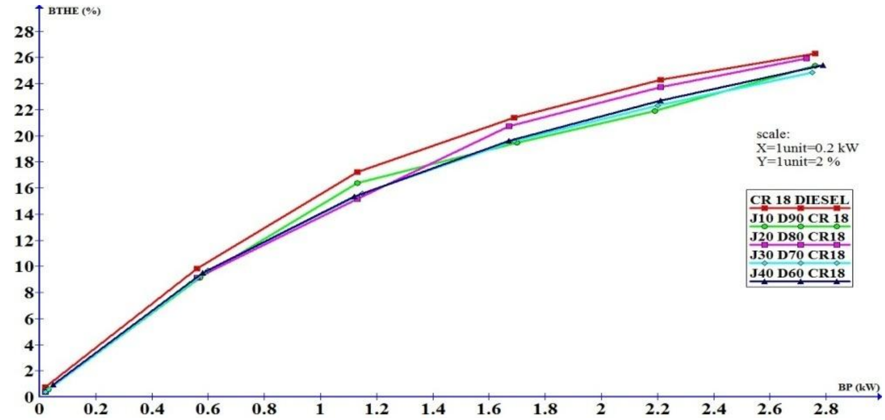

Fig.4: BP (kW) v/s BTHE (%)

From the graph it is observed that, as the break power increases break thermal efficiency also increases gradually, and it becomes stable at rated load that is 10 kg. Break thermal efficiency of biodiesel is slightly less than diesel and it is comparable with the diesel. The biodiesel has lower break thermal efficiency because of its lower calorific value. At maximum load the J20 biodiesel found that 25.95% compare to diesel value 26.30%.

8.2 Brake specific fuel consumption for fuels

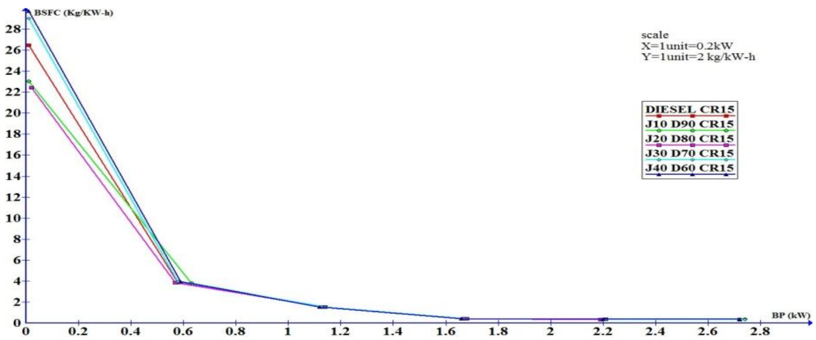

Fig.5BP (kW) v/s BSFC (kg/kWh)

From the graph it is observed that, as the break power increases break specific fuel consumption decreases gradually, and it becomes stable at rated load that is 10 kg. Break specific fuel consumption of biodiesel is

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ISSN 2348 - 7550

slightly more than diesel and it is comparable with the diesel. The biodiesel has higher break specific fuel consumption because the viscosity of diesel is lower as compare to all blends of biodiesel. At maximum load the J20 biodiesel found that 0.34kg/kWhcompare to diesel value 0.33kg/kWh.

8.3 Mechanical efficiency for fuels

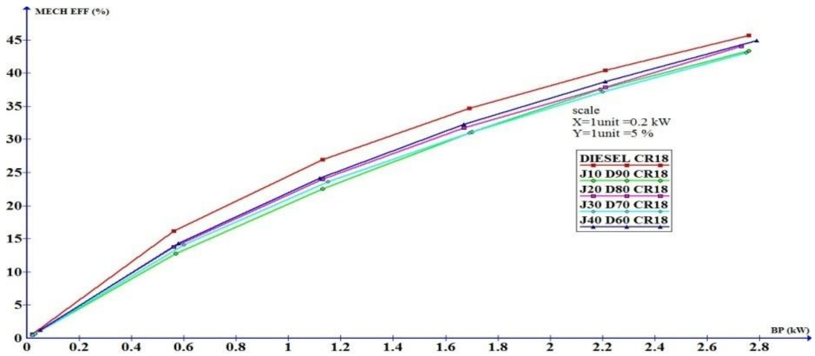

Fig.6 BP (kW) v/s Mechanical efficiency (%)

From the graph it is observed that, as the break power increases mechanical efficiency also increases gradually, and it becomes stable at rated load that is 10 kg mechanical efficiency of biodiesel is slightly less than diesel and it is comparable with the diesel. The biodiesel has lower mechanical efficiency because of its lower calorific value. At maximum load the J40 biodiesel found that 44.88% compare to diesel value 45.65%.

