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Impact of Various Compression Ratio on the Compression Ignition Engine with Diesel and Mahua Biodiesel

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Abstract : In this paper, the experimental investigation analyses various characteristics of diesel engine like performance, combustion and emission with diesel and 20% concentration of mahua biodiesel blend in diesel. Both the diesel and biodiesel fuel was injected at 23 ºBTDC. The testing was carried out at various compression ratios. Biodiesel was extracted from mahua oil, 20% (B20) concentration with diesel is used in all compression ratios. The compression ratios were 17.5, 16.5 and 15.5 by raising the clearance volume. The main objective of analyzing the effect of various compression ratios is to reduce the oxides of nitrogen. The result concluded that higher the compression ratio better the performance and lower the emission. By reducing the compression ratio, the oxide of nitrogen was lower for both diesel and biodiesel compared with higher compression ratio of 17.5.
Keywords: Methyl Ester of Mahua, Biodiesel Blend, Performance, Combustion, Emission.

1. Introduction:

Due to global warming and depletion of petroleum product, a need of research for alternative fuel is most necessary in the world. Present CI engine necessitates clean combustion and increase in performance with varying operating condition. The demand of energy is raised mainly because of life style change, large amount of energy utilized in industrial, agricultural irrigation and raising in automobile. When looking for various sources of alternate fuel, it should safe guard the environment and ensure the long term availability of fuel[1]. In recent years, number of research is going on bio based energy. Bio based fuel has the more probability to aid the demand of fuel in proper method.

The large amount of renewable energy is obtained from biomass energy. The vegetable oil is derived from various sources of biomass energy. The non edible oil is less cost than edible oil. The non edible oil plant is grown in any climatic condition. Number of advantages results in using the vegetable oil such as increasing in agricultural economics, rural development and other main important advantage is reduced emission[2]. The chemical property of this fuel leads to reduce the emission. Presently many researchers investigated to reduce the emission in three methods. The first one for design parameter, second one for operating parameter and last one for fuel modification. The operating parameter includes various injection timing, various nozzle hole size and various compression ratio, and fuel modification for biodiesel, alcohol fuel, syngas gas and hydrogen fuel etc.

Biodiesel reduces particulate matter considerably. The biodiesel is used in straight diesel engines results in considerable decrease of emission except NOx[3]. The properties are nearly equal to that of diesel.

2. Various method of Bio diesel conversion:

The main disadvantages connected with utilization of vegetable oil are their high viscosity and poor volatility. The following methods is used to reduced the viscosity, the methods are preheating, transesterification with alcohols, combination with diesel and alcohol, dual fuelling with gaseous and liquid and use of additives.

Viscosity of the vegetable oil can be reduced by preheating, it leads to improvement of fuel injection. The suitable pre heating temperature of the vegetable oil is 60°C, it viscosity is closer to diesel fuel. Preheated oil increases the injection parameters and improves the air fuel mixture in cylinder. As the result, it is shown to have decrease in emission and increase in performance[4]. In transesterification method brake the molecule structure with help of alcohol and catalyst.

Bio diesel was increased the rate of heat release. Higher engine output was indentified in biodiesel compare to raw vegetable oil. Transesterification method has the main advantage of vegetable oil being easily mixed with alcohol and run the engine without modification. This transesterification method is increasing the properties of vegetable oil. Results found using blends of vegetable oil and methanol to run the engine proved that the brake thermal efficiency is similar to diesel and decreases the emission[5-7].

The dual fuel mode is very successful method in compression ignition engine with various combination of fuel. In dual fuel mode, any types of modification can be made in diesel engine. This method various range of liquid fuel and gaseous fuel. This method shows the result with high thermal efficiency with less amount of smoke at maximum load. The little quantity of additive is to be blended in the bio diesel fuel; it improves the efficiency and reduce the emission. The role of additives is to shorten the delay period[8].

