Jatropha Biodiesel as an Alternative Fuelfor CI Engine: Review

Praveen A. Harari

Assistant Professor, Department of Mechanical Engineering, SGOICOE, Belhe (Pune), Maharashtra, India.

ABSTRACT

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. The main advantage of vegetable oil over the conventional fuel (as diesel in the diesel engine) is of reducing the cost and able to reduce net CO_2 *and CO emissions to atmosphere due to their agricultural origin. Among all the alternative fuels Jatropha oil is also one. This review has been taken up to identify the performance and emission using Jatropha biodiesel.*

Keywords: *Jatropha biodiesel, blends, CI engine, performance, emission.*

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1. INTRODUCTION

Due to the gradual depletion of world petroleum reserves and the impact of environmental pollution of increasing exhaust emissions, there is an urgent need for suitable alternative fuels for use in diesel engines. In view of this, vegetable oil is a promising alternative because it has several advantages; it is renewable, environmentally friendly and produced easily in rural areas, where there is an acute need for modern forms of energy.The use of non-edible vegetable oils compared to edible oils is very significant because of the tremendous demand for edible oils as food and they are far too expensive to be used as fuel at present. Rapid increase in the prices of petroleum products and harmful exhaust emissions from engines jointly created renewed interest among researchers to find the suitable alternative fuels. It is concluded that the use of any vegetable oil possess some problems when subjected to prolonged usage in internal combustion engines. These problems are attributed to high viscosity, low volatility of neat vegetable oils. High viscosity of vegetable oil causes some problems in atomization by injector systems and combustion in cylinders of diesel engines. Some of the common problems in the long run are coking and trumpet formation on the injectors, carbon deposits, oil ring sticking and gelling of lubricating oil as a result of contamination by the vegetable oils. There are different methods for reducing viscosity of vegetable oils such as preheating, blending and transesterification. Jatropha oil has better yield as well as thermo physical properties near to diesel fuel. As the edible oil prices are escalating day by day so that researchers are working on non-edible oils. It is a plant growing almost throughout India. The oil content is approximately 40%. Jatropha curcas is a plant belonging to the family of Euphorbiaceae occurring almost throughout India. It is found in India, in a semi wild condition near villages. Jatropha plant can grow rapidly almost anywhere even on gravelly, sandy and saline soils. It has hardly any special requirement with regard to climate and soil. It can even grow in the crevices of rocks. Its water requirement is extremely low. It yields within 4 to 5 years and has a long productive period of around 50 years yielding handsome returns annually.

2. JATROPHA IN INDIAN CONTEXT

Jatropha curcas is the most widely used variety for the purpose of biodiesel extraction. Jatropha curcas is found in the tropics and subtropics and likes heat, although it does well even in lower temperatures and can withstand a light frost. Its water requirement is extremely low and it can stand long periods of drought by shedding most of its leaves to reduce transpiration loss. Jatropha curcas is also suitable for preventing soil erosion and shifting of sand dunes. There are number of varieties of Jatropha. Best among these is Jatropha curcas. Some of the others are

- Jatropha curcas (nontoxic)
- Jatropha integrerrima
- Jatropha gossypifolia
- Jatropha glandulifera
- Jatropha tanjorensis
- Jatropha multifida

Jatropha oil is lauded as being sustainable, and that its production would not compete with food production, as it can also survive and sustain in unfertile land, it can grow even on gravelly and sandy soils. It can thrive on the poorest stony soil. Jatropha can be intercropped with many cash crops such as coffee, sugar, fruits and vegetables, which offers both fertilizer and protection against livestock. Oil content of Jatropha seeds varies from 28% to 40%. The oil contains 21% saturated fatty acids and 79% unsaturated fatty acids. There are some chemical elements in the seed, Cursin, which are poisonous and render the oil not appropriate for human consumption. These factors render Jatropha oil as most appropriate form for producing biodiesel substituting petroleum diesel. It has desirable physicochemical and performance characteristics comparable to diesel. Each jatropha seedling should be given a 2m x 2m area to grow. 20% of seedlings planted will not survive. Jatropha seedlings yield seeds in the first year after plantation. After the first five years, the typical annual yield of a jatropha tree is 3.5kg of beans. The oil is extracted from seeds using an oil press (expeller type used) which can extract around 75% of oil from seeds. The residue can be used as biomass feedstock to power electricity plants or used as fertilizer (it contains nitrogen, phosphorus and potassium). India is keen on reducing its dependence on coal and petroleum to meet its increasing energy demand and encouraging Jatropha cultivation is a crucial component of its energy policy.

Fig-1: Jatropha curcas plant

Fig-2: Jatropha curcas seed

3. TRANSESTERIFICATION REACTION

It is most commonly used and important method to reduce the viscosity of vegetable oils. In this process triglyceride reacts with three molecules of alcohol in the presence of a catalyst producing a mixture of fatty acids, alkyl ester and glycerol. The process of removal of all the glycerol and the fatty acids from the vegetable oil in the presence of a catalyst is called esterification.

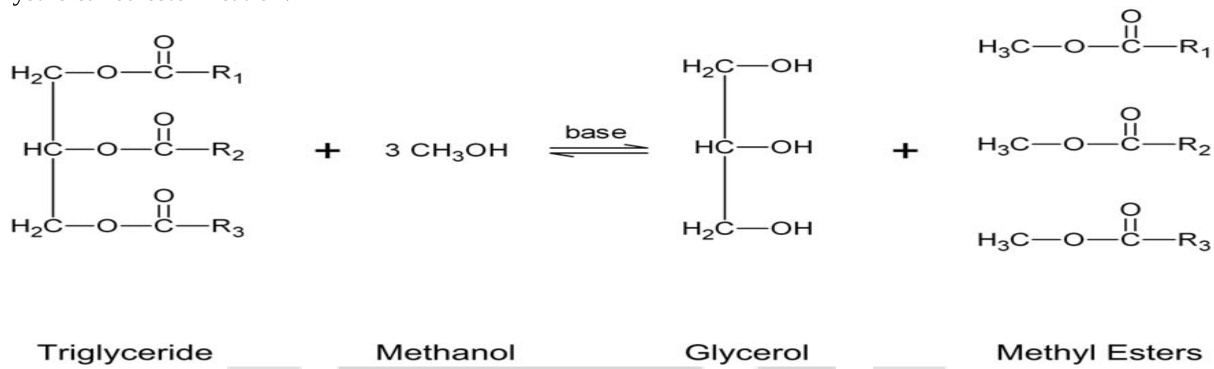

Fig-3: Transesterification reaction

4. LITERATURE REVIEW

1. R. K. Yadav, S. L. Sinha [1]

Conducted experiments on, performance of diesel engine using blends of conventional diesel and Jatropha biodiesel as alternative fuel for clean environment.In this work, biodiesel produced from Jatropha oil has been used. The fuel samples containing 0%, 10%, 20%, 30%, 40%, 50%, 75% & 100% blends of Jatropha biodiesel and conventional diesel have been tested on single cylinder, four stroke, water cooled, direct injection diesel engine of kirloskar Make (Rated power 10 hp at 1500 rpm). Engine performance and exhaust emissions characteristics have been measured and analyzed.

