International Conference on Innovative Research in Engineering, Management and Sciences
International Journal of Scientific Research in Computer Science, Engineering and Information Technology
© 2019 IJSRCSEIT | Volume 4 | Issue 9 | ISSN : 2456-3307

Performance, Combustion and Emission Characteristics of Diesel Engine Fueled With Jatropha/Diesel Blend

Gopal Kaliyaperumal[1], Damodharan Dillikannan[2], Melvin Victor De Poures[3], Mukilarasan Nedunchazhiyan[4]

[1]Department of Mechanical Engineering, New Horizon college of Engineering, Bengaluru, KA, India
vkgopalme@gmail.com[1]
[2]Department of Mechanical Engineering, Jeppiaar Engineering College, Chennai, TN, India
damumech07@gmail.com[2]
[3]Department of Mechanical Engineering, Saveetha school of Engineering, Chennai, TN, India
melvin.victor02@gmail.com[3]
[4]Department of Mechanical Engineering, Jeppiaar Institute of Technology, Chennai, TN, India
mukil09tea19@gmail.com[4]

ABSTRACT

In this study the role of performance and emission characteristic of single cylinder four stroke compression ignition engine have been investigated with different biodiesel blends at various ratios of jatropha oil and diesel.This experiment were conducted at injection timing 23˚BTDC and the injection pressures are 210 bar respectively with blends D90J10, D80J20, D70J30. In this investigation the various performances such as brake thermal efficiency, specific fuel consumption and exhaust gas emissions of CO, HC, NO_X and smoke are analyzed and compared with neat ULSD and jatropha. The investigation were carried out using an experimental set-up consisting of a single-cylinder diesel engine coupled with AVL gas analyzer and the exhaust gas details were observed by smoke meter and the performance, combustion and emission characteristics were analyzed for the test blends. Experimental results indicated that, HC, CO, smoke emissions are reduced and NOX emissions are higher when compared to neat ULSD. BSFC is increased and Brake Thermal Efficiency (BTE) is lesser than ULSD and D80J20 has the best efficiency among the test blends. Comparing emission results, D70J30 has the lowest CO and HC emissions and D90J10 has lower NOX emissions which is still higher than the ULSD and also has the lowest smoke opacity.

Keywords : Diesel engine, Bio-Diesel, Jatropha oil, Performance and Emission

I. INTRODUCTION

Diesel engine plays a vital role in power generation, transportation and industrial activities. The main advantages of the diesel engine over the gasoline spark ignition engine include its durability, reduced fuel consumption and lower emission of carbon monoxide and unburned hydrocarbon. Due to higher efficiency diesel engines are of high interest in light duty vehicles. India stands 4th in the world of oil consuming countries with an oil utilization of 3,182,000 barrels per day from its 70% used as the form of diesel and its pollution problem appeared many years ago. Diesel engines cause higher emission of particulate matter (PM), carbon monoxide (CO), Hydrocarbon (HC) and nitric oxides (NOX) causing various global hazards such as climatic Change, ozone layer depletion, green house effect, global warming, and smog acid rain water bodies and reduce in air quality. Due to the increased hazardous effects of emission from engine to reduce these effects many researchers have contributed their work by different ways like engine modification, fuel alteration, exhaust gas treatment etc.,[2]

In this way we operate engines with biodiesels alternative fuel at different injection timing and injection pressure without modification of previous engines. It is commonly accepted that there is some advancement of injection time when biodiesel is used in place of diesel because of its bulk density. The higher bulk density and viscosity transfers the pressure wave through fuel pipe lines faster and an earlier needle lift will lead to advanced injection. Due to the difference in cetane number, it is often suggested that injection timing be retarded to attain more complete combustion of vegetable oil based fuels and also Fuel injection pressure in diesel engine plays an important role in engine performance. Higher injection pressure decreases fuel particle diameter which aids in better formation of mixing of fuel to air during ignition period, as a result of which engine performance will increase. High-pressure injection in combination with small orifice can achieve lean combustion which allows better fuel atomization, evaporation and improved emissions. High injection pressure also reduces soot emissions.[4]

A. C.I Engine

In compression ignition engines air is compressed in to the engine cylinder. Due to this the temperature of the compressed air rises to 700-900ºC. At this stage diesel is sprayed in to the cylinder in fine particles. Due to a very high temperature, the fuel gets ignited. This type of combustion is called constant pressure combustion because the pressure inside the cylinder is almost constant when combustion is taking place.

