Performance, emissions and combustion analysis of C.I engine using jatropha and mustard oil biodiesel using different injection pressure and injection timing

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ABSTRACT
The world at present is confronted with the twin crisis of fossil fuel depletion and environmental degradation. Increase in energy demand, stringent emission norms and depletion of oil resources have led the researchers to find alternative fuels for internal combustion engines. The improper mixing of vegetable oils with air leads to incomplete combustion. The best way to use vegetable oils as fuel in compression ignition (CI) engines is to convert it into biodiesel. Biodiesel is a methyl or ethyl ester of fatty acids made from vegetable oils and animal fat.. Engine performance values such brake thermal efficiency, brake power, torque, cabon dioxide, carbon monoxide, Nox, Smoke density and fuel consumption have been investigated both of variation engine speeds -fixed load and fixed engine speed variation loads by changing the fuel injection pressure from 180 ,200,220 and 240 bar, the investigation revealed that the optimum pressure for jatropha and mustard oil with di ethyl ether as 220 bars. The objective of this study is the analysis of the performance, combustion and emission characteristics of the jatropha and mustard oil methyl esters and comparing with petroleum diesel in 25% biodiesel with 180bar injection pressure and 21°BTDC, 50% biodiesel with 200bar injection pressure and 23° BTDC injection timing, 75% biodiesel with 220bar injection pressure and 25° BTDC of injection timing and 100% biodiesel with 240bar injection pressure and 27° BTDC of injection timing on both Jatropha and mustard oil. The tests were carried out on a 4.4 KW, single cylinder, direct injection, Air-cooled diesel engine. The results of investigations carried out in studying the fuel properties of Jatropha oil methyl ester(JOME) and Mustard oil methyl ester (MOME) its blend with diesel fuel from 0 to 80% load by percentage and in running a diesel engine with these fuel to reduction in exhaust emissions together with increase in brake power, brake thermal efficiency and reduction in specific fuel consumption make the blends of jatropha and mustard esterified oil (B75) a suitable alternative fuel for diesel and could help in controlling air pollution.

Keywords – Jatropha, Mustard oil methyl ester, Injection pressure, Biodiesel, Diethyl ether.

1. INTRODUCTION

India is rich in coal and is abundantly endowed with renewable energy in the form of solar, wind, hydro, and bio-energy. However, the country's hydrocarbon reserve is only billion tons, accounting for a mere of the world's reserve [4,8,13]. Many alternative fuels like biogas, methanol, ethanol and vegetable oils have been evaluated as a partial or complete substitute to diesel fuel. The vegetable oil directly can be used in diesel engine as a fuel, because their percentage of energy content is high and nearly equal to diesel [2, 7, 12]. The technology of production, the collection, extraction of vegetable oil from oil seed crop and oil seed bearing trees is well known and very simple [1]. The oil is extracted from the jatropha and mustard seeds and converted into methyl esters by the transesterification process. Fuels and their scare availability have lead to extensive research on Diesel fuelled engines [3, 5, 7]. A better design of the engine can significantly improve the combustion quality and in turn will lead to better break thermal efficiencies and hence savings in fuel[6]. India is rich in coal abundantly and endowed with renewable energy in the form of solar, wind, hydro and bio-energy has a very small hydro carbon reserves Vegetable oils, the main source of biodiesel, have considerably higher viscosity and density compared to diesel fuel. Despite transesterification process, which has a decreasing effect on the viscosity of vegetable oil, it is known that bio-diesel still has some higher viscosity and density when compared with diesel fuel [9, 15, 22, 24]. The viscosities of fuels have important effects on fuel droplet formation, atomization, vaporization and fuel-air mixing process, thus influencing the exhaust emissions and performance parameters of the engine. There have been some investigations on using preheated raw vegetable oils such as palm and jatropha oil in diesel engines [12, 14, 16,19]. However, it is known that vegetable oils have considerably higher viscosity compared with diesel fuel. It was declared that CO, HC and particulate matter emission were improved because preheating reduced the viscosity of raw vegetable oil to almost the level of diesel fuel and caused a better combustion is preheated to some temperature where the viscosity is equal to viscosity of diesel at room temperature[11,17,20]. Along with this preheating, compression ratio is also varied. The collective effect of preheating of fuel and different compression ratios for the engine is studied and analyzed [21]. On increasing of Compression Ratio, the intake air is compressed to higher pressure and all the air particles are much close to each other [22]. When the fuel is injected into that air, the rate of reaction in between air and fuel particles will improve.

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Increase in the temperature of fuel, will lead to better atomization and reduction in particulate size.

2. VEGETABLE OIL USED AS A BIODIESEL

Recent years, biodiesel have received significant attention both as a possible renewable alternative fuel and as an additive to the existing petroleum-based fuels. Biodiesel exhibits several merits when compared to that of the existing petroleum fuels. Many researchers have shown that particulate matter, unburned hydrocarbons, carbon monoxide, and sulphur levels are significantly less in the exhaust gas while using biodiesel as fuel. However, an increase in the levels of oxides of nitrogen is reported with biodiesel. Presently, considerable research has been undertaken to understand the performance characteristics of biodiesel-fueled engine as well as the biodiesel production Emulations also find attraction to use as a fuel in diesel engines due to the reduction in smoke and NOx emission using oil water emulsion as fuel. There have been some investigations on using preheated raw vegetable oils such as jatropha and mustard oil in diesel engines. However, it is known that vegetable oils have considerably higher viscosity compared with diesel fuel. The main objective of this experimental investigation is to determine the effects of the viscosity of jatropha and mustard, which is decreased by means of preheating process, on the performance parameters and exhaust emissions of a diesel engine. For this aim, jatropha and mustard was produced by transesterification method using jatropha and mustardoil and methyl alcohol, and its properties were determined [21,24]. Then, this biodiesel was preheated up to three different temperatures and tested in the diesel engine at all load conditions. Intensive research is going on throughout the globe for a suitable diesel substitute [16,19]. In this race among different alternatives, vegetable oils have attained primary place as some of their physical, chemical and combustion related properties are nearly similar to that of diesel fuel. In a developing country like India, major concentration has been focused on non-edible vegetable oils as the fuel alternative to diesel because edible vegetable oils have their use in our day-to-day life[8,15,17,23]. However, most of the biodiesel produce to higher oxides of nitrogen (NOx) when fueling with biodiesel for a cleaner air and cleaner environment. Aside from being renewable and biodegradable, biodiesel reduces most emissions while engine performance and fuel economy are nearly the same as the conventional fuel existing engine could be operated on the esters tested without any major modification. Higher density, viscosity and molecular weight make it difficult to atomize the biodiesel at low temperature at the engine low loads causing more CO emissions. The main reason for the lower CO emissions at high loads from the combustion of the biodiesel is the inbuilt oxygen content which makes the combustion of biodiesel more complete when the engine works at high loads. At the engine high loads, HC emissions from the combustion of the biodiesels are all less than that of diesel possibly due to the higher viscosity and higher molecular weight of the chinese pistache biodiesel leading to difficulties to evaporate at low temperatures at engine low loads