Results showed that, as the load increases, BTE increases for all the fuel samples tested including diesel up to80% of rated engine load for all the fuel samples. The maximum value of efficiency has been found for JB20 fuel sample as 28.14% which was 4.26% higher than diesel for 80% of rated engine load. The BTE of JB100 sample was observed to be lower than conventional diesel for the entire brake load.The fuel samples JB10 - JB20perform better than diesel. BSFC decreases with increase in the engine load for all the blends of fuel tested on the engine till 80% of the rated load, beyond that it further increases. Using lower percentage of biodiesel in diesel blends (up to JB20) the BSFC of the engine was lower than that of diesel for all loads. In case of JB30 - JB100 blends, the BSFC was found to be higher than that of diesel. It was observed that EGT of Jatropha biodiesel was found to be lower than the conventional diesel for all the brake loads. The EGT of diesel at rated load was 515°C where as for jatropha biodiesel, it was 478°C. It was also observed that EGT increases with the increases in engine load for the fuel samples tested. EGT of JB10 has been found equal to diesel. The maximum EGT has been found as 515°C for diesel and JB10 at full load. As the biodiesel content increases in fuel sample, EGT reduces. CO reduces in engine exhaust as load increases up to 70% of rated load beyond that it further increases. As the Jatropha biodiesel content increases in fuel sample, it reduces up to JB20, after that it further increases. For all the samples of fuel tested on engine, un-burnt hydrocarbon reduces with increase of load up to 70% of engine load after that it further increases. As biodiesel content increases in fuel sample, it reduces upto JB50, after that it further increases. As load increases, NO_X increases till 80% of rated load, beyond that it further reduces for most of the samples of fuel tested. The maximum concentration of NO_X has been found to be 470ppm for JB30 blend at 80% of rated load.The smoke percentage increases as load increases for all the blends tested. The smoke percentage in exhaust has been found to be 58% at full load for JB10 fuel which was 9.375% lower than diesel sample.

2. M. Venkatraman, G. Devaradjane [2]

Conducted experiments on, performance and exhaust emissions of a low heat rejection diesel engine using Jatropha oil as fuel. In this work, experimental investigation on low heat rejection engine withraw

Jatropha oil, methyl ester of Jatropha oil, methyl ester of Jatropha oil - Kerosene blend in the proportion of 70:30and diesel was carried out.

Results showed that, the BTE was lower with raw Jatropha oil as compared to diesel. The maximum BTE with raw Jatropha oil was about 22.54% whereas it was 24.43% with diesel at 75% load condition. The BTEwas higher with methyl ester of Jatropha oil and 30% Kerosene blend compared to raw Jatropha oil. The values were 23.89% and 23.40% respectively. Exhaust gas temperature was high with raw Jatropha oil than diesel. The maximum temperature of exhaust gas at peak brake power output was 352°C with raw Jatropha oil and 331°C with methyl ester of Jatropha oil. The maximum exhaust temperature of methyl ester of Jatropha oil - Kerosene blend was 320°C.The exhaust gas temperature of raw Jatropha oil, methyl ester of Jatropha oil and methyl ester of Jatropha oil - Kerosene blend was higher than that of diesel. HC emission of raw Jatropha oil, methyl ester of Jatropha oil and methyl ester of Jatropha oil - Kerosene was lower than that of diesel. At full load condition HC emission was 92 ppm for raw Jatropha oil, 83 ppm for methyl ester of Jatropha oil, 128 ppm for methyl ester of Jatropha oil- Kerosene blend and 132 ppm for diesel. CO emission levels were lower with raw Jatropha oil, methyl ester of Jatropha oil and methyl ester of Jatropha oil- Kerosene blend when compared to diesel. The CO of the raw Jatropha oil was 0.34% at full load, 0.32% for methyl ester of Jatropha oil-Kerosene blend, 0.35% for methyl ester of Jatropha oil and 0.37% for diesel. The NO_X concentration was 639 ppm for methyl ester of Jatropha oil, 632 ppm for raw Jatropha oil, 358 ppm for methyl ester of Jatropha oil-Kerosene blend and 649 ppm for diesel. Smoke level at the maximum power output was 4.25 BSU with raw Jatropha oil. The smoke level with diesel was 2.25 BSU at maximum power.The peak pressure with the methyl ester of Jatropha oil was higher.

3. Venkata Ramesh Mamilla, M.V.Mallikarjun, Dr. G.LakshmiNarayanaRao [3]

Conducted experiments on, effect of combustion chamber design on a DI diesel engine fuelled with Jatropha methyl esters blends with diesel. In this work, a single cylinder constant speed air-cooled four-stroke direct injection diesel engine of 4.4 kW was selected for the experimental investigations to evaluate the performance and emission characteristics fuelled with Jatropha oil (JTME) and its blends (20%, 40%, 60%, 80% and 100%). Further investigations on the effect of 20% Jatropha methyl esters (JTME) with diesel on performance, combustion and emission characteristics of diesel engine with different combustion chamber geometries (Spherical, toroidal and Re-entrant) was carried out.

Results showed that, BTE was slightly lower for methyl esters and their blends compared to diesel at all loads.At rated power (4.4kW) the BTE of diesel, 20%JTME, 40%JTME, 60%JTME, 80%JTME and JTME were 33.36%, 32.8%, 31.6%, 31.22%, 30.87% and 29.37% respectively.As percentage of methyl ester in the fuel increases the percentage of CO was continuously reduced.There was an increase in HC emissions for all the test fuels as the load increases.Increasing the percentage of the methyl ester in the fuel drastically reduces HC emissions. The NO_X emissions increase with increase in power for all the test fuels.At any brake power increase in the emission of nitrogen oxides (NO_X) with increase in percentage of methyl ester in the fuel was observed.The NO_X emissions increase with increase in percentage of methyl esters in the blend.Smoke density decreases with increase in methyl ester in the fuel blend. BTE of 20% JTME was lower compared to that of diesel with standard engine SCC. BTE of TCC was higher when compared to SCC and RCC at all loads. At full load, CO emissions of the 20% JTME decreased significantly when compared with those of standard diesel engine (SCC). CO emissions slightly increase with TCC than SCC and RCC for 20% JTME. At full load, HC emissions of the 20% JTME decreased significantly when compared with those of standard diesel engine (SCC). HC emissions slightly increases with TCC than SCC and RCC for 20% JTME. NO_X emissions were lower for TCC when compared to SCC and RCC for 20% JTME, but it was higher when compared with standard diesel (SCC). At all loads, smoke emissions for the 20% JTME decreased significantly than those of standard diesel engine (SCC). Smoke emissions were found lower for TCC than SCC and RCC.