B. Fuel injection pressure

The performance and emission characteristics of diesel engines depends on various factors like fuel quantity injected, fuel injection timing, fuel injection pressure, shape of combustion chamber, position and size of injection nozzle hole, fuel spray pattern, air swirl etc. The fuel injection system in a direct injection diesel engine is to achieve a high degree of atomization for better penetration of fuel in order to utilize the full air charge and to promote the evaporation in a very short time and to achieve higher combustion efficiency. The fuel injection pressure in a standard diesel engine is in the range of

2000 to 1700 rpm depending on the engine size and type of combustion system employed. The fuel penetration distance become longer and the mixture formation of the fuel and air was improved when the combustion duration became shorter as the injection pressure became higher. When fuel injection pressure is low, fuel particle diameters will enlarge and ignition delay period during the combustion will increase. This situation leads to inefficient combustion in the engine and causes the increase in NOx, CO emissions.

C. Need of alternative fuel and types

The main reason for alternative fuel is that the consumption and demand of petroleum products are increasing every year due to urbanization, increase in vehicular density and power requirement is going up and to reduce emission produced by today's diesel engine, which in turns require a clean burning fuel that perform well under the variety of operating conditions. Alternative fuels are derived from resources other than petroleum and blended with petroleum products. Some are produced domestically, reducing our dependence on imported oil, and some are derived from renewable sources. Often, they produce less pollution than gasoline or diesel. Some of the alternative fuels are Ethanol, Biodiesel gas, Hydrogen and Electricity etc., Due to the increase the use of fossil fuels and the demand of its fuel resources the cost also increased because of this reasons its need to find out the another fuel source with low cost, less emission and with better performance its named alternative fuel.

D. Biodiesel

Biodiesel is a fuel equivalent of petro diesel with the exception of its derivation from biological sources. Both non-toxic and renewable, biodiesel essentially comes from plants and animals. A fuel comprised of mono-alkyl esters of long chain fatty acids derived from vegetable oils or animal. The major source of biodiesel is soybean oil, but other oils include rapeseed, canola, palm, cottonseed, sunflower, and peanut. All of which can be replenished through farming and recycling. Biodiesel can even be made from recycled cooking grease although biodiesel can be used in its pure form, it is usually blended with standard diesel fuel. Blends are indicated by the abbreviation Bxx, where xx is the percentage of biodiesel in the mixture. Much attention has been focused on the thought of it one day replacing fossil fuels as the world's primary transport energy source. Biodiesel is safe and can be used in diesel engines with few or no modifications needed.

E. Raw materials for biodiesel production

The second choice is making biodiesel using straight vegetable oil, or SVO. To do this, one would have to take a single-tank SVO system, replace the injectors and glow plugs, and add fuel heating. A two tank SVO system can also be used, which allows the oil to pre-heat and become thinner. With this system, the vehicle starts and stops using regular diesel and then switches to the SVO when it is hot enough. The third choice is to convert used cooking grease. Used cooking grease can be acquired through a local restaurant for free and put into a processing system. The grease is put into a cleansing unit, which heats the grease and separates the waste from the oil. Once the grease is cleaned, certain chemicals must be added in order to finalize the biodiesel process.

F. Jatropha

Jatropha is a shrub that adapts well to arid environments. Jatropha curcas is the most known variety; it requires little water or additional care, therefore, it is adequate for warm regions with little fertility. Productivity may be reduced by irregular rainfall or strong winds during the flowering season. Yield depends on climate, soil, rainfall and treatment during sowing and harvesting. Jatropha plants become productive after 3 or 4 years, and their lifespan is about 50 years. Oil yield depends on the method of extraction, it is 28–32% using presses and upto 52% by solvent extraction. Since the seeds are toxic, jatropha oil is nonedible. The toxicity is due to the presence of curcasin a globulin and jatrophic acid as toxic as ricin.