3. CHARACTERISATION OF VEGETABLE OILS

The annual Jatropha seed production potential in India is about some hectare. The estimated availability of Mustrad seed is about per annum. Jatropha seed kernels contain brown colored oil. At present, jatropha seed oil does not find any major application and hence even the natural production of seeds itself remains underutilized. The significant properties of jatropha and mustard seed oil are found out during the present investigation. The comparisons of properties of jatropha and mustard seed oil with that of other oils are given in. The characteristics of the vegetable oils fall within a fairly narrow band and are quite close to those of the diesel oil. Jatropha and mustard seed oil have about less heating value than that of diesel oil due to the oxygen content in their molecules [18]. The purpose of the investigation is to analyze the effects on diesel engine performance when fueled with the blends of biodiesel and diesel in various proportions on volume basis. The experimental data generated are documented and presented here using appropriate graphs [8, 14]. These tests are aimed at optimizing the concentration of ester to be used in the biodiesel–diesel mixture for long-term engine operation. In each experiment, engine parameters related to thermal performance of the engine such as fuel consumption and applied load are measured. In addition to that, the engine emission parameters such as carbon monoxide (CO), carbon dioxide (CO_2), smoke density and exhaust gas temperature are also measured.

4. JATROPHA

The fact that Jatropha oil cannot be used for nutritional purposes without detoxification makes its use as energy or fuel source very attractive as biodiesel. In Madagascar, Cape Verde and Benin, Jatropha oil was used as mineral diesel substitute during the Second World War. Jatropha curcas (Linnaeus) is a multipurpose bush/small tree belonging to the family of Euphorbiaceae. It is a plant with many attributes, multiple uses and considerable potential. The plant can be used to prevent and/or control erosion, to reclaim land, grown as a live fence, especially to contain or exclude farm animals and be planted as a commercial crop [34]. It is a native of tropical America, but now thrives in many parts of the tropics and sub-tropics in Africa [27,29]. The availability and sustainability of sufficient supplies of less expensive feedstock will be a crucial determinant delivering a competitive biodiesel to the commercials filling stations. Fortunately, inedible vegetable oils, mostly produced by seed-bearing trees and shrubs can provide an alternative [10]. With no competing food uses, this characteristic turns attention to Jatropha curcas, which grows in tropical and subtropical climates across the developing world The seeds of Jatropha contain viscous oil, which can be used for manufacture of candles and soap, in cosmetics industry, as a diesel/paraffin substitute or extender [28,32]. This latter use has important implications for meeting the demand for rural energy services and also exploring practical substitutes for fossil fuels to counter greenhouse gas accumulation in the atmosphere.

5. MUSTRAD OIL

Mustard oil has about 60% mono unsaturated fatty acids of which erucic acid and oleic acid, it has poly unsaturates of

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which is the omega- alpha-linolenic acid and omega linoleic acid and it has saturated fats. Mustard seeds, like all seeds of the Brassica family. Mustard plant is identified by plant with a many-branched stem, and lobed, roughly yellowish green lyre-shaped leaves, appox. Long[30, 34]. Bright yellow flowers are produced during winter session. The dark brown seeds are very small and spherical in shape and after crushing in rolling machine mustard oil can be subtract from the seed of mustard plant. It is generally used in cooking. Every year the production of mustard seed in India mostly in Rajasthan, Haryana, M.P., Gujrat, Orrisa, Jharkhand, Chhatisgarh and Bihar goes on increasing continuously due to the demand for it. So the endeavor was to use the surplus mustard oil as an alternative to diesel fuel. The edible oils of vegetable origin are the most important sources of cooking oil. The country produces nearly 25 million tonnes of such oilseeds out of which mustard alone constitutes of the production. Mustard oil is the popular cooking oil in Northen, Central, Eastern and North Eastern Region. Natural unrefined mustard oil extracted through cold process is quite pungent. The consumers of traditional product prefer pungent oil [25,33]. Till now the extraction of pungent oil could be possible only by Rotary Ghani due to mustard seed moisture range of low temperature of extraction in wooden bowl wherein the pungent principle - allyl isothiocyanate does not evaporate. However, the expeller made of metallic components and high compression ratio raises the seed temperature upto resulting in loss of pungent principles [26,31]. The "Modern" oil expeller provides high pungency mustard oil by low temperature crushing through incorporation of a water cooled chamber and processing at critical moisture levels of oilseed.

6. TEST METHODS

6.1. Tranesterification

Tranesterification is the most common method to produce biodiesel, which refers to a catalyzed chemical reaction involving Vegetable oil, and an alcohol to yield fatty acid alkyl esters and glycerol i.e. crude glycerine. The process of 'transesterification' is sometimes named methanolysis or alcoholysis[10]. This method is used to convert the Jatropha, Mustrad oil in to Jatropha, Mustrad oil methyl ester. After transesterification, viscosity of Jatropha, mustard oil methyl esters (JOME, MOME) is reduced by 75-85% of the original oil value. It is also called fatty acid methyl esters, are therefore products of transesterification of Jatropha and mustard oil and fats with methyl alcohol in the presence of a KOH catalyst. During the reaction, high viscosity oil reacts with methanol in the presence of a catalyst KOH to form an ester by replacing glycerol of triglycerides with a short chain alcohol. [Triglycerides (Jatropha and mustrad oil) + Methanol → Jatropha, mustard oil methyl ester + Glycerol] Methanol/methyl alcohol is preferred for JATROPHA and MUSTARD preparation by using transesterification as it provides better separation of methyl ester and crude glycerin thus facilitating the post-reaction steps of obtaining biodiesel.

7. EXPERIMENTAL SETUP AND PROCEDURE

A single cylinder, water cooled, four stroke direct injection compression ignition engine with a compression ratio of 16.5: 1 and developing 3.7 kW power at 1500 rpm was used for this work (Figure. 1). The specification of the test engine is shown in table 1. The engine was coupled with an eddy current dynamometer .Fuels used were diesel jatropha and mustard oil blends at pre heated to 50°C, 70°C, 90°C. Load was applied in 5 levels namely, 0%, 20%, 40%, 60%, and 80%. Load, speed, air flow rate, fuel flow rate, exhaust gas temperature, exhaust emissions of HC, CO and smoke were measured at all load conditions. The Redwood Viscometer is used to measure the viscosity of fuels at various temperatures. The exhaust gas analyzer model Horiba The exhaust gas analyzer model Horiba MEXA-584L was used to measure carbon monoxide (CO) and hydrocarbon (HC) levels. The analyzer is a fully microprocessor controlled system employing non destructive infrared techniques.