4. Amit Agarwal, Dr. M. K. Singh [4]

Conducted experiments on process optimization for biodiesel production from Jatropha oil and its performance evaluation in a CI engine. In this work, a four stroke, single cylinder diesel engine was used to carry out performance andemission tests. Different blends such as 20%, 40%, 60%, 80%, 100% of Jatropha biodiesel with neat diesel were tested.

Results showed that, as the brake mean effective pressure increases, BSEC decreases for all fuel blends. At highest pressure JB80 shows the lowest BSEC. BTEwas higher for JB100 for all brake mean effective pressures. At full load, JB100 shows the highest CO emissions. HC emission was higher in unblended diesel and NO_X was higher in pure Jatropha biodiesel.

5. Meyyappan Venkatesan [5]

Conducted experiments on effect of injection timing and injection pressure on a single cylinder diesel engine for better performance and emission characteristics for Jatropha biodiesel in single and dual fuel mode with CNG. In this work, test were carried out to examine the performance and emissions of a direct injection diesel engine blended with Jatropha biodiesel prepared with methanol to get Jatropha oil methyl ester (JOME). Experiments were conducted with JOME single and dual fuel mode with compressed natural gas (CNG) in a single cylinder 4-stroke diesel engine. Performance parameters such as brake thermal efficiency (BTE) and brake specific fuel consumption (BSFC), emissions such as CO, UBHC, smoke density and NO_Xwere determined at three injection pressures of 180, 200 and 220 bar and two injection timings 27°bTDC and 31° bTDC.

Results showed that, BSFC of diesel at standard injection pressure of 180 bar and injection timing of 27° bTDC was 0.61kg/kW-hr at low loads of operation. At higher loads of operation BSFC was 0.30kg/kW-hr. The values for CNG-Diesel for low load and higher loads were 0.83 and 0.32kg/kW-hr. For CNG-Diesel at all the three injection pressures at low loads it was 0.83kg/kW-hr with very little variations and itwas nearly equal to that of diesel at higher loads. BTE for diesel baseline at 180bar pressure 27° bTDC was 13.75% and 28% at low and high loads of operation respectively. A very high value of UBHC nearly 320ppm was obtained at all pressures at low loads for CNG-diesel operation when compared to very low value of 7ppm for diesel operation. It was nearly 65 ppm at higher loads of operation at all the three pressures due to better mixing and combustion. The values of CO emission were nearly 0.15% at low loads of operation at all the three pressures and 0.22% at higher loads. The values for diesel were 0.01% at low loads and 0.07% at higher loads of operation. The values of smoke density of 2 to 30ppm at low loads and 55 to 97 at higher load at three pressures when compared to 1to 71 for diesel from low load to high loads.At low loads NO_X emission approaches to that of diesel with 22ppm and at higher loads it was 140ppm at all loads of operation.

6. S.M.A. Ibrahim, K.A. Abed, M.S. Gad [6]

Conducted experiments on, diesel engine performance using Jatropha biodiesel. In this work, Jatropha biodiesel fuel blends were mixed by volumetric percentage of 20, 40, 70 and 100% with diesel fuel and burned in a diesel engine to study engine performance and emission. These tests were performed on a four stroke, single cylinder, water cooled diesel engine at different loads and rated speed of 1500 rpm.

Results showed that, for all cases specific fuel consumption fuel reduces with increase in load. The specific fuel consumption was higher for B100 compared to that of diesel fuel and all diesel-biodiesel blends. At different loads, the brake thermal efficiency was increased with increasing the load. The decrease in thermal efficiency for B100 compared with diesel fuel and all diesel-biodiesel blends. The exhaust gas temperature increases with increase in the load for all blends. The exhaust gas temperature was higher for B100 Jatropha biodiesel compared to diesel oil and all diesel-biodiesel blends. The volumetric efficiency increases with the increase in engine load. Volumetric efficiency was lower for B100 Jatropha biodiesel compared to diesel oil and all diesel- biodiesel blends. The volumetric efficiency decreases with the increase in biodiesel percentage in the blend. Increasing load results in a decrease in air-fuel ratio (A/F) for biodiesel blends, indicating that a richer mixture was required at higher loads. At low loads the air-fuel ratio was higher for biodiesel blends as compared with diesel fuel. But as load increases the A/F ratio was lower for biodiesel blends as compared with diesel. CO_2 emissions of diesel-biodiesel blends fuels have the tendency to increase with increase in engine load. Biodiesel blends emit the lowest level of CO_2 emissions. Higher percentage of biodiesel in the blend emits low amount of CO_2 emissions. The decrease in carbon monoxide emission for biodiesel and its blendswas observed. NO_X emissions increased with increasing engine load. The increase in NO_Xemission for the biodiesel was observed. HC emissions for biodiesel blends were lower than that of diesel fuel. HC emissions decreases with increasing biodiesel percentage in the blend and reaches minimum value when pure biodiesel was used as a fuel. There was decrease in O_2 content in the exhaust with increase in load was observed. The oxygen emissions increase with increase in biodiesel percentage in diesel-biodiesel blends. The percentage of oxygen in the exhaust was maximum for pure biodiesel and it decreases for other blends in the order B70, B40, B20 and diesel oil.

7. P. Suresh Kumar, Ramesh Kumar Donga, P. K. Sahoo [7]

Conducted experiments on, comparative study between performance and emissions of Jatropha biodiesel and diesel under varying injection pressures. In this work, an IDI diesel engine was tested by diesel, 100% biodiesel (B100), with respect to varying fuel injection pressures of 160, 170 and 180 kgf/cm^2. The engine characteristics with Jatropha biodiesel were compared against those obtained using diesel fuel.