G. Separation of the reaction products

The separation of reaction products takes place by decantation. The mixture of fatty acids methyl esters (FAME) separates from glycerin forming two phases, since they have different densities; the two phases begin to form immediately after the stirring of the mixture is stopped. Due to their different chemical affinities, most of the catalyst and excess alcohol will concentrate in the lower phase (glycerin), while most of the mono, di, and triglycerides will concentrate in the upper phase (FAME). Once the inter phase is clearly and completely defined, the two phases may be physically separated. It must be noted that if decantation takes place due to the action of gravity alone, it will take several hours to complete. This constitutes a bottleneck in the production process, and in consequence the exit stream from the transesterification reactor is split into several containers. Centrifugation is a faster, albeit more expensive alternative. After the separation of glycerin, the FAME mixture contains impurities such as remnants of alcohol, catalyst and mono, di, and triglycerides. These impurities confer undesirable characteristics to FAME, for instance, increased cloud point and pour point, lower flash point, etc. In consequence a purification process is necessary for the final product to comply with standards. This will be discussed in the next section.

H. Purification of the reaction products

The mixture of fatty acids methyl esters (FAME) obtained from the transesterification reaction must be purified in order to comply with established quality standards for biodiesel. Therefore, FAME must be washed, neutralized and dried. Successive washing steps with water remove the remains of methanol, catalyst and glycerin, since these contaminants are water-soluble. Care must be taken to avoid the formation of emulsions during the washing steps, since they would reduce the efficiency of the process. The first washing step is carried out with acidified water, to neutralize the mixture of esters. Then, two additional washing steps are made with water only. Finally the traces of water must be eliminated by a drying step. After drying, the purified product is ready for characterization as biodiesel according to international standards. An alternative to the purification process described above is the use of ion exchange resins or silicates. Glycerin as obtained from the chemical reaction is not of high quality and has no commercial value.

Therefore, it must be purified after the phase separation. This is not economically viable in small scale production, due to the small glycerin yield. However, purification is a very interesting alternative for large scale production plants, since, in addition to the high quality glycerin, part of the methanol is recovered for reutilization in the transesterification reaction both from FAME and glycerin, and thus lowering biodiesel production costs. The steady increase of biodiesel production is fostering research for novel uses of glycerin in the production of high-value- added products. It must be noted that the stages of the biodiesel production process are the same for the entire production scales laboratory, pilot plant, small, medium, and large scale industrial. However, the necessary equipment will be significantly different.[8]

Saurabh Singh Experimented on Use of Biodiesel in CI Engines at the experiment he says Vegetable oils are a suitable alternative to diesel in compression ignition (CI) engines. The use of vegetable oils in a C I engine results in low CO, HC and smoke opacity emissions compared to a conventional diesel fuel. Biodiesel, a clean renewable fuel, has recently been considered as the best substitute for a diesel fuel because it can be used in any CI engine without the need for modification. Chemically, biodiesel is a mixture of methyl esters with long chain fatty acids and is typically made from non-toxic, biodiesel resources such as vegetable oils (Jatropha, Karanja, Thumba etc.), animal fats or even waste cooking oils (WCO). Biodiesel processing is required to refine the vegetable oil feedstock and convert it into biodiesel, so as to meet the desired C I engines fuels specifications. This paper describes the basic processing required for the vegetable oil feedstock to make it usable in C I engines.[1]

Hemanandh.J analyzed the experiment on Diesel Engine Blended with Refined Vegetable Oil, In the scenario of fossil fuels and in ever depleting, there is always a scope for alternative fuels and this paper aims to study blends of diesel with Refined corn oil (BRC) on a stationery engine. The experiment is done on krisloskar direct injection 4 stroke diesel engine, single cylinder, air cooled 4.4 kW constant speed at 1500 rpm with an compression ratio 17.5:1. Methyl esters of BRC were transesterified with sodium meth oxide before blending with diesel. For different blends at diesel (10%, 30%, 40%) in volume at specific injection pressures (180bar, 210 bar and 240bar) against different loads (0%, 25%, 50%, 75%, and 100%) have been tried in the experiment to study NOx, CO, HC, Smoke emissions with exhaust temperature. A 3- hole nozzle has been used and the emission are analyzed with AVL gas analyzer.Even though marginal increase in NOx with exhaust temperature at higher temperature are noticed the decrease in engine temperature by 3 deg in addition to HC and CO an significant. He conclude the higher pressure plays a crucial reduction of emissions as in 240 bar with 40% diesel. The NOx emission is generally less for lower percentage of blends with lower pressures and at higher pressure the emission of NOx increases. Biodiesel smoke opacity is marginally high when compared with diesel. Engine temperature increases during the lower loads and it decreases against higher loads.[3]