M.Ravi et al.[9] investigated in CI engine with biodiesel and pure diesel. Analysis is done on the engine performance fuelled with diesel and biodiesel in various blends ratio. The biodiesel blend of 40% concentration shows better performance characteristics and exhaust emission. R. Senthil et al.[10] used three different fuel such as methyl ester of Polanga, methyl ester of Jatropha and methyl ester of Karanja with diesel, the blends ratio prepared in volume basis of 20% and 50% at three different load condition (zero load, middle load and full load). By the comparison of the results, higher pressure and shorter delay period is found on methyl ester of jatropha blends. For other blends of Polanga biodiesel and Karanja biodiesel delay period is shorter compared with diesel. M. James Selvakumar et al[11] investigated variable compression ratio engine such as 16.5, 18.5 and 19.5 with fuel as a Annona Methyl Ester. The results identified that B20 at higher compression ratio of 19.5 showed lower emission and the performance is similar for diesel. Without modification of engine, thermal efficiency superior is found in higher compression ratio. V.Manieniyan etal.[12] investigated in a single cylinder diesel engine with five different blends of biodiesel and diesel fuel at three compression ratio 14, 16 and 18 were tested constant rpm. From the results noticed, compression ratio 18 is better among the other compression ratio. Similarly B20 blends shows higher performance compares to other blends at all compression ratios.

3. Experimental work:

In this experimental investigation was analysis in three different compression ratio in various load at rated speed at 1500 rpm. It is a single cylinder, four stroke, vertical, water cooled DI diesel engine. The line diagram of the experimental setup is shown in figure 1. The engine details were mention in table 1. The both diesel and biodiesel fuel was injected at 23 ºBTDC. In this work, experimentation was carried at different compression ratio of 17.5, 16.5 and 15.5. Biodiesel was extracted from mahua oil used in 20% (B20) concentration with diesel in all compression ratios. The physical property in B20 MEOM is given in table 2. Smoke reading was identified by smoke meter and hydrocarbon, carbon monoxide and oxides of nitrogen emission were collected from engine tail pipe. The engine cooling was made by water at constant flow rate for entire experiments. Engine load was varied by adjusting knob, it connected to the eddy current dynamometer. The fuel utilization was measured by burette with periodic time. During this interval of time, the utilization of fuel was measured, with the help of the stopwatch. In each load the performance parameter and emission parameter were measured. The experimental system line sketch is plotted in fig 1. The inlet and exhaust gas temperature were measured by Chromel-Alumel K-type thermocouples. The combustion parameter was measured by combustion analyzer.

Table 1 Details of experimental engine

Manufacturer	Kirlosker TV – I
Category	Vertical cylinder, DI diesel engine, VCR engine
Number of cylinder	1
Bore × Stroke	87.5 mm × 110 mm
Compression ratio	17.5
Speed	1500 rpm
Rated brake power	5.2 kW
Cooling system	Water cooling
Injection timing	23°BDTC

Table 2 physical properties in B20 MEOM

Test Property	B20 MEOM
Density at 15° C kg/m^3	879.6
Kinematic Viscosity at 40°C	4.53
Flash Point (PMCC) °C, (min)	126
Pour point °C	4
Gross Colorific value k.cal/kg	9823