Results showed that, at 100% load the brake thermal efficiency ofJSVO improves as the fuel injection pressure was increased while keeping advance angle of fuelinjection is 19°, 21°, 23° and 25° and JSVO brake thermal efficiency starts decreasing when advance angle was increased beyond 25° bTDC. For diesel brake thermal efficiency decreases at sameconditions. The CO emission continuously increasing for diesel as the angle of fuel injection was increased from 19° bTDC to 25° bTDC in step of 2° for all load conditions. In case of JSVO, CO decreasing with increase in advance angle of fuel injection up to the angle of 23° bTDC at all load conditions but the CO emissions starts increasing as the angle further increased to 25° bTDC andCO emission continuously increasing for diesel as the fuel injection pressure was increased from160,170 and180 kgf/cm^2 in step of 10 kgf/cm^2 for all load conditions. The CO_2 emission of JSVO increases gradually as the advance angle of fuel injection was increased up to 23° bTDC but the CO_2 emission start decreasing beyond 23° bTDC of fuel injectionwhich shows the fuel combustion efficiency starts deteriorating and CO_2 emission continuouslydecreasing for diesel as the fuel injection pressure is increased from 160,170 and180 kgf/cm^2 in stepof 10 kgf/cm^2 for all load conditions. The NO_X emission was continuously increasing for diesel as the angle of fuel injection was increased from 19° bTDC to25° bTDC in step of 2° for all load conditions. The NO_Xemission was decreasing for Jatropha biodiesel with increasing advance angle of fuel injection up to the angle of 23° bTDC at all theload conditions but the NO_X emission starts increasing angle was further increased 24° bTDC. The NO_X emission of diesel fuel at all the angles of fuel injection was lower than the NO_X emission of JSVO. The NO_X emission at recommended operating point for JSVO(23° bTDC, 180 kgf/cm^2) was least. The HC emission of JSVO decreases as the fuel injection pressure increases.The smoke emission was decreasing in the case of JSVO with increase in advance angle of fuel injection up to the angle of 23° bTDC at all load conditions but the smoke emission starts increasing as the angle further increased to 25° bTDC.The smoke emission of diesel fuel at all the angles of fuel injection was lower than the smoke emission of JSVO. On comparison this was also observed that the smoke emission of diesel at 100% load conditions were less than the smoke emission of JSVO.

8. T. Venkateswara Rao, G. Prabhakar Rao, K. Hema Chandra Reddy [8]

Conducted experiments on, Pongamia, Jatropha and Neem methyl esters as biodiesel on CI engine. In this work, experimental investigations have been carried out to examine properties, performance and emissions of different blends (B10, B20, and B40) of PME, JME and NME in comparison to diesel.

Results showed that, the Kinematic Viscosity (at room temperature of 35°C) of different blends of methyl esters B10, B20,B40 and B100 were higher than the viscosity of diesel. But up to B20 the viscosity of biodiesel was very close to the viscosity of diesel. A slight drop in brake thermal efficiency was found with methyl esters (biodiesel) when compared with diesel. It was observed that the brake thermal efficiency of B10 and B20 were very close to brake thermal efficiency of diesel. B20 methyl ester had equal efficiency with diesel. Pongamia methyl ester (PME) had better brake thermal efficiency than compared with the methyl esters of Jatropha and Neem. Biodiesel gives less smoke density compared to petroleum diesel. When percentage of blend of biodiesel increases, smoke density decreases. Smoke density increases for B80 and B100 due to insufficient combustion. Smoke density also decreases when load increases. Biodiesel gives less Carbon monoxide than compared to petroleum diesel. When percentage of blend of biodiesel increases, Carbon monoxide decreases. But Carbon monoxide increases for B60, B80 and B100 due to insufficient combustion. Biodiesel gives fewer Hydrocarbons than compared to petroleum diesel. When percentage of blend of biodiesel increases Hydrocarbons decreases. But Hydrocarbons increase for B60, B80 and B100 due to insufficient combustion.

9. Shyam Pandey, Amit Sharma, P. K. Sahoo [9]

Conducted experiments on, performance and emission characteristics of a diesel engine fuelled with Ethanol, Diesel and Jatropha based biodiesel blends. In this work, the blends used were B0D95E5, B0D90E10, B15D70E15 and B20D60E20.

Results showed that, the engine efficiency decreases between 0.10% and 13.5%, highest reduction in efficiency was found in B0D90E10 fuel. The brake specific fuel consumption was greater at smaller loads, but it decreases at medium and higher loads. The BSFC increases with increasing oxygenate content. The sequence was D100, B0D95E5, B0D90E10, B15D70E15 and B20D60E20. The increase was higher at small loads (5.7%, 7.6%, 8.8% and 9.5%) respectively, the highest variation was found for B20D60E20 (22.2%) at medium load. At high load the values were comparable with that of diesel.NO_X level increase with increase in engine loads for both diesel and various blends. The NO_X emissions for diesel fuel were 50% higher than that of B0D90E10 fuel blends lower load range. During medium load range, the NO_X emission of diesel was 84% more than the B0D90E10 fuel blend. For high load range, the NO_X emission of diesel was 34% more than the B0D95E5 fuel blend. The lowest CO emission was from the B0D90E10 fuel which was compared with the diesel fuel represents a reduction of 40%. HC emissions showed negative trends with load, all the blends and pure diesel HC emission decreases with increase in loads. It can be noticed that the HC emission for B0D90E10 was showed a drop in the range of 32% to 40%. For B0D95E5 it drops by 20% to 25% as compared to base fuel diesel. During medium and high loads HC emissions increased in the range 45 - 47% and 27 - 32% for B15D70E15 and B20D60E20 respectively. The smoke opacity for the pure diesel fuel was 40% less than the smoke opacity of B15D70E15 fuel blend, for small loads. At medium loads, the smoke opacity of the B0D95E5 fuel blend was 52.5% less than that of pure diesel fuel. At higher load range, the smoke opacity of B0D95E5 fuel blend was 72% less than that of pure diesel. The exhaust gas temperature of diesel was 14% morethan that of the B0D90E10 blends at higher loads.

10. AdithyaMurali, Bijoy Xavier, Jaseel K.P., Taju Antony A.T., ThabsheerMoideen, Viswajith D., Ranjith K [10]

Conducted experiments on, performance characteristics of diesel engine operated on Jatropha biodiesel with LPG jet induction. In this work, investigation explores with a series of experiments towards effective combustion of air, LPG and Jatropha mixture wherein the LPG jet was inducted through air inlet to form a homogeneous mixture, and novel methods for improving efficiency such as fuel magnetization and preheating were employed. Changes in the performance of the engine and emission levels compared with conventional diesel fuel were noted.