Fig-1: Experimental Setup

Table.1: Specification of test engine

Make	Kirloskar AV-1
Type	Single cylinder, water cooled,
Max.power	3.7 kW at 1500 rpm
Displacement	550 CC
Bore x Stroke	80 x 110 mm
Compression ratio	16.5:1
Fuel injection timing	21deg BTDC
Loading device	Eddy current dynamometer

8. FUEL INJECTION PRESSURE

The fuel injection system in a direct injection diesel engine is to achieve a high degree of atomization in order to enable sufficient evaporation in a very short time and to achieve sufficient spray penetration in order to utilize the full air charge. The fuel injection system must be able to meter the desired amount of fuel, depending on engine speed and load and to inject that fuel at the correct time and with the desired rate. Further on, depending on the particular combustion chamber, the appropriate spray shape and structure must be produced. A supply pump draws the fuel from the fuel tank and carries it through a filter to the high-pressure injector. During this phase of the project, injection pressure is varied. low injection pressures of 190 bar the BTE is lowest possibly due to the coarser size of fuel particles and lower depth of penetration in the combustion chamber resulting in longer time for combustion. The injection pressure of this high speed diesel engine is approximately 190 bar. The injection pressure of the injector can be varied by tightening or

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loosening the screw of the injector as shown in the figure. The injector pressure can be determined by a fuel injector pressure tester. 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. When the injection pressure is increased to 220 bar the better mixing and proper utilization of air converted more heat into the useful work resulting in higher BTE. When injection pressure is further increased to 240 bar the BTE decreased as against the normal trend. When the injection pressure is increased fuel particle diameters will become small. The mixing of fuel and air becomes better during ignition delay period which causes low smoke level and CO emission. But, if the injection pressure is too high ignition delay become shorter. So, possibilities of homogeneous mixing decrease and combustion efficiency falls down. Therefore, smoke is formed at exhaust of engine.

9. FUEL INJECTION TIMING

Each test cycle was conducted at different loading condition, so that the engine would then be required to perform the same task. In diesel engines, only about 80% of the air inducted can effectively be utilized during the combustion process, the remainder having insufficient time to mix with the fuel. This is one of the reasons why diesel engines of a given capacity have lower power output than petrol engines of the same capacity and speed. In addition, maximum power output of the engine demands that the maximum peak cylinder pressure occur crank angle after TDC. To meet these demands, the period of fuel injection was advanced by given injection timing of BTDC. Engine performance deteriorated in an attempt to further advance the timing. The effect of advanced injection timing on the performance of natural gas used as primary fuel in dual-fuel combustion has been examined. The engine ran smoothly on this timing but seemed to incur penalty on fuel consumption especially at high load levels.

10.PROPERTIES OF BIO-DIESEL

10.1.Density

Density is an important property of CI engine fuel. Figure.2 shows density for diesel, biodiesel and their blends. It is observed that B25, B50, B75, B100, Jatropha and Mustard oil almost same density as that of diesel at room temperature (30°C). So preheating is not required for using B25, 50, B75 has about 1.62% higher density than diesel and it attains same density as that of diesel fuel of 42°C. So preheating B75 at this temperature is necessary for using it in CI engine. Similarly B100 has 3.4% higher than that of diesel fuel. We find that density of the fuel increase with the increase in blending number, the intake manifold of the engine should be redesigned so that preheating can be done utilizing the exhaust of CI engine.

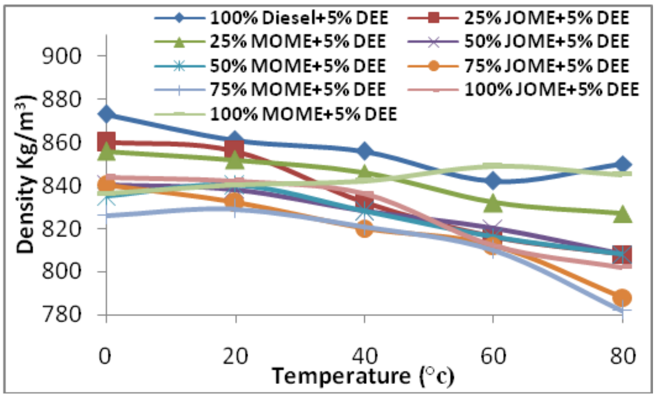

Fig. 2. Density of Jatropha and Mustard oil blends

10.2. Kinematic viscosity

Viscosity of the fuel exerts a strong influence on the shape of the spray, high viscosity for example, causes low atomization and high penetration of the spray jet. Note that a cold engine, with higher viscous oil, discharge will almost a solid stream of fuel in to the combustion chamber and starting may be difficult while a Smokey exhaust will almost invariably appear. On the other, hand very low viscous fuel would cause to pass through the leakage of piston and piston prevents accurate metering of the fuel B25, B50, B75, B100 and jatropha, mustard of diethyl ether have almost the same viscosity at room temperature, and it is about 3.2 times higher than the diesel. But a slight preheating would cause to achieve comparable viscosity as that of diesel fuel. So using B25, B50, B75, B100 blend would not cause much change in the fuel spray pattern, and thus these fuels can be used in the existing diesel engines without modification of the fuel supply system. On the other hand B100, jatropha and mustard is a much viscous fuel, and its viscosity is about 6 times higher than that of diesel fuel.

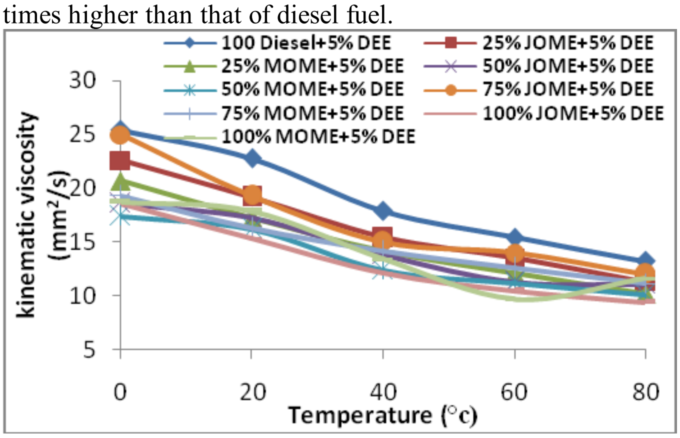

Fig. 3. kinematic Viscosity of Jatropha and Mustard oil blends

11. RESULTS AND DISCUSSION

Experimental investigation were carried out for performance and exhaust emission of the engine for blends of diesel and methyl ester of jatropha and mustard oil .

11.1. Brake thermal efficiency (BTE)

With increasing brake power, the BTEs of vegetable oils and diesel also increased; however, they tended to decrease when further increase in brake power was observed. The BTEs of the Jatropha curcas oil and mustard oil are lower than those of diesel fuel throughout the entire range, possibly

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due to the lower calorific value and the high viscosity of Jatropha oil compared with diesel fuel. At maximum load condition, the specific fuel consumption of biodiesel is more than 12% than that of diesel. It may be noted that the calorific value of biodiesel is lower than that of diesel.The brake thermal efficiencies of diesel and the blends of biodiesel with diesel were seen increased with increase in load but tended to decrease with further increase in load. The maximum thermal efficiency achieved.