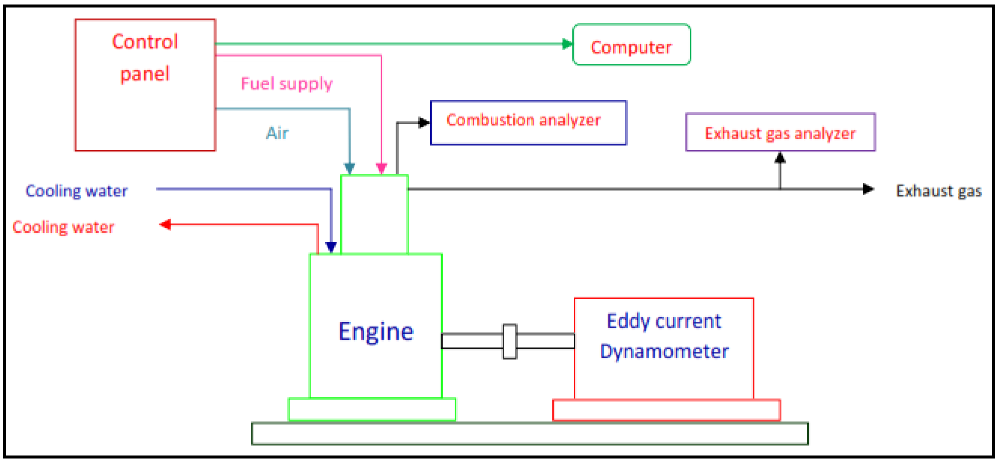

Figure 1. line sketch of experimental system

4. Result and Discussion

4.1 Performance analysis:

4.1.1 Specific fuel consumption:

Impact of various compression ratio on specific fuel consumption and various load fuelled with diesel and B20 MEOM fuel is plotted in figure 2. In full load the specific fuel consumption for diesel is 0.3 kg/kW h, and B20 MEOM blend is 0.3 kg/kW h in higher compression ratio of 17.5. The lower specific fuel consumption is obtained in higher compression ratio. In compression ratio 17.5, specific fuel consumption is reduced in 16.6% for diesel and 13.6% for B20MEOM. The specific fuel consumption is raised with decrease in compression ratio. From this graph, the result shows at 17.5 compression ratio the air/fuel concentration is mixed properly in cylinder chamber.

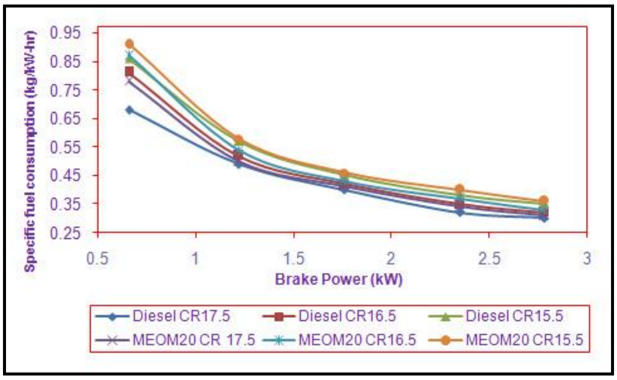

Figure 2 specific fuel consumption with brake power

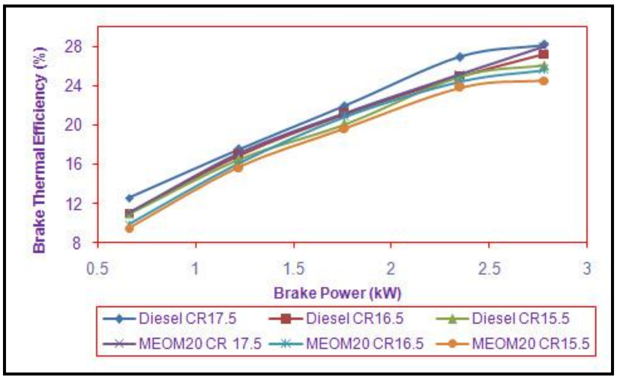

Figure 3 brake thermal efficiency with brake power

4.1.2 Brake Thermal Efficiency

Impact of various compression ratio on brake thermal efficiency and brake power of engine fuelled with diesel and B20 MEOM fuel is as plotted in figure 3. The engine power is relative to thermal efficiency. If the compression ratio is increases also increased in thermal efficiency. The maximum efficiency for diesel is 28.18% and 28.04 % for B20MEOM at higher compression ratio in full load condition. This effect is influenced by complete combustion occurred in higher compression ration compared with lower compression ratio. The air and fuel mixture is unstable in lower compression ratio. It leads to poor combustion tendency.

4.2 Emission characteristics:

4.2.1 Carbon monoxide:

Impact of various compression ratio on carbon monoxide (CO) and brake power fuelled with diesel and B20 fuel is as plotted in figure 4. The CO emission is higher at minimum load in higher compression ratio and lower at maximum load in lower compression ratio. The lower CO emissions found at maximum load conditions are 0.13 % by volume for diesel and 0.11% by volume for B20 MEOM blend at higher compression ratio. CO is lower for B20 MEOM, this is for biodiesel blends make up the oxygen deficiency at full load condition.