Results showed that, the fuel consumption was least when a 12 cc/s jet of LPG was induced into the inlet manifold of the engine. The next lower value of fuel consumption was in the case of the 8cc/s LPG jet injection. The fuel consumption was highest for the case of 100% Jatropha biodiesel without fuel magnetization at low brake power values, and for 100% Jatropha biodiesel with fuel magnetization at high Brake power values. Mechanical efficiency was highest for the case of 100% Jatropha biodiesel with fuel magnetization closely followed by the case of the 12 cc/s LPG jet injection, and lowest for the case of 100% Jatropha biodiesel without fuel magnetization. The brake thermal efficiency was highest for the case of the 12cc/s LPG injection, followed by the case of the 8 cc/s LPG jet injection. Brake thermal efficiency was least for the case of diesel. Indicated thermal efficiency was highest for the case of 100% Jatropha biodiesel without fuel magnetization, followed by the case of the 8 cc/s LPG jet injection, and was lowest for the case of diesel.

11. M. Mofijur, H. H. Masjuki, M. A. Kalam, A. E. Atabani [11]

Conducted experiments on, evaluation of biodiesel blending, engine performance and emissions characteristics of Jatropha curcas methyl ester: Malaysian perspective. In this work, Physico-chemical properties of Jatropha biodiesel and its blends with diesel followed by engine performance and emissions characteristics of B10, B20 and B0 were studied.

Results showed that, torque increases steadily with speed up to a maximum value, and then falls with further increases in speed. The engine torque of B0 fuel was always higher than that of the B10 and B20 fuels. The maximum torque was recorded at 1800 rpm, and it was 21.1 Nm, 20.45 Nm, and 20.12 Nm for B0, B10 and B20 respectively. The average torque reduction for B10 and B20 as compared to B0 was 3.08% and 4.6%, respectively. Brake power increased steadily with engine speed. The maximum brake power of the engine was recorded at 2400 rpm, and it was 4.06 kW, 3.87 kW, and 3.70 kW for B0, B10 and B20 respectively. The average brake power reduction for B10 and B20 in compared to B0 fuel was 4.67% and 8.86%, respectively. The BSFC for biodiesel-blended fuels was higher compared to diesel. The average BSFC for B0, B10, and B20 was 273.5 g/kWh, 278.46 g/kWh, and 281.9 g/kWh, respectively. The average NO_X emission for all fuel samples B20, B10 and B0 were 422 ppm, 411 ppm and 398 ppm respectively. B10 and B20 give 3% and 6% higher NO_X emission than that of diesel fuel. Unburned HC for B10 and B20 were lower than that of diesel fuel. The average reductions in HC emission for B10 and B20 compared to B0 were 3.84% and 10.25% respectively. HC emissions were reduced as the percentage of biodiesel in the blends increases. The average reduction in CO emission for fuels B10 and B20 compared to B0 were 16% and 25% respectively. CO emission was decreased with increasing biodiesel percentages in the blends.

12. Y.V.Hanumantha Rao, Ram Sudheer Voleti, A.V.Sitarama Raju, P. Nageswara Reddy [12]

Conducted experiments on, Jatropha biodiesel and additive in diesel engine. In this work, the performance of single cylinder water-cooled diesel engine using Multi-DM-32 diesel additive and methyl ester of Jatropha oil as the fuel was evaluated for its performance and exhaust emissions.

Results showed that, specific fuel consumption was lower than the diesel for various proportions of Jatropha oil with diesel at constant operated conditions. The percent increase in specific fuel consumption was increased with decreased amount of diesel fuel in the blended fuels. The brake thermal efficiency with biodiesel and its blends was found to be slightly higher than that of diesel fuel at tested load conditions. The brake thermal efficiencies of engine, operating with biodiesel mode were 22.2, 30.6 and 37.5 percent at 2, 2.5 and 3.5 kW load conditions respectively. The exhaust gas temperature of blended fuels and biodiesel at 3.5 kW load condition was 19% higher than that of 2 to 2.5 kW load conditions. The exhaust gas temperature increased with increase in load and amount of blended biodiesel in the fuel. The CO_2 increased with increase in load conditions for diesel and for biodiesel blended fuels. The CO reduction by biodiesel was 17.5, 17, 16, 14 and 14 percent at 1, 1.5, 2, 2.5 and 3.5 kW load conditions. With diesel fuel mode the lowest CO was recorded as 610 mg/kg at 1.5 kW load and as load increased to 3.5 kW, CO also increased to 898 mg/kg. The amount of CO emission was lower in case of biodiesel blended fuels and biodiesel than diesel. A slight increase in NO_X was observed for blends of Esterified Jatropha diesel compare to diesel. Smoke increases with increase in brake power. Smoke emission was lesser for blends of Esterified Jatropha diesel compared to diesel. When percentage of blend of biodiesel increases, smoke density decreases, but smoke density increases for B50 and B75 due to insufficient combustion. With the addition of additive there was better atomization of fuel takes place, leads to improved combustion hence fuel consumption was decreased with increase in power. It was observed that smoke density reduced in case of Esterified Jatropha with additive when compared to diesel. The reduction smoke density decreased up to 2kW, thereby smoke density gradually increased at higher loads.

13. M. NematullahNasim, Ravindra BabuYarasu, R. H. Sarda [13]

Conducted experiments on, compression ignition engine powered by preheated neat Jatropha oil. In this work, experiments were conducted for the fuel inlet temperatures of 30°C (J-00), 50°C (J-50), 70°C (J-70), 90°C (J-90) and 110°C (J-110).

Results showed that, for all fuel inlet temperatures, the specific fuel consumption varies with increasing load. At all loading conditions, that fuel consumption shows an increasing trend with preheating up to 70°C of fuel inlet temperature after that it decreased up to 90°C of fuel inlet temperature. Highest values of fuel consumption were observed at 110°C preheated condition of fuel. The brakes thermal efficiency was slightly lower than that of the corresponding diesel fuelat higher fuel inlet temperature and at higher load on the engine. Efficiency was found higher than mineral diesel for methyl ester of Jatropha oil at all loading conditions of the engine. Efficiency obtained with neat Jatropha oil showing decreasing trend as the fuel inlet temperature increased except for 90°C of fuel inlet condition. The exhaust gas temperature for the fuels tested increases with increase in the load. At all loads, diesel was found to have the higher temperature and the temperatures for the neat Jatropha oil and its methyl ester showed a downward trend. The variation in exhaust temperature was more at higher load with respect to the lower loading condition of the engine. It shows a decreasing trend up to 90°C preheated condition after that increasing trend up to 110°C, this variation was more after 40% of engine loading condition was up to full load.

14. N. ManikandaPrabu, Dr. S. Nallusamy, K. ThirumalaiRasu [14]

Conducted experiments on, Jatropha Curcas biodiesel for optimum blend characteristics. In this work, the various results with different blends of diesel and Jatropha oil (considering 0%, 10%, and 20%) on single cylinder direct injection engine were experimentally found.