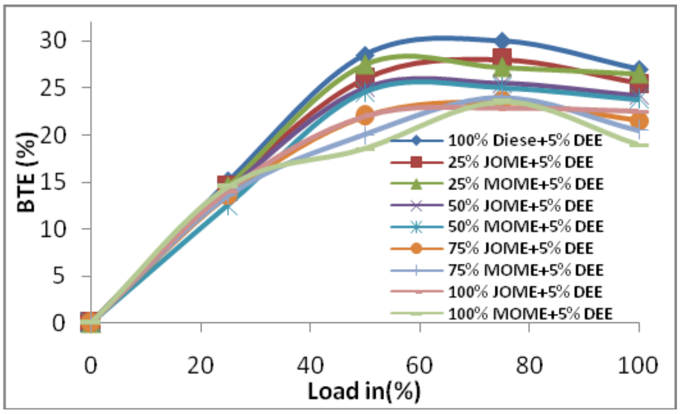

Figure.4. Brake thermal efficiency with load

11.2. Brake specific fuel consumption (BSFC)

This is mainly due to the combined effects of the relative fuel density, viscosity, and heating value of the blends. The higher density of Jatropha oil led to mustard more there by increasing the specific fuel. The higher bulk modulus results in more discharge of fuel for same result increase in BSFC. This is due to the higher percentage increase in brake power with load as compared to the increase in fuel consumption. Using lower percentage of biodiesel in biodiesel–diesel blends, the brake specific fuel consumption of the engine is lower than that of diesel for all loads. This lower brake thermal efficiency obtained for B100 could be due to the reduction in calorific value and increase in fuel consumption as compared to B25. While running the engine with unrefined jatropha and mustard, brake thermal efficiency is always lower than the biodiesel as well as diesel.

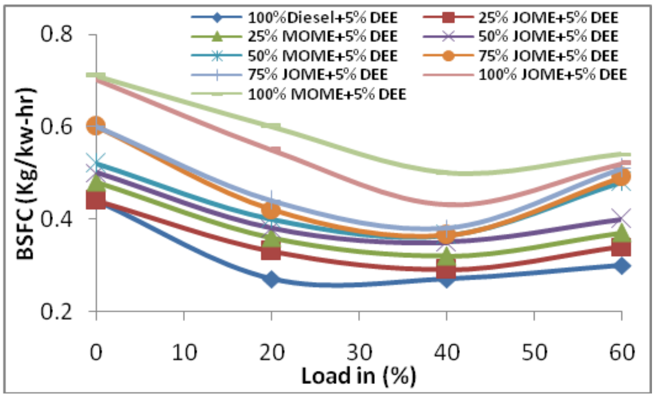

Fig. 5 BSFC with load

11.3. Exhaust gas temperature

This fact is reflected in brake thermal efficiency and brake specific fuel consumption as well. When biodiesel concentration is increased, the exhaust gas temperature increases by a small value. While using 100% jatropha and mustard oil, higher exhaust temperature is attained, which is indicating more energy loss in this case . The exhaust gas temperature increases with increase in load for all tested fuels.The increase in exhaust gas temperature with load is obvious from the fact that more fuel is required to take additional load. Exhaust gas temperature is an indication of the extent of conversion of heat into work, which happens inside the cylinder. It is noted that the exhaust gas temperature using different fuels at various load levels are nearly the same. Exhaust gas temperature increases with increase in power for all the fuels. As the biodiesel fuel concentration is increased, the exhaust gas temperature also increased. The higher exhaust gas temperature is 379°C at higher power for B100. This increase in the exhaust gas temperature may be due to the high viscosity of the biodiesel, changing the injection.

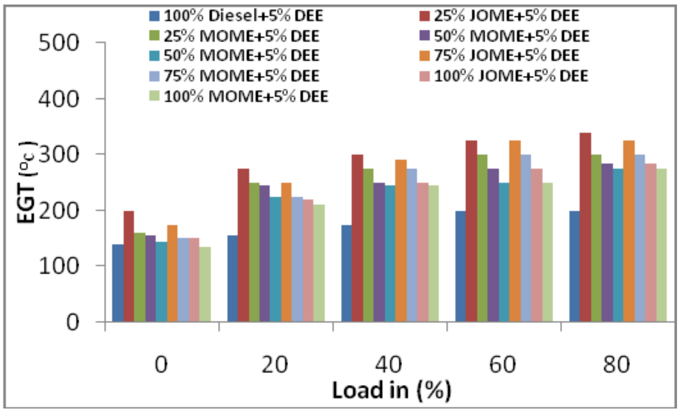

Fig. 6 Exhaust gas temperature with load

11.4. Emissions of Nitrogen Oxides (NOx)

It is well know remains inert up to a certain temperature and above this level it does not remain inert and it participates in chemical reaction. At the end of the combustion, gas temperature inside cylinder arises around 1500°C. At this temperature oxidation of nitrogen takes place in presence of oxygen inside the cylinder. On the other hand, since the formation of nitrogen oxides do not attain chemical equilibrium reaction, then after the end of expansion stroke when the burned gases cool and the formation of NOx freeze, the concentration of the formed NOx in the exhaust gas remain unchanged.. An advance of fuel injection timings in engine operating on mechanical type fuel injectors when using biodiesels which are having lower compressibility compared to diesel thus lower compressibility and higher speed of sound in biodiesel shorten ignition delay permitting can combustion conditions conducive for NOx formation. This proves that the most important factor for the emissions of NOx is the combustion temperature in the engine cylinder and the local stoichiometry of the mixture. This is the most important emission characteristic of plant oil as the NOx emission is the most harmful gaseous emission from engines; therefore, its reduction has always been the goal of engine researchers and makers. This emission character of NOx for plant oil is very useful in the application of plant oil to diesel engines as a kind of alternative fuel for petroleum-based ordinary diesel fuel.

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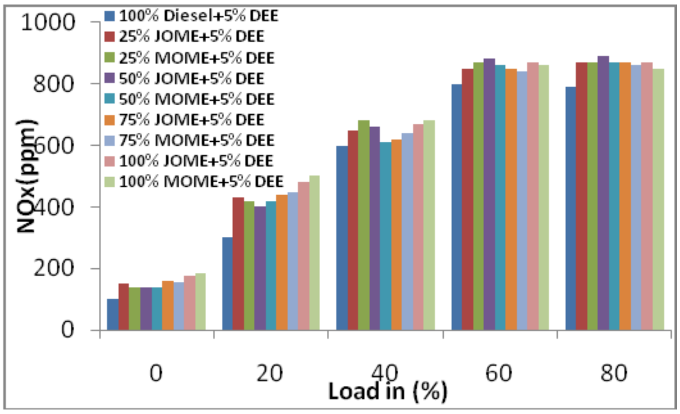

Fig. 7 NOx emissions with load

11.6. Carbon Monoxide

The comparative analysis of CO is shown in fig 8 volume of CO initially decrease but increase at full load indicating better burning conditions mixtures, but as diesel combustion is occurred with lean mixture and has an abundant amount of air, CO from diesel combustions is low. For bio-diesel mixtures CO emission was lower than that of diesel fuel, because biodiesel mixture contains some extra oxygen in their molecule that resulted in complete combustion of the fuel and supplied the necessary oxygen to convert CO to CO_2. This is possible due to the high viscosity of vegetable oils; the higher the viscosity, the more difficult it is to atomize vegetable oils.