Sungyong Park investigated on Emission characteristics of exhaust gases and nanoparticles from a diesel engine with biodiesel-diesel blended fuel (BD20) in that journal he explained obout the study sought to investigate the characteristics of the exhaust emissions, and nanoparticle size distribution of particulate matter (PM) emitted from diesel engines fueled with 20% biodiesel-diesel blended fuel (BD20). The study also investigated the conversion efficiency of the warm-up catalytic converter (WCC). The emission characteristics of HC, CO, NOx and nano-sized PM were also observed according to engine operating conditions with and without exhaust gas recirculation (EGR). The study revealed that the maximum torque achievable with the biodiesel diesel blended fuel was slightly lower than that achievable with neat diesel fuel at high-load conditions. Smoke was decreased by more than 20% in all 13 modes. While the CO and THC emissions of BD20 slightly decreased, the NO emission of BD20 increased by 3.7%. Measured using the scanning mobility particle sizer (SMPS), the total number and total mass of the nanoparticles in the size range between 10.6nm and 385nm were reduced by about 10% and 25%, respectively, when going from D100 to BD20. The particle number and mass for both fuels were reduced by about 43% when going from with EGR to without EGR. When EGR was applied in the engine system, the particle number and mass were reduced by 24%, and 16%, respectively, when going from D100 to BD20.[5]

S.Jindal epeimented on Effect of injection timing on combustion and performance of a direct injection diesel engine running on Jatropha methyl ester. He said the fuel properties of biodiesel are comparable with that of diesel and lower blends with diesel are found suitable even for long term uses. Higher blends are still away from acceptance due to poor performance, mainly due to the reason that, the present age engines are the result of extensive research keeping petro diesel only as fuel in mind. Biodiesel being a fuel of different origin and quality, the engine design needs revision and different settings for optimum performance. As the combustion advances with biodiesel due to early entry, retarding the injection timing by 3° is found to increase the thermal efficiency by 8% and reduce the specific fuel consumption by 9% when Jatropha methyl ester is used as fuel. Highest exhaust temperature and indicated power are obtained on 3°retarded injection. By retarding the injection, the fuel delivery is also reduced resulting in slightly lower pressure rise with peak shifting towards outward stroke reducing the negative work.[12]

II. METHODS AND MATERIAL

A Productivity of Jatropha depends on precipitation rates, soil moisture availability, soil characteristics. Annual yield levels at 2-3 tons dry seeds have been proposed as achievable in semi-arid areas and on wastelands, while 5 tons ha-1 can be obtained with good management on good soils receiving 900-1200 mm average annual rainfall. Jatropha has not yet undergone breeding programs with selection and improvement. The productivity varies greatly from plant to plant and environmental factors are reported to have a dominating role over genetics in determining seed size, weight and oil content.[6]

A. Properties of jatropha oil

The switch from petroleum-based diesel compared to biodiesel has its advantages and disadvantages. There are changes in energy efficiency based on composition, changes in environmental impacts, and differences in cost between the two types of diesel.

TABLE I.

COMPARISON OF PROPERTIES DIESEL AND JATROPHA OIL [6]

Sr. No	Parameter	Diesel	Jatropha. curcas oil
1	Energy content (MJ/kg)	42-46	38.2
2	Density (gm/cc), 30°C	0.836–0.850	0.93292
3	Kinematic viscosity (cSt), 30°C	4.2	55
4	Specific Weight (15/40 °C)	0.84-0.85	0.91-0.92
5	Solidifying point (°C)	-14.0	2.0
6	Flash point (°C)	80	180
7	Fire point (°C)	78	256
8	Pour point (°C)	-6	6
9	Ignition point (°C)	257	340
10	Cetane value	40-55	38-40
11	Sulphur (%) by Wt	1.0-1.2	0-0.13
12	Oxygen (%, w/w)	1.19	11.06
13	Carbon (%, w/w)	86.83	76.11
14	Hydrogen (%, w/w)	12.72	10.52
15	Ash Content (%, w/w)	0.01±0.0	0.03±0.0