Results showed that, the optimized blend was found to be B20 oil in terms of specific fuel consumption.The brake thermal efficiency with biodiesel and its blends was found to be slightly higher than that of diesel fuel at tested load conditions. Efficiency of the B20 blend was increased than diesel. At higher power output conditions, due to higher peak and exhaust temperatures the NO_X values were relatively higher compared to low power output conditions. A slight increase in NO_X was observed for blends of Esterified Jatropha Diesel compare to diesel. The CO_2 increased with increase in load conditions for diesel and for biodiesel blended fuels. The CO_2 increased with increase in load conditions for diesel and for biodiesel blended fuels. The Jatropha biodiesel followed the same trend of CO_2 emission, which was higher than in case of diesel. The CO reduction by biodiesel was 17.5, 17, 16, 14 and 14% at 1, 1.5, 2, 2.5 and 3.5 kW load conditions.

15. Rahul D. Gorle, Diwesh B. Meshram, Pratik L. Naik, Vivek S. Narnaware[15]

Conducted experiments on, optimization of effective parmeter of Jatropha biodiesel using Taguchi method and performance analysis using CI engine. In this work, the performance and emission characteristics of various blends of Jatropha biodiesel with diesel on a single cylinder four stroke diesel engine was studied.

Results showed that, the BSFC for B10 was nearer to that of diesel fuel. All the blends show slightly better thermal efficiency at higher load conditions. Exhaust gas temperature was found to increase in both concentration of biodiesel in blends and engine load. The exhaust gas temperature rises from 120°C at no load to 200°C for various blends.The exhaust gas temperature with blends having high percentage of Jatropha oil was high as compared to diesel at higher loads. CO emission was found to decrease with the increase in proportion of biodiesel in the blends. CO emissions were increased with increase in engine load. The CO emission of biodiesel was lower compared to diesel. The values of HC emission decrease with increase in proportion of biodiesel in the fuel blends. The emissions of unburnt hydrocarbon for biodiesel exhaust were lower than that of diesel fuel. The smoke opacity increases with increase in Jatropha methyl ester blends in diesel fuel at higher load conditions.

16. M. Loganathan, A. Anbarasu, A. Velmurugan [16]

Conducted experiments on, emission characteristics of Jatropha - Dimethyl Ether fuel blends on a DI diesel engine. In this work, the different blends such as BDE 5 (biodiesel 95% and dimethyl ether 5%), BDE 10 (biodiesel 90% and dimethyl ether 10%) and BDE 15(biodiesel 85% and dimethyl ether 15%) were tested in the engine.

Results showed that, brake thermal efficiency has the tendency to increase with increase in applied load. The thermal efficiency of all blends of biodiesel-dimethyl ether (BDE) was higher than that of neat Jatropha oil (B100). The BTE of BDE5, BDE10 and BDE15 blends gives the higher efficiency compared to neat biodiesel. BTE of BDE5, BDE10, and BDE 15 was 6%, 10%, and 3% higher than that of neat Jatropha at full load (3.7 kW). For all fuels tested, BSFC was found to decrease with increase in the load. The BSFC of Jatropha-Dimethyl ether blends were higher than that of neat biodiesel for all loads. The BDE blends gives more fuel consumption compared to neat Jatropha oil (B100). BSFC for BDE5, BDE10 and BDE15 were 8%, 12% and 17% higher than that of neat Jatropha. Compared with neat Jatropha oil, the BDE blends gives lower HC emissions. The HC emissions for Jatropha oil were 34 ppm, while for BDE5, BDE10 and BDE15 were 19 ppm, 25ppm and 27 ppm respectively, at full load. The percentage of reduction in HC was 42%, 36% and 26% for BDE5, BDE10 and BDE15 respectively. For higher blends namely BDE10 and BDE15 the percentage of HC reduction was low. The CO emission of BDE5, BDE10 and BDE15 fuel was lower than that of neat Jatropha oil at all loads. With increasing Jatropha-Dimethyl ether percentage, CO emission level increases. The reductions of CO for BDE5, BDE10 and BDE15 was 67%, 51% and 35% respectively at full load, compared to neat Jatropha oil. The exhaust gas temperatures were increased for all the fuels with the increase of applied load. The minimum exhaust gas temperature was obtained for neat Jatropha oil. The NO_X emissions increase with increase in the engine load. Compared with the neat Jatropha oil, the NO_X emissions for BDE15 decreased by 15% at full load.With increase of dimethyl ether quantity with biodiesel, the NO_Xemission also increase. The percentage of reduction of NO_X for BDE5, BDE10 and BDE15 was 17%, 28%, and 35% at full load compare to neat Jatropha oil.

17. Dr. HiregoudarYerrennagoudaru, Manjunatha K, Chandragowda M [17]

Conducted experiments on, twin cylinder diesel engine using Jatropha and Hippie oil blend with Ethanol. In this work, biofuel (20% Jatropha + 70% Hippie oil + 10% Ethanol) as a CI engine fuel. A four stroke Twin cylinder CI engine was adopted to study the brake thermal efficiency, brake specific energy consumption, and emissions at zero load & full load with the fuel of biofuel.

Results showed that, as load increases brake thermal efficiency was also increases for diesel as well as biofuel. Particulate Matter tends to increase with load. Particulate Matter was comparatively lower with biofuel. Particulate Matter emission increases with increase in load in diesel as fuel but in biofuel. Diesel has higher Particulate Matter level when compared to biofuel. The CO level increases when diesel has a fuel. CO level was comparatively lower when compared to diesel.

18. Benjamin TernengeAbur, AbubakarAdamuWara, Gideon AyubaDuvuna, Emmanuel EnenomaOguche [18]

Conducted experiments on, parametric study of Jatropha blended gasoline fuel in compression ignition engine of a small capacity diesel engine. In this work, the blends were 40/60%, 30/70%, 20/80% and 100% Jatropha biodiesel with diesel were prepared.

Results showed that, the reference fuel shows a decreasing trend of brake thermal efficiency with increase in engine speed. Generally, there was consistent decrease in the brake thermal efficiency with the addition of Jatropha oil in biodiesel Jatropha blends. The maximum brake thermal efficiency has been observed with B100 with a value of 12.23%. The engine exhibit more fuel consumption pattern as the engine speed increases with higher blends having more rate of fuel consumption. For the biodiesel Jatropha, B100 exhibited the lowest specific fuel consumption at all speeds and load conditions. Higher powers were obtained at lower engine speeds for diesel and Jatropha biodiesel blends. There was decrease in the brake power as engine speed increases for increased percentage substitution of Jatropha oil. The optimum brake power for the Jatropha biodiesel blends were for B60 while B100 exhibited the minimum brake power. The biodiesel Jatropha blends exhibited good characteristics in exhaust gas temperature as it reduces for increased in the engine speed. Exhaust gas temperature were lower for biodiesel Jatropha blends in comparison to diesel with B80 having the optimum result. For higher biodiesel Jatropha blends, there were significant reductions in the percentage heat losses with B80 having the minimum. It was noted that the biodiesel Jatropha fuel blends lost less useful heat energy when compared to diesel reference fuel. The air/fuel ratio values increases at higher engine speeds for diesel reference fuel and other biodiesel Jatropha blends with diesel having higher values. The maximum air/fuel ratio value observed for biodiesel Jatropha blends was for B100. There were increased in engine noise for higher biodiesel Jatropha blends. The diesel reference demonstrated better volumetric efficiency at all speeds with B100 having the best among the biodiesel Jatropha blends.