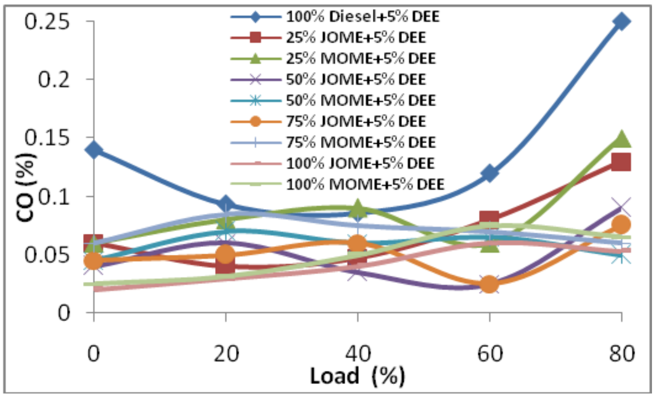

Fig. 8 CO emission with load

11.7. Hydrocarbon

HC emissions are lower at partial loads but tend to increase at higher loads for both fuels. This is due to the lack of oxygen, which is caused by engine operation at a higher equivalence ratio. The higher cetane number of biodiesel results decrease in HC emission due to shorter ignition delay. It is observed that the hydro carbon emission of various fuels is lower in low and medium loads but increased at higher loads. This is because, at higher loads, when more fuel is injected into the engine cylinder, the availability of free oxygen is relatively less for the reaction. The variation of carbon dioxide with brake power is shown in fig 9 as expected, it is noted that the carbon dioxide emission increases with increase in load. HC emission with load for different fuels. It is observed that HC emission of the various blends was lower at partial load, but increased at higher engine load. This is due to the availability of less oxygen for the reaction when more fuel is injected into the engine cylinder at higher engine.

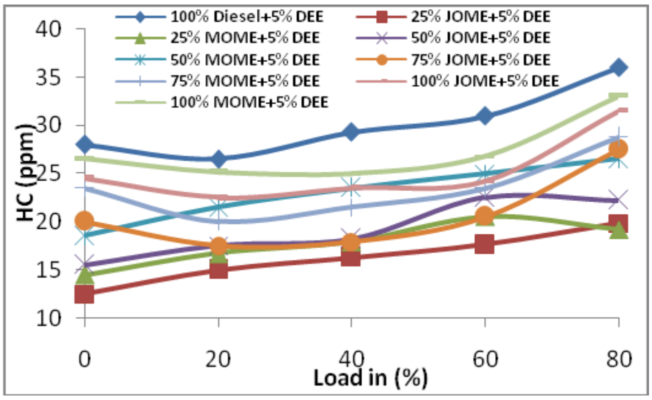

Fig. 9 HC emission with load

11.8. Oxygen

The variation of Oxygen content that can be slightly arises the properties to show the identification of the engine performance that can be slightly arises the proportion of the material of the jatropha oil with load for mustard oil blends-DF blends is shown in figure 10. It is clear that oxygen present in the exhaust gas is decreases as the load increases. It is Obvious that due to improved combustion, the temperature in the combustion chamber can be expected to be higher and higher amount of oxygen is also present, leading to formation of higher quantity of NOx, in jatropha oil-DF blends. In presence of oxygen atoms in the straight vegetable oil based alkyl ester helps to combust fuel completely and reduces smoke substantially oxygen content in exhaust emissions was higher for both types of test blends.

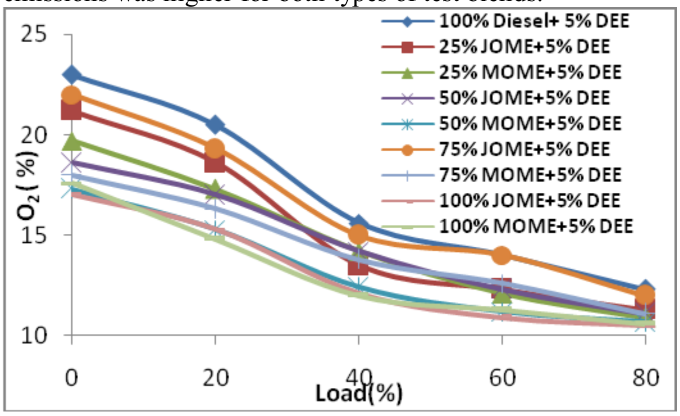

Fig. 10 O_2 with load

11.9. Carbon dioxide

In the range of the whole engine load, the CO_2 emissions of diesel fuel are higher than that of the other fuels because vegetable oil contains oxygen element. The carbon content is relatively lower in the same volume of fuel consumed at the same engine load, and consequently, the CO_2 emissions from the vegetable oil and its blends are lower. The CO_2 emissions from a diesel engine indicate how efficiently the fuel is burnt inside the combustion chamber. As discussed earlier, the ester-based fuel burns more efficiently than diesel. If percentage of blends of Jatropha and mustard oil increases, CO_2 increases. The CO_2 emissions are directly proportional to the percentage of Jatropha in the fuel blend. Since Jatropha and mustard diethyl ether is an oxygenated fuel, it improves the combustion efficiency and hence increases the

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concentration of CO_2 in the exhaust. Carbon dioxide levels are affected by air/fuel ratio, spark timing, and any other factors which effect combustion efficiency.

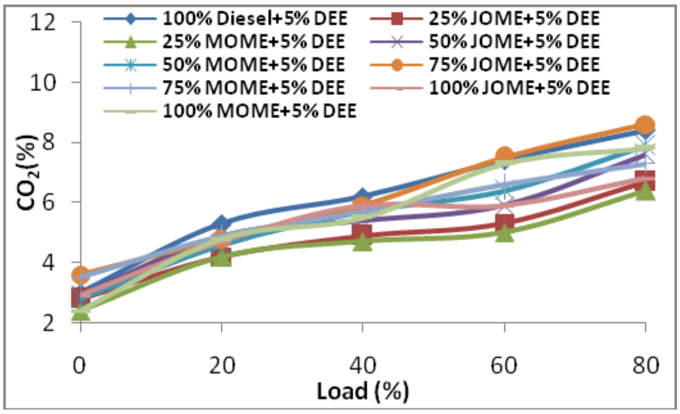

Fig. 11 CO_2 with load

11.10 .Smoke density

Smoke density increases with increasing load for all the blends of jatropha ether and mustard oil. If percentage of blends of jatropha increases, smoke density mustard decreases. Because of increasing the load the fuel entering in to the cylinder increases in that proper oxygen is not allowed for that the smoke density is high for the diesel. The viscosity of Jatropha and mustard is comparatively lower than neat diesel. Due to this, the spray pattern and fuel penetration are improved. The smoke density is slightly higher that of diesel and other Biodiesel. This is due to uneven fuel spray pattern in the combustion chamber, because of vapour locking in the pump and pipe line. The smoke density is decreased from at full load. Smoke opacity values are also lower for the same combination. Improved and complete combustion could be the reasons for obtaining lower smoke opacity values with oxygenated additives.