8.4 Air fuel ratio for fuels

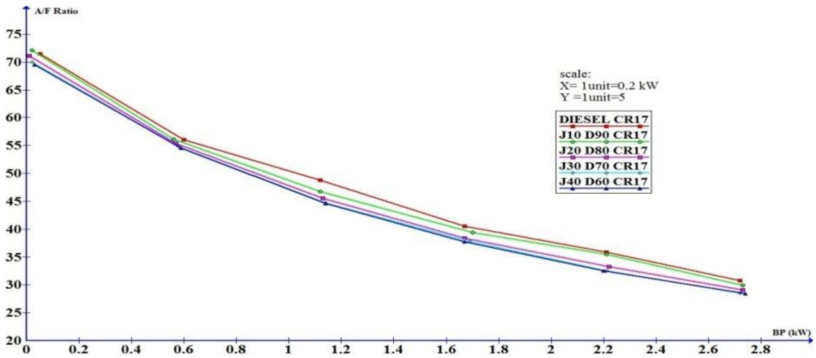

Fig.7: BP (kW) v/s A/F Ratio

From the graph it is observed that, as the break power increases A/F ratio decreases gradually, and it becomes stable at rated load that is 10 kg. A/F ratio of biodiesel is slightly less than diesel and it is comparable with the diesel. The biodiesel has lower A/F ratio because diesel has less viscosity and it atomises easily as compared to diesel. At maximum load the J10 biodiesel found that 29.98 compare to diesel value 30.82.

8.5 CO emission for fuels

From the graph it is observed that as the load increases the emission of CO increases gradually, and it becomes stable at rated load 10kg. The emission of CO for diesel is higher as compared to all blends. Because biodiesel

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has intrinsic oxygen molecule so CO is converted to CO_2.At maximum load for diesel is 0.30% and for all biodiesels it is less than diesel.

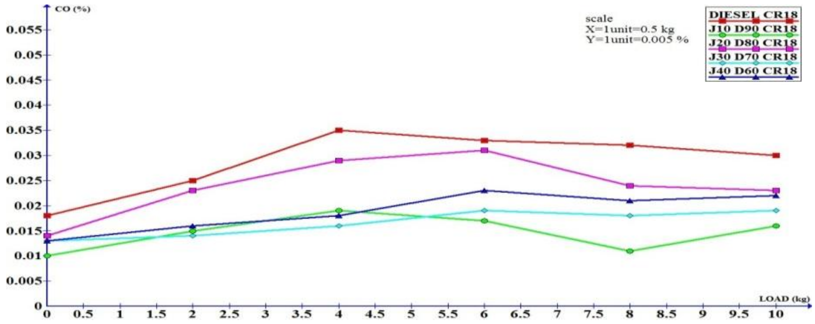

Fig.8: Load (kg) v/s CO emission (%)

8.6 CO_2 emission for fuels

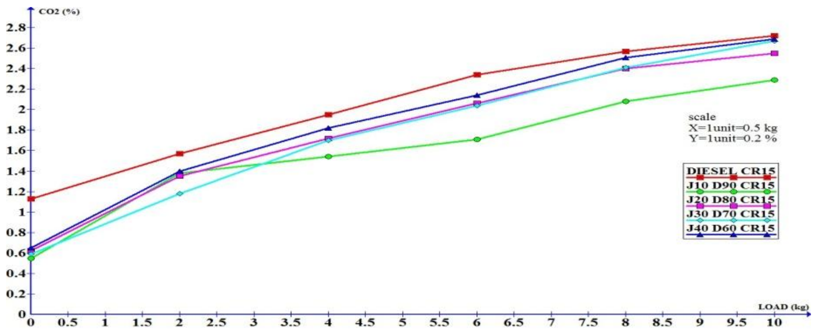

Fig.9 Load (kg) v/s CO_2 emission (%)

From the graph it is observed that as the load increases the emission of CO_2 increases gradually, and it becomes stable at rated load 10kg. The emission of CO_2 for diesel is higher as compared to all blends. Because diesel has more carbon molecules in its molecular structure compared to biodiesel. At maximum load for diesel is 2.72% and for all biodiesels it is less than diesel.