19. S. Jindal [19]

Conducted experiments on, effect of injection timing on combustion and performance of a direct injection diesel engine running on Jatropha methyl ester. In this work, effect of injection timing on the combustion, performance andemissions of a small power diesel engine, commonly used for agriculture purpose, running on purebiodiesel, prepared from Jatropha (Jatropha curcas) vegetable oil was carried out.

Results showed that, retarding the injection timing by 3° increases the thermal efficiency. Advancement of injection is not desirable as it leads to drop in thermal efficiency of the engine. With JME as fuel, the thermal efficiency at full load increases from 22.96% to 24.90% on retarding by 3° and to 23.38% on retarding by 6°. On advancing the injection by 3°, the thermal efficiency drops to 22.58%. About 8% improvement in thermal efficiency was obtained by retarding the injection timing by 3°. With the advancement of the injection timing, the specific fuel consumption increases whereas retarding leads to improvement. With JME as fuel, the BSFC value increases to 0.40 from 0.39 kg/kW-hr on advancing the injection by 3° and it decreases to 0.36 and 0.37 kg/kW-hr on retarding the injection by 3° and 6° respectively. On advancing the injection, the mean effective pressure in the cycle drops. This results in lower indicated power. The indicated power of the engine increases slightly on retarding the injection by 3° whereas it decreases on further retarding to 6° or advancing by 3°. When the injection was retarded by 3°, better mean pressure was obtained and engine runs smoother. The indicated power and mean effective pressure with JME increases to 5.25 kW and 6.60 bar from 4.96 kW and 6.09 bar respectively on retarding the injection by 3°. The indicated power changes to 5.04 kW and 4.80 kW and mean effective pressure changes to 6.30 bar and 5.84 bar at 6° retard and 3° advance respectively. On advancing the injection, the pressure in the cylinder reaches to higher value as compared to the retarded injection scheme. On retarding the injection, the rate of pressure rise decreases slightly with a shift away from TDC and the ignition delay also increases. With advancement of injection by 3 degreesthe peak rate of heat release was at 357 degree crank angle and on retarding by 3 and 6 degrees, the peak heat release rate was found at 362 and 363 degrees against 361 degree with standard timing.

20. Sunil Kumar, AlokChaube, Shashi Kumar Jain [20]

Conducted experiments on, CI engine performance using diesel blended with Jatropha biodiesel. In this work, a stationary single-cylinder four-stroke CI engine was tested with diesel blended with Jatropha biodiesel in 0%, 5%, 20%, 50%, 80% and 100%.

Results showed that, SFC was showing an increasing trend for B80 and B100 for higher loadings. For B0 to B50 fuel consumption was decreasing with respect to increase in loading. Lowest BSFC was observed for

B0 (254.5 g/kW-hr) than B5 (268.4 g/kW-hr) and B20 (278.5 g/kW-hr) at 13.33% load. As a blended fuel B20 has marginally higher BSFC than B0. Highest BSFC was observed for B100 (597.5 g/kW-hr) at 13.33% load. B80 and B100 fuel were found to give lowest BSFC at 60% load. The BTE of the engine was observed to increase with increase in the load and was found maximum for B0 (32.05%) at 100% of load. For B5 (30.56%) and B20 (30.01%) BTE was lower as compared to that of B0 at 100% load. For higher blends B50 and above, full load BTE was lower as compared to that of B0. Lowest value of HC emissions at 17 - 21 ppm was observed for B50. Highest value of HC emissions was observed for B0 (65 ppm) at 100% load. HC emissions for B20 were in the range of 24-32 ppm. B20 depicts lower HC emissions even at higher loading. Slightly higher HC emissions were observed at higher loading for B80 and B100. The NO_X emission for all the fuels tested resulted in an increasing trend with respect to load. NO_X emissions were higher for B5, B20, B50, B80 and B100 as compared to B0. The exhaust gas temperature for all the fuels tested increases with increase in the load. Exhaust temperatures for B0 were in the range of 143°C to 441°C. At all loads, B100 was found to have the highest temperature of 561°C and the temperatures for the different blends showed a upward trend with increasing concentration of JME in the blends. Smoke opacity showed an increasing trend for diesel blended with biodiesel. B20 showed lower opacity compared to B50, B80 and B100 fuel. The engine emits more CO for diesel as compared to diesel blended with JME under all loading conditions. The CO concentration was marginally present for the blend of B50 for all loading conditions and as the JME concentration in the blend increases above, 50%, very marginal presence of CO was observed. At heavy loading B80 and B100 shows increase in CO emissions. The CO_2 emission increased with increase in load for all blends. B20 and B50 fuel emits less amount of CO_2 in comparison with diesel. B50 emits least amount of CO_2 emissions. Using higher content JME blends, an increase in CO_2 emission was noted. The O_2 was observed to decrease withincrease the load under all types of fuel. The oxygen gradually decreases with increasing diesel blendedwith Jatropha biodiesel. At full load condition oxygen was low in B100 as compared to that for B5, B20, B50 and B100. Volumetric efficiency observed for B0, B5, B20, B50, B80 and B100 fuel showed an almost similar trend.

21. Amol Bharat Varandal, Prof. Nitin Malviya [21]

Conducted experiments on, performance and emission characteristics of diesel engine with Jatropha biodiesel blends. In this work, performance and exhaust emissions biodiesel blends (B20 to B50) in a Variable Compression Ratio (VCR) diesel engine was carried out.