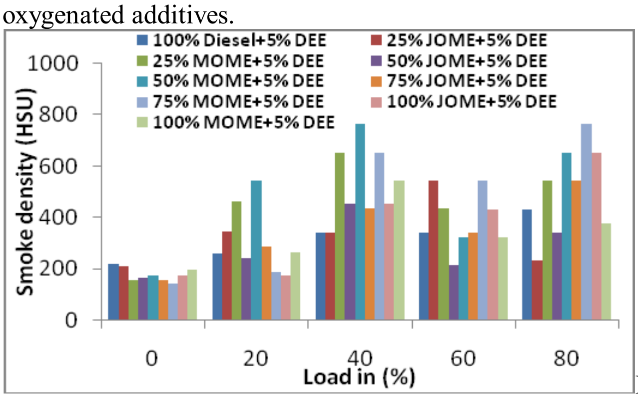

Fig. 12 Smoke density with load

11. 11. Brake specific energy consumption

Brake specific energy consumption (BSEC) is an ideal parameter for comparing engine performance. These figures 13 show that the BSEC is lower for jatropha and mustard compared to diesel at higher load is 2.8%. The reduction in viscosity leads to improved atomization, fuel vaporization and combustion. It may also be due to better utilization of heat energy, and better air entrainment. It can also be seen that the minimum BSEC attained using jatropha and mustard higher load was closer to that of diesel. It can be observed that the specific energy consumption in different fuel injection line of 180bar, 200, 220 to 240 bar operation is higher when compared to that of diesel operation. This is due to low in making more heterogeneity in air fuel mixture resulting in increase in specific energy consumption.

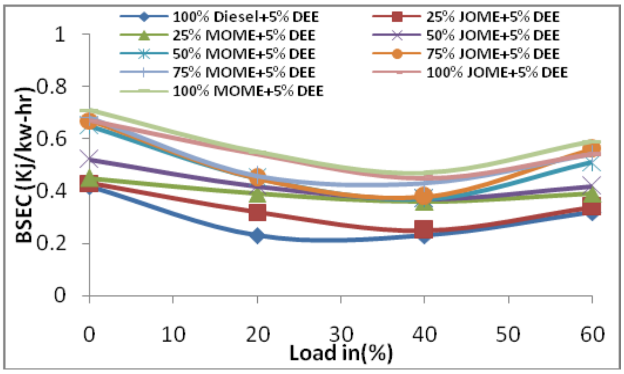

Fig.13 BSEC with load

11.12. Brake power

It can be observed from the figure 14 that as the load increases, brake power increases to the maximum at 70% load and then decreases for all the fuel samples. When the brake power produced by the engine at different loads for different mixtures of dual fuel is compared, it is found that the brake power increases up to B50 and then it decreases. When the brake power at different loads is compared for diesel and different combinations of dual fuel, it is noted that the brake power is higher for the dual fuel combinations from B25 to B30 than diesel. In the case of B100 the brake power is more or less equal to that of diesel. For the dual fuel combinations from B500 to B75, the brake power is less than that of diesel. Hence it can be concluded that the dual fuel combination of B40 can be recommended for use in the diesel engines without making any engine modifications.

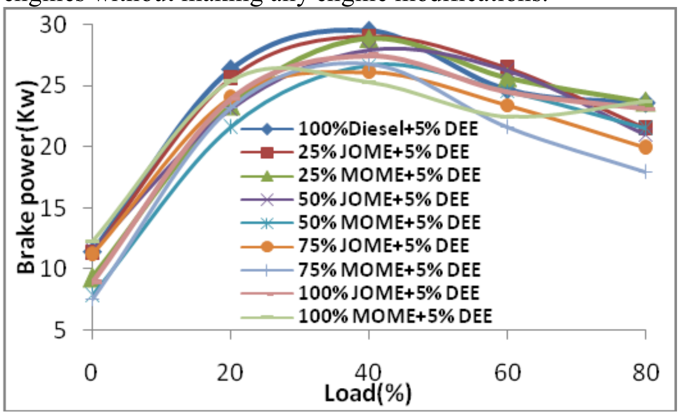

Fig.14 Brake power with load

11.13.Torque

The relationship between the load and the torque for various fuels is shown in Figure15. It can be observed that as the load increases, torque increases to the maximum at 60% load and then decreases for all the fuel samples. When the torque produced by the engine at different loads for the diesel and various mixtures of dual fuel is compared, it is found that the torque increases up to B50 and then it decreases. The increase in torque is due to the higher calorific value of diesel and that of the dual fuel mixtures from B25 to B100, as well as complete combustion of fuels. In the case of dual fuel mixtures from B50 to B100, the quantity of jatropha and mustard biodiesel increases which results in low calorific

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value. Because of this low calorific value the torque decreases for the blends from B50 to B75.

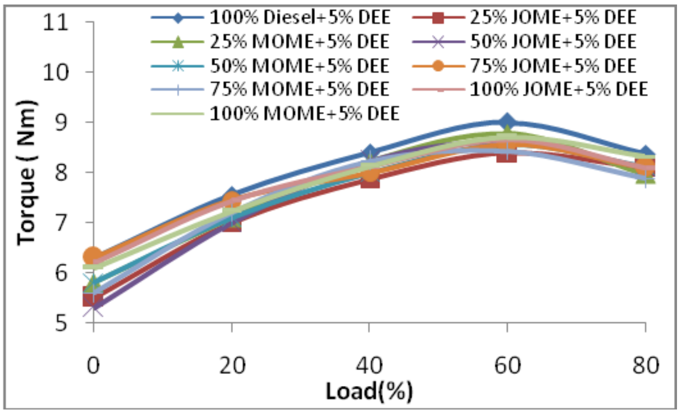

Fig.15 Torque with load

12. COMBUSTION PARAMETERS

12.1. Heat release rate

The start of combustion for B25 start of injection was at 327°. The initial value dip in the heat release rate curve move towards after 325° due to the energy absorbed by the injected fuel for evaporation. Ignition occurred at 354° as can be seen by the positive heat release following the initial evaporation dip in the amount of fuel burning during the premixed combustion chamber. The heat release rate at 100% load with crank angle for jatropha and mustard oil blends is given in Figure 16. The maximum heat release rate of standard diesel, B25, B50, B75 and B100 has been observed. The reduced hear release rate for the oils blended with diesel fuels could be due to the improved ignition. Due to the better combustion when compared that of a neat diesel of the heat release rate is analyzed based on the changes in crank angle variation of the cylinder. The heat release rate of waste of its poor mixture formation tendencies and the biodiesel burns solely on account thus the ignition delay is about 11° crank angle. It has observed that the heat release rate decreases at the start of combustion and increases further may be due to the air entrainment combined with lower air/fuel mixing rate and effect of viscosity of the blends. The most significant observation is that the peak heat release rate is lower in the case of biodiesel as compared to diesel of heat release pattern of B50 is quite similar to that of standard diesel, whereas other blends deviate more from that of standard diesel. The heat release rate of standard diesel is higher than oil blend due to its reduced viscosity and better spray formation. If the biodiesel blends increase the heat release rate is decreased.