8.7 Hydrocarbon emission for fuels

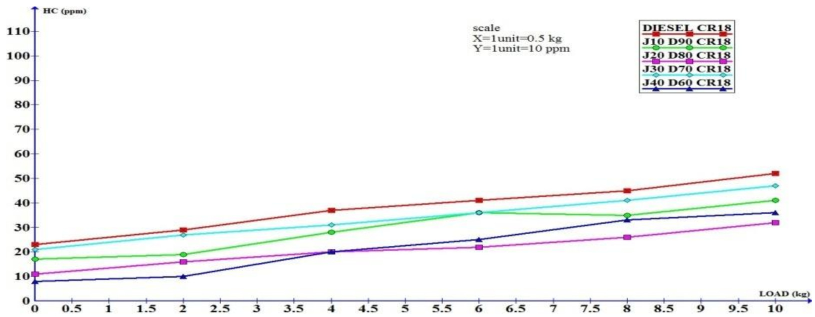

Fig.10: Load (kg) v/s HC emission (ppm)

From the graph it is observed that as the load increases the emission of HC increases gradually, and it becomes stable at rated load 10kg. The emission of HC for diesel is higher as compared to all blends. Because biodiesel having intrinsic oxygen so it is completely combusted and less emission of unburnt hydrocarbon. At maximum load for diesel is 52 ppm and for all biodiesels it is less than diesel.

8.8 NO_x emission for fuels

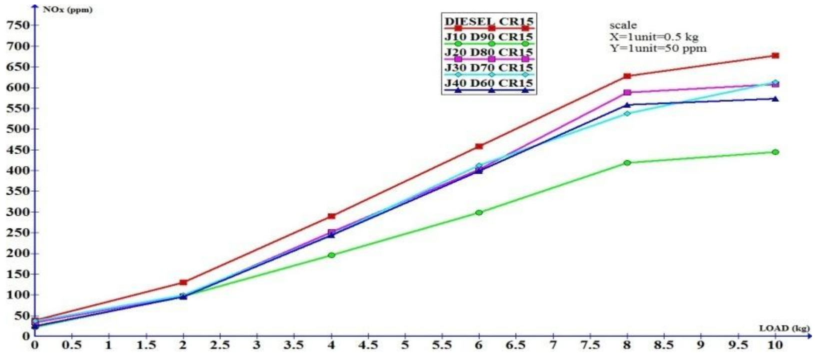

Fig.11 Load (kg) v/s NO_x emission (ppm)

From the graph it is observed that as the load increases the emission of NO_x increases gradually, and it becomes stable at rated load 10kg. The emission of NO_x for diesel is higher as compared to all blends. As the temperature increases NO_x emission also increases and diesel has higher exhaust temperature because calorific value of diesel is more. At maximum load for diesel is 678 ppm and for all biodiesels it is less than diesel.

IX CONCLUSION

Performance and emission characteristics of VCR, single cylinder diesel engine has been found out using blended Jatropha biodiesel and diesel as a fuel. As we found that optimum performance and emission characteristics will below 40% blend of biodiesel from the literature survey. Accordingly experimentation has been done on above mentioned engine using Jatropha biodiesel blended with 10%, 20%, 30%, 40% along with diesel at constant speed of 1455rpm and variable load range of (0-10kg).

Blended Jatropha biodiesel fuelled engine characteristics have been compared with pure diesel fuelled engine. The following are the conclusions

- The break thermal efficiency for Jatropha blend J20 is 26.95% which is nearer to the diesel thermal efficiency 27% at compression ratio 18.
- The specific fuel consumption for Jatropha blend J20 is 0.34 kg/kWh which is higher than diesel value 0.33 kg/kWh at compression ratio 15.
- The volumetric efficiency for Jatropha blend J10 biodiesel found that 80.78% compare to diesel value 80.96% at compression ratio 18.
- The A/F ratio for Jatropha blend J10 biodiesel found that 29.98 compare to diesel value 30.82 at compression ratio 17.
- The mechanical efficiency for Jatropha blend J40 biodiesel found that 44.88% compare to diesel value 45.65% at compression ratio 17.
- The CO_2 emission for Jatropha blend J10 is much lower than that of diesel value at compression ratio 18.

- The COemission for Jatropha blend J10 is much lower than that of diesel value at compression ratio 15.
- The UBHCemission for Jatropha blend J20 is much lower than that of diesel value 18.
- The NO_x emission for Jatropha blend J10 is much lower than that of diesel value at compression ratio 15.

So finally from above points it is concluded that J20 is giving better performance and emission engine characteristics.

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