B. Characteristics of jatropha oil

Non-edible oil generally contains about 3-4 %wax and gum. De-waxing and degumming of plant oils is required not only for smooth running of the CI engine but also to prevent engine failure even if plant oils are blended with diesel. It is therefore necessary to remove wax and gum from the fresh oil before it could be used in CI engine. Analysis of Jatropha seeds revealed that the percentage of crude protein, crude fat and moisture were 24.60, 47.25 and 5.54% respectively (Akintayo, 2004). Crude-Jatropha oil, a non-edible vegetable oil shows a greater potential for replacing conventional diesel fuel quite effectively, as its properties are compatible to that of diesel fuel. It is however found from researches that the neat jatropha oil can be used to run the engines in mini-vans for rural transportation, haulage trucks, farm tractors and other agricultural machinery, but may require little modification. Density, cloud point and pour point of Jatropha oil are found to be higher than diesel. Higher cloud and pour point reflect unsuitability of Jatropha oil as diesel fuel in cold climatic conditions but the flash and fire points of Jatropha oil is very high compared to mineral diesel. Hence, Jatropha oil is extremely safe to handle . Higher carbon residue from Jatropha oil may possibly lead to higher carbon deposits in combustion chamber of the CI engine. Low sulphur content in Jatropha oil results in lower SOx emissions.

Presence of oxygen in fuel improves combustion properties and emissions but reduces the calorific value of the fuel. Jatropha oil has approximately 90% calorific value compared to diesel. Nitrogen content of the fuel also affects the NOX emissions. Higher viscosity is a major problem in using vegetable oil as fuel for diesel engines. Viscosity of Jatropha biodiesel is 4.84cSt at 40°C. It is observed that viscosity of Jatropha oil decreases remarkably with increasing temperature and it becomes close to diesel at temperature above 90°C.[7]

C. Advantages of the jatropha plant

- Low cost seeds.
- High oil content.
- Small development period.

• Grow on good and despoiled soil.

• Grow in low and high rainfall areas.

• Does not require any special maintenance.

• Can be harvested in non-rainy season.

• Size of the plant makes the collection of seeds convenient.

• Multi products are developed using a single jatropha plant. The products include bio-diesel, soap, mosquito repellent, and organic fertilizer.[9

D. Economics benefits

• Increase employment activity and increase Employment on the countryside

• Emits up to 100% less sulfur dioxide

• Reduces smoke particulates at about 75%

E. Schematic diagram

The experiment aims at determining appropriate proportions of biodiesel & diesel for which higher efficiency is obtainable. Hence, experiments are carried out at constant speed, comparing the performance of compression ignition engine operated on blends of diesel. The blend is checked under loads 0%, 25%, 50%, 75% and 100% with injection timing 23° by different injection pressure 210 bar.

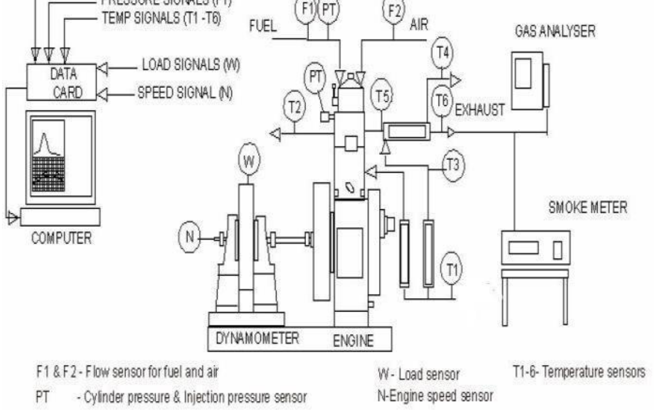

Figure 1. Schematic Diagram

The samples are prepared by using the 600 ml measuring jar. Figure shows the schematic diagram of the complete experimental setup for determining the effects of jatropha oil as bio diesel on the performance and emission characteristics of compression ignition engine.