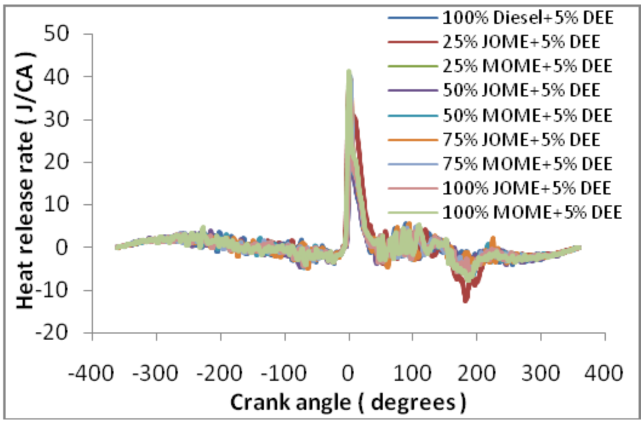

Fig 16 Crank angle Vs Heat release rate

12.2 Peak pressure

Peak pressure depends mainly on the combustion rate in the initial stages, which is influenced by the fuel intake component in the uncontrolled heat release phase. In compression ignition engines the peak pressure depends on combustion rate in the initial combustion period the variation of cylinder pressure with crank angle for diesel, jatropha and mustard oil and its blends at full load conditions. It has observed from the Figure that, the peak cylinder pressure decreases at the start of combustion and increases further. Peak pressure of 66.7, 64.45, 69.21, 67.13, 65.9 and 64.27 are found for percentages of pure diesel. It is observed that peak pressures has been recorded for standard diesel, B25, B50, B75 and B100 respectively. since the properties such as calorific value, velocity, density, and density are brought closer to diesel after transesterification of the vegetable oil, no major variation in the pressure are found. The cylinder peak pressure is lower that of standard diesel because of the high viscosity and low volatility of biodiesel which in turn depends on the amount of fuel taking part in the uncontrolled combustion phase.

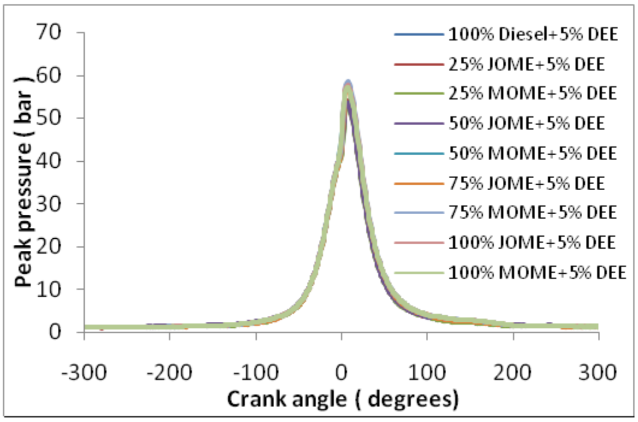

Fig 17 Crank angle Vs Peak pressure

12.3 Rate of pressure rise

The variation of the rate of pressure rise for the tested fuels of jatropha and mustard oil with engine load. Rate of pressure rise is indicative of noisy operation of an engine. A value exceeding 8 bar / CA is generally considered as unacceptable.

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From the graph, it can be observed the rate of pressure rise is higher for jatropha and mustard oil operation, which is followed by B25, B50, B75, B100 and diesel fuelled operation. jatropha emulsion show higher as compared to diesel fuel due to lower ignition delay those results in earlier combustion and higher peak pressures also, the premixed combustion heat release is higher for jatropha and mustard based blend which may be responsible for higher rate of pressure rise. Same trends obtained for other blend ratios of the entire load under consideration. In a CI engine, the peak pressure depends on the combustion rate in the initial stages, which is influenced by the amount of fuel taking part in the uncontrolled combustion phase, which in turn governed by the delay period jatropha and mustard oil results in lower peak pre sure and lower maximum rate of pressure rise as compared to neat diesel. The occurrence of peak pressure and maximum rate of pressure rise jatropha and mustard oil moved away compared to neat diesel. Generally, if delay is more occurrence of peak pressure moves away compared to lower delay combustion. Thus, the slight higher viscosity and poor volatility of biodiesel results in lower peak pressure and maximum rate of pressure rise as compared to neat diesel.

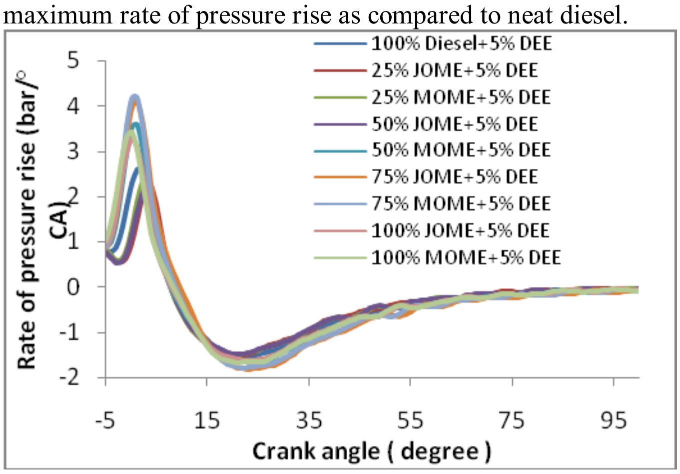

Fig.18.Crank angle Vs Rate of pressure rise

12.4. Combustion duration

In this time duration that accounts from the beginning of the heat release to the end of heat release. The effect of crank angle on second derivatives of the pressure. The ignition delay period is calculated based on the static injection timing. It has been observed that the total duration of combustion is shorter for biodiesel and diesel blends while comparing them with standard diesel. The duration of the point of start of combustion is taken as the second derivatives of the combustion chambers pressure versus time becomes positive. Ignition delay of Jatropha and Mustard oil is slightly higher as compared to neat diesel due to low cetane number and higher self ignition temperature**.** The decrease in combustion duration is due to the efficient combustion of the injected fuel.

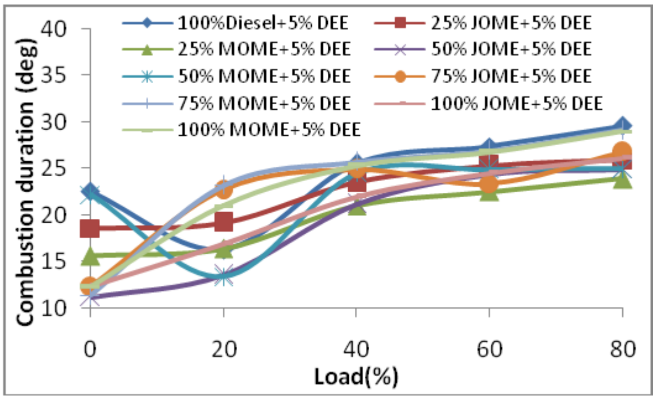

Fig.19. Load Vs Combustion duration

12.5. Cumulative heat release rate

The variation of cumulative heat release with crank angle is presented in the figure 20. The figure 20 shows that there is a tendency of earlier heat release for jatropha and mustard oil but the cumulative heat release value of diesel fuel quickly exceeds the CHR for B25 andB50 blend even though combustion for diesel fuel starts later. The main reason for the decreases in the CHR is lower heating value of B25 and other B50 based blend as compared to diesel fuel. CHR increased with the rise in the engine load to the increase in the quantity of fuel injected into the cylinder. CHR increased with the increased in engine load for all tested fuels. It is seen that the premixed combustion region is lesser for jatropha and mustard oil indicating that with neat diesel fuel greater mixing is enhanced. The slight high viscosity and density of jatropha and mustard oil result in inferior atomization and vaporization and lead to reduction in fuel air mixing rates. Hence, more burning occurs in the diffusion phase (Fig.20). This could explain the lower NOx, higher CO and HC emissions with jatropha and mustard oil..