Results showed that, the lowest BSFC values obtained using diesel, B20 and B30, for full load were 0.25, 0.27 and 0.28 kg/kW-hr respectively. The BSFC was observed to decrease sharply with increase in load for all fuels. The highest value of BTE using diesel was 34.02% whereas it was 31.99% and 31.27% in case of B20 and B30 respectively. B50 gives BTE of 24.87% which lowest for all blends at same load conditions. The change of load from 25% to full load resulted in increase in BTE for biodiesel blends. As the load increases the exhaust gas temperature increases for the biodiesel blends. The diesel fuel shows less exhaust gas temperature as compared to all the biodiesel blends at all loads. The exhaust gas temperature for the diesel, J20, J30, J40 and J50 were 315°C, 320°C, 324°C, 331°C and 335°C respectively. As the biodiesel blend ratio increases the exhaust gas temperature also increases. The CO emissions for biodiesel blends were lower when compared to diesel. The CO emission decreases with the increase in load upto 75% load and at full load it sharply increases. With percentage of biodiesel increasing in blend fuel, CO emissions of blend reduced. The HC emission for biodiesel blends were lower that the diesel for all loads. B50 showed lower HC followed by the B40, B30 and B20 for all loads. The NO_X emission for biodiesel blends was more compared to diesel. With increase in blend ratio the NO_X emission increases. The biodiesel and its blends were found to emit a larger amount of NO_X, while diesel fuel produced the lowest amount of NO_X emission.

22. Karthick.D., Dwarakesh. R., Premnath [22]

Conducted experiments on, combustion and emission characteristics of Jatropha blend as a biodiesel for compression ignition engine with variation of compression ratio.In this work, the compression ratio was reduced from 17.5 to 16.8:1 by increasing the bowl size of the piston. The different blends such as J20, J17+DEE3%, J16+DEE4%, J15+DEE5% were used for experimentation on the engine.

Results showed that, for zero load condition, conventional piston produces a maximum smoke emission with J20 fuel and a minimum smoke emission was produced with J15+5DEE fuel. J15+5DEE fuel for conventional piston and J16+4DEE for modified piston produces minimum smoke emission compared to others. J16+4DEE fuel for both conventional and modified piston produces minimum NO_X emissions compared to other blends. By comparing conventional piston with the modified piston, the NO_X values were lesser for modified piston. J17+3DEE show combustion characteristics almost similar to diesel fuel when compared with other blends. Peak pressure was maximum for diesel fuel compared to biodiesel blends. The sudden pressure rise was observed between the crank angle of -5 to -3.5deg for all the blends and maximum pressure was attained between the crank angle of 5 to 8 deg. When brake power was 3.589, the conventional piston produces maximum brake thermal efficiency with J17+3DEE fuel and it produces minimum brake thermal efficiency with J16+4DEE fuel. For the same BMEP value, modified piston produces maximum BTE with J17+3DEE fuel and it produces minimum BTE with diesel fuel. The brake thermal efficiency of blends was increasing with increase in applied load. J17+3DEE with conventional piston and modified piston produce maximum efficiency compared to other fuel blends.

23. Saurabh Sharma, Rohit Singh, Mayank Mishra, Gaurav Kumar Mitra and Rakesh Kumar Gangwar [23]

Conducted experiments on, performance and emission analysis of diesel engine using biodiesel and preheated Jatropha oil. In this work, the comparison between B40 and B80 biodiesel and preheated biodiesel on the base line of mineral diesel.

Results showed that, for all fuel tested, the power increased with increased in the load. The engine power decreased with the utilization of biodiesel. There was no significant difference in engine power between biodiesel and diesel. For all tested fuels, with the increasing load from 0 to 80%, BSFC decrease with the load. BSFC for blends of the biodiesel was something higher than that of diesel. For the lower concentration of the biodiesel in the blend, thermal efficiency of the engine improved compared to the condition when engine runs on the biodiesel.Thermal efficiency was found to be lower for higher blends concentrations compared to that of mineral diesel. For the preheated Jatropha biodiesel thermal efficiency was higher than the blends of biodiesel. CO emissions for the diesel were higher than that of the blends of Jatropha biodiesel. At80% load CO emission rapidly. The emissions of CO increase with increasing load. CO emission for the B80 was slightly higher than that of the B40. The CO_2 increased with increase in load conditions for diesel and for biodiesel blended fuels.CO_2 emission for the diesel was higher than that of the any blends of the biodiesel. For all of blends, the HC emissions were less than that of the diesel fuel. O_2 emission was maximum for the preheated biodiesel. Emission of the O_2 decrease with the increase in the load and it was minimum at 80% load. The smoke emission found to increase continuously with the increase in load. Smoke emission for the diesel was maximum and minimum for the preheated Jatropha oil, blends of Jatropha biodiesel shows intermediate performance for the smoke emission, the lies between the diesel and preheated Jatropha oil in the smoke emission characteristics. At the zero load smoke emission was high but as the load increase it value decrease till 60% load, but at 80% load it value suddenly increase. Smoke emission for the diesel was minimum at the 60% load approximate 20% 18CR, and for the B40 and B80 blends also minimum at 60% load.

24. S. Mahalingam, P.Suresh Mohan Kumar, R.V. Pranesh [24]

Conducted experiments on, performance and emission characteristics of a bio dual fuelblends in diesel engine for variation of injection pressures. In this work, by varying the injection pressures, the performance and emission characteristics were investigated for a dual biofuel (Jatropha oil and Rubber seed oil) in a diesel engine.The experiments were conducted for each of the injection pressures 200, 220 and 240 bar with the different proposition such as 20% and 60% of biodiesel blends with pure diesel fuel.

Results showed that, the BSFC was decreased at no load to full load condition.For the injection pressure of 220 bar the BSFC of B60 blend gradually decreased at no load to full load. At 240 bar used in the test engine, the BSFC was reduced from 0.40 kg/kW-hr to 0.24 kg/kW-hr. From the result, at 240 bar and full rated power, the BSFC always increased at different load condition. The maximum thermal efficiency with dual fuel oil was about 31.5% whereas that of the diesel was 30.5% at maximum rated power output. For the injection pressure of 220 bar with blend B60, BTE increased up to 32% as compared to the diesel fuel.At 240 bar, for B20 the thermal efficiency reduced from no load to full load conditions. The CO emission of diesel engine decreases from zero loads to the full load. For the diesel fuel at 220 bar the emission increased up to 14%. Using dual fuel of Rubber seed and Jatropha oil, the CO amount was decreased.When load increases, the HC emission was reduced in pure diesel and biodiesel fuels. At 220 bar the HC increased at low load as 23% and 26% at higher load. For the designed pressure of 220 bar and with B20 and B60, the NO_X emission gradually increased comparatively low as 204 ppm at no load condition and 1120 ppm at full load condition.From the result at 240 bar, the blend B20 gives the better result compared to the other biodiesel fuel and pure diesel fuel.

5. CONCLUSION

Jatropha biodiesel satisfies the important fuel properties as per ASTM specification of biodiesel. Engine works smoothly on Jatropha methyl ester with performance compared to diesel operation. The Jatropha biodiesel can be successfully substituted as alternative fuel for CI engine.

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