F. Test engine and facilities

Tests were conducted in a 1-cylinder, constant-speed, 4-stroke, DI diesel engine. The existing population of this diesel engine driven pump-sets in India is about 14.42 million and more than a million and a half were added to this every year with a projected growth of 7%. This sector alone consumed 8.55% of India's total diesel consumption (69 MMT) in the year 2012–13 and this directly exposes a large population of farmers in India to its toxic diesel exhaust. Hence this engine is chosen for this study.The exhaust gas was passed through a cold trap and a filter element to separate moisture before entering the gas analyzer. HC emissions were measured in parts per million (ppm) of hexane (C6) equivalents while CO emissions were measured in terms of volume percentage. The effect of ambient temperature and humidity on NOx emissions should be accounted in order to compare engines across different locations at different atmospheric conditions.

TABLE II.

ENGINE SPECIFICATIONS

Make and model	Kirloskar, TV1 make
Number of cylinders	1

Combustion chamber	Hemispherical open type
Piston	Shallow Bowl-in type
Bore, mm	87.5
Stroke, mm	110
Connecting rod length, mm	234
Swept volume, cm3	661.45
Clearance volume, cm3	36.87
Compression ratio	17.5:1
Rated power, kW	5.2
Rated speed, rpm	1500
Injection type	Direct Injection
Number of Nozzle holes	3
Spray-hole diameter, mm	0.25
Injection pressure, bar	210
Injection timing, CA bTDC	23
Injection duration, CA	20–30
Cone angle,	110
Needle lift, mm	0.25

G. Experimental procedure

Initially the engine was run on no load condition and its speed was adjusted to 1500 ±10 rpm. The engine was then tested at no load and at 25, 50, 75 and 100 percent loads. For each load condition, the engine was run for at least three minutes after which data were collected. First the pure diesel was tested at the above loading conditions and the data are collected use of the data's the performance are calculated and the emissions are noted by gas analyzer. Then the blended biodiesel poured into the fuel reservoir and the biodiesel allowed into the engine after the engine was running for five three minutes with biodiesel as fuel at normal condition. After that the first set of data are noted at standard injection timing of diesel engine 23º BTDC at 210 bar injection pressure at the same condition the gas analyzer give exhaust emission data. With the help of collected information at different conditions and for other test blends the engine performance and emission characteristics are analyzed. The result and comparison is shown below at the form of graph.

III. RESULTS AND DISCUSSION

A The performance, combustion and emission characteristics of the engine fueled with Jatropha biodiesel blends were discussed with reference to baseline engine fueled with fossil diesel (ULSD) and operating under naturally aspirated conditions.

A. Performance analysis

Fig.2 illustrates the variation of BSFC and BTE with all engine loads for jatropha blends with ULSD as reference. Initially the BSFC decreases on increasing the load and BSFC is almost constant at peak conditions. At peak load J100 has highest BSFC compared to other test blends.At peak load conditions, all the test blends have more BSFC than ULSD. Since the density of the blends increases more energy is required for atomization and combustion, hence more fuel is consumed which influences the engine performance. BTE increases with increase in the load and diesel has the maximum BTE at peak load condition and among the test blends D80J20 has higher BTE which is 1.1% less than the diesel.

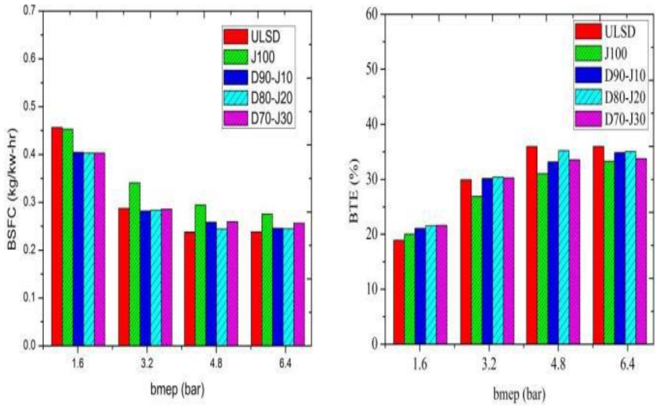

Figure 2. Performance analysis chart

B. Combustion analysis

Fig.3 represents the combustion data analysis with the variation of HRR and pressure in comparison with ULSD at rated power output of the engine. Since jatropha has low cetane number, it prolongs the ignition delay. The ignition delay causes more fuel to be burnt in the premixed combustion phase which increases the rate of pressure rise leading to faster burning rate and heat release rate(HRR). D90J10 has the highest HRR and D80J20 has the lowest among test blends. The heat release rate increases to a peak value and gradually decreases on increasing the crank angle.