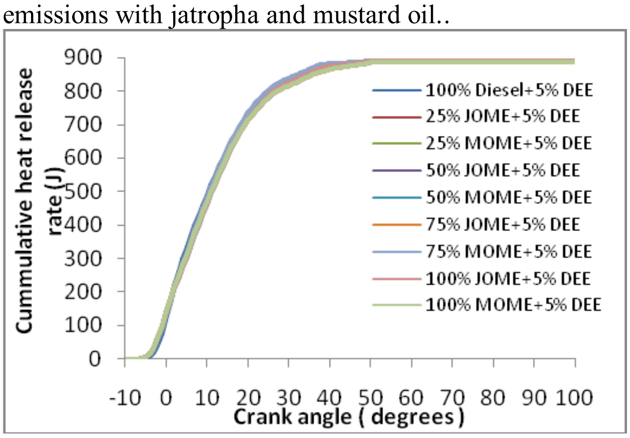

Fig.20.Crank angle Vs Cummulative heat release rate

12.6. Maximum combustion pressure

It has been observed that the waste Jatropha and Mustard oil blend B75% gives higher combustion pressure compared to that of standard diesel due to longer ignition delay of Blended biodiesel. The fuel absorbs more amount of heat from the cylinder immediately after injection, resulting in longer ignition delay .The peak pressure of 66.7, 64.45, 69.21, 67.13, 65.9 and 64.27 are found for percentages of pure diesel. Pressure for standard diesel and Jatropha and mustard oil blends B25, B50, B75 and B100 respectively at full load. This is happened due to the rapid and complete combustion of fuels inside the combustion chamber. This is the most important emission characteristics of jatropha and

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mustard oil and its blends, as the Nox emission is the most harmful gaseous emissions from engines, the reduction of it is always the target for engines, the reduction of it is always the target for application of vegetable oil and its blends to diesel engines in the form of alternative fuel for its diesel fuel. Thus, the slight higher viscosity and poor volatility of the biodiesel results in lower peak pressure and maximum rate of pressure rise as compared to neat diesel.

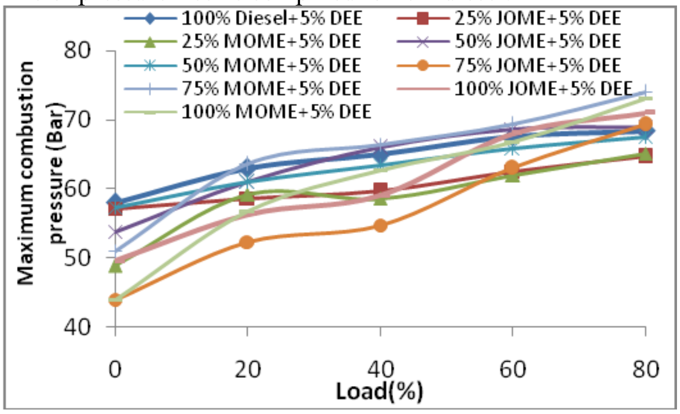

Fig.21. Load Vs Maximum combustion pressure

12.7. Cylinder pressure with number of cycles

Shows the maximum pressure with number of cycle. The pressure variation in the cycle is important in the analysis of the combustion characteristics of any fuel. In compression ignition engines the peak pressure depends on combustion rate in the initial combustion period, which in turn depends on the amount of fuel taking part in the uncontrolled combustion phase. it is observed that there will be both wide and narrow variations of air fuel ratio for measured cycles. The variation of cycle is normally rely on fuel droplet size, droplet penetration, droplet momentum, penetration rate, maximum penetration, degree of mixing it with air, evaporation rate and radiant heat transfer rate . The optimum pressure is found in B100 Jatropha and Mustard oil compare to all other fuels. The in-cylinder pressure is an indicator of the cyclic variations. In-cylinder traces for 25 cycles are taken for analysis as single cycle variations is too tedious and not in practice. Air-fuel ratio and maximum flame speed are the two most important parameters which affect the peak cylinder pressure. The other fuels are slightly lower than B100 jatropha and Mustard.

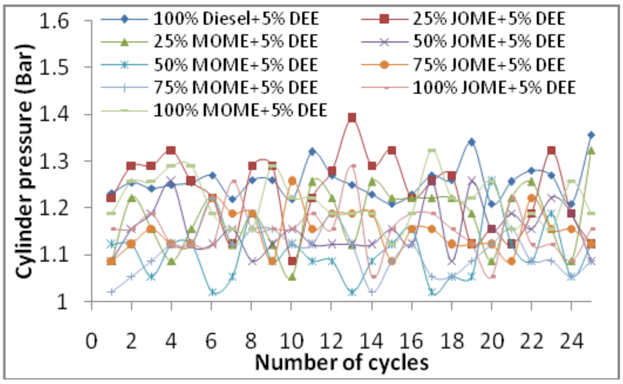

Fig.22.Number of cycles Vs Cylinder pressure

CONCLUSIONS

- Performance and emissions of diesel engine fueled with blends of biodiesels of jatropha and mustard with diesel fuel are experimentally investigated.
- Jatropha and mustard based biodiesels can be directly used in diesel engines without any modifications.
- The thermal efficiency of the engine was lower, while the brake-specific fuel consumption was higher on Jatropha oil than on diesel.
- Most of the major exhaust pollutants such as CO, CO_2 and HC are reduced with the use of neat biodiesel and the blend as compared to neat diesel.
- But NO_X emissions increase when fuelled with diesel–biodiesel fuel blends as compared to conventional diesel fuel. This is one of the major drawbacks of biodiesel.
- CO, HC, and CO_2 emissions from Jatropha oil were higher than from diesel fuel during the entire process of the experiment.
- CO emissions from neat sea lemon oil and its diesel blends were higher compared with those of standard diesel.
- Brake power for neat diesel have higher values than blended bio-diesel at all loads and difference of brake power between neat diesel.
- NOx from neat Jatropha and Mustard oil and its diesel blends are lower than those of standard diesel fuel in 220bar injection pressure and 23°BTDC.
- The smoke emission for neat Jatropha and Mustard oil was 20% more at full load compared with those of standard diesel 220bar injection pressure and 23° BTDC.
- Brake thermal efficiency is higher for neat diesel at all loads and lowers for blends of bio-diesel and difference of brake thermal efficiency between neat diesel and blended bio-diesel decreases as load increases.
- Comparatively 220 bar injection pressure and 23° BTDC injection timing is the best to reduce the NOx, HC, Brake thermal efficiency and smoke level in biodiesel 75 %.
- The exhaust gas temperature is found to increase with concentration of jatropha and mustard methyl ester in the fuel blend due to coarse fuel spray formation and delayed combustion.

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