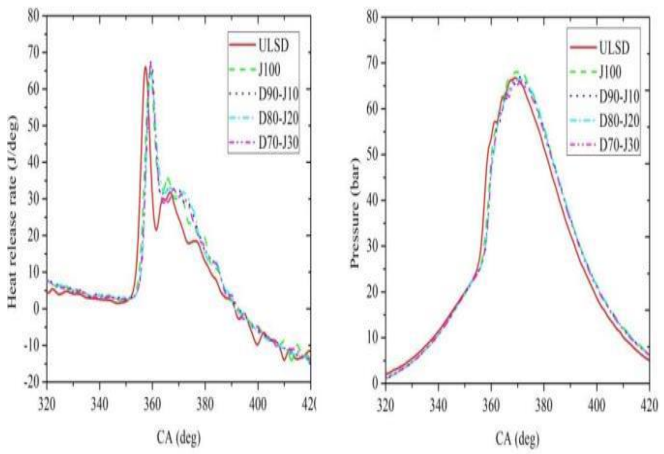

Figure 3. Combustion data analysis

From the analysis, J100 has the highest peak pressure and D70J30 has the lowest peak pressure. Longer combustion time increases the pressure hence J100 has maximum pressure.

C. Emission analysis

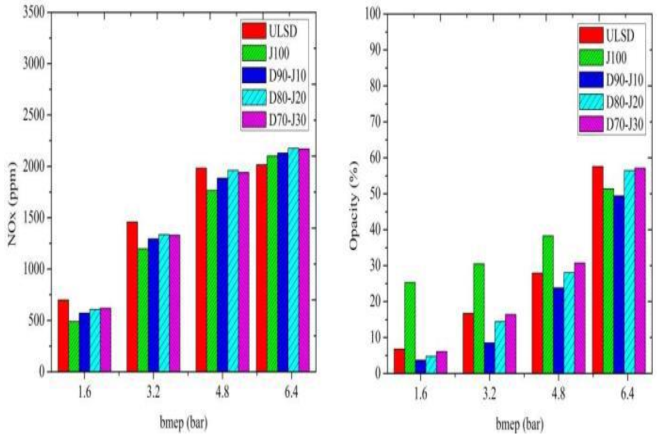

Figure 4 . NOx emissions and smoke opacity

The variation of NOx emission for jatropha blend with various engine loads are shown in Fig.4. NOx emissions increase with increase in the load conditions and at peak load, diesel has the lowest NOx and among the test blends J100 has the lowest NOx emission and D80J20 has the highest emission. This is due to the high nitrogen content in jatropha plant. At initial and medium loads, diesel has higher NOx emission than the other test blends. Smoke opacity levels increase with increase in the load characteristics. At initial and medium loads J100 has maximum smoke opacity. At peak load diesel has the maximum smoke opacity and D90J10 has the lowest smoke opacity at all load conditions. This is because jatropha has high carbon content and lower the jatropha ratio, lower the smoke opacity levels.

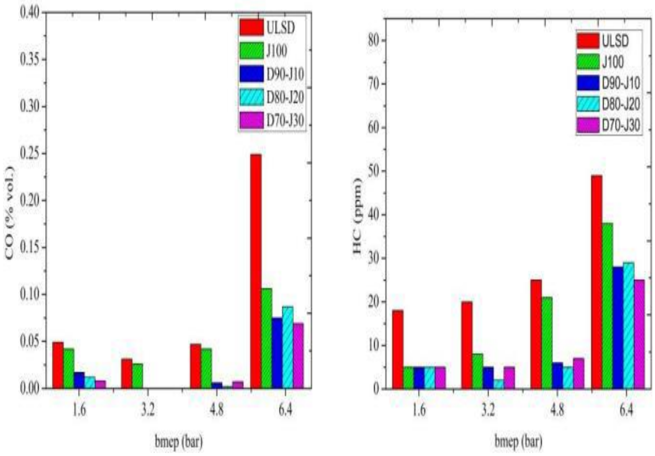

Figure 5. HC and CO emissions

The variation of CO emission under various loads conditions for jatropha blends are shown in Fig.5. The CO emission is low for test blends at initial loads and very low at medium loads. At peak load condition diesel ULSD has more CO emission and among the test blends D70J30 has the lowest CO emission which is 4 times less than the ULSD emission.Analyzing the HC emissions, HC emissions increase with increase in the load and at peak load ULSD has high emission. Comparing among the test blends J100 has the highest HC and D70J30 has the lowest. At initial and medium loads D80J20 has the minimum HC emission.

IV. CONCLUSION

In this project, load performance and emission tests were conducted and data were collected and compared. Engine function had been monitored and the combustion, performance and emission characteristics were analyzed and the following conclusions were made

- At all load conditions, D80J20 has low BSFC and J100 has the highest BSFC when compared to other blends.
- At all load conditions, D80J20 has higher efficiency among the test blends which is 1% less than the efficiency of ULSD.
- At peak load conditions, ULSD emits more CO and among the test blends D70J30 has the lowest emission which is nearly 4 times less than the ULSD.
- At peak load condition, D70J30 has lowest HC and ULSD has the highest HC emission.
- At peak load condition, D70J30 shows the highest NOx emission and ULSD has the lowest emission.
- At peak load condition, ULSD has highest smoke opacity and D90J10 has the lowest smoke opacity

V. REFERENCES

[1] Saurabh Singh“ Experiment on Use of Biodiesel in CI Engines”. 2013

[2] Knothe G, Dunn RO, Bagby MO “Biodiesel, the use of vegetable oils and their derivatives as alternative diesel fuels”. In Fuels and Chemicals from Biomass, 1st edition. American Chemical Society, New York. 1997

[3] Hemanandh.J “analyzed the experiment on Diesel Engine Blended with Refined Vegetable Oil”. 2014

[4] Freedman B, Pryde EH, Mounts TL “Variables affecting the yields of fatty esters from transesterified vegetable oils”. J Am Oil Chem Soc 61(19):1638–1643 .1984

[5] Sungyong Park “investigated on Emission characteristics of exhaust gases and nanoparticles from a diesel engine with biodiesel-diesel blended fuel” . 2011

[6] Sahoo P.K. and L.M.Das “Combustion analysis of jatropha, Karanja and Polanga based biodiesel as fuel in a diesel engine” “Elsevier-Fuel 994-999. 2009

[7] S K. Sharma, RK. Doss and R.Kumar “Performance Parameters Analysis of CI engine by using mixture of diesel, jatropha oil and Mno”. International journal of Mechanical and Production engineering. 2013

[8] V.Arunmozhiselvan, R.B.Anand and M.Udayakumar “Effect of CeO2 in diesel and bio diesel blended on the performance and emission characteristic of CI engine” ARPN Journal of Engineering and Applied Sciences. 2009

[9] Pi-qiang Tan, Zhi-yuan Hu, Di-ming Lou, and Zhi-jun Li “Exhaust emission from a light-duty diesel engine with jatropha biodiesel fuel” Elsevier . 2012

[10] M.L.S Deva Kumar, S.Drakshayani and K.Vijaya Kumar Reddy “Effect of Fuel Injection Pressure on Performance of Single Cylinder Diesel Engine at Different Intake Manifold Inclinations”.

[11] M. Pandian1 , S.P. Sivapirakasam2 and M. Udayakumar “Influence of Injection Timing on Performance and Emission Characteristics of Naturally Aspirated Twin Cylinder CIDI Engine Using Bio-diesel Blend as Fuel” International Journal of Recent Trends in Engineering, Vol. 1, No. 5, May 2009.

[12] S. Jindal “epeimental on Effect of injection timing on combustion and performance of a direct injection diesel engine running on Jatropha methyl ester”. 2011