4.2.2 Hydrocarbon:

Impact of various compression ratio on hydrocarbon (HC) and brake power fuelled with diesel and B20 fuel is as plotted in figure 5. With decrease in compression ratio, HC emission also increases for both diesel and B20 MEOM. This is due to oxygen lack and makes possible incomplete brining. At compression ratio 17.5 hydrocarbon lower is found as 27 ppm and 33 ppm in diesel and B20 MEOM respectively at maximum load. At the same full load condition with 16.5 and 15.5 compression ratio HC emissions differs from 34 to 43 ppm and 38 to 51 ppm for diesel and B20 MEOM respectively. It was a cause to fuel concentration is higher at maximum load and insufficiency oxygen occupied as lower compression ratio was implemented.

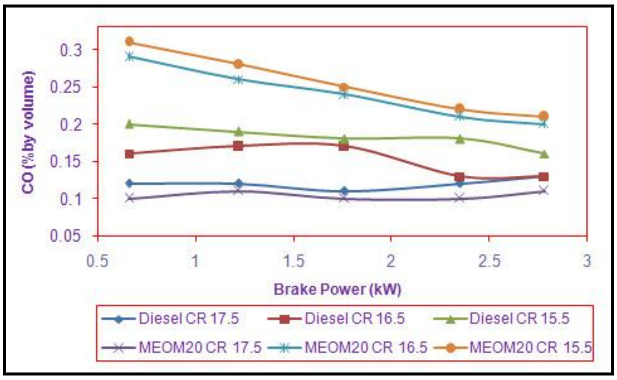

Figure 4 Carbon monoxide with brake power

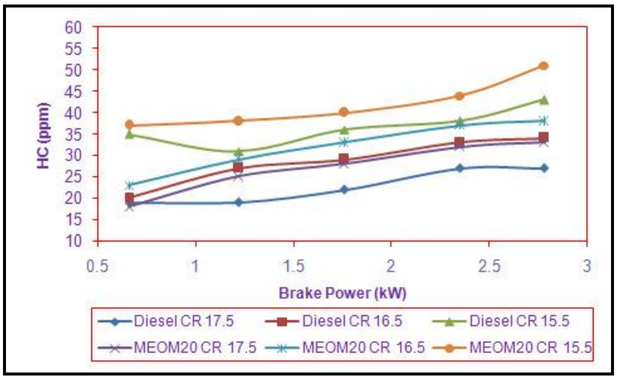

Figure 5 Hydrocarbon with brake power

4.2.3 Oxides of nitrogen:

Impact of various compression ratio on oxides of nitrogen (NOx) and brake power fuelled with diesel and B20 MEOM fuel is as plotted in figure 6. The plot shows that the oxide of nitrogen is decreased with decreases in compression ratio. The oxides of nitrogen for diesel is 1572 ppm and B20MEOM 1781 ppm at maximum load in compression ratio 17.5 while the corresponding figures for various compression ratio 16.5 and 15.5 of diesel and B20 MEOM are 953ppm, 846ppm, 974ppm and 946ppm respectively. The lower NOx is found in lower compression ratio, the main reason is lesser oxygen content. It leads to improper burring and lower temperature produced. The higher NOx is created at higher temperature in combustion chamber.

4.2.4 Smoke density:

Impact of various compression ratio on smoke density and brake power fuelled with diesel and B20 MEOM fuel as plotted in figure 7. The smoke density is increased with the compression ratio of 16.5 and 15.5. The smoke density is lesser for B20 MEOM blend at all compression ration compare with diesel fuel. The main concept here is, naturally bio fuel has more oxygen content compare diesel fuel. In full load and lower compression ratio condition, the content of oxygen in the bio fuel may promote comprehensive burning this cause lesser smoke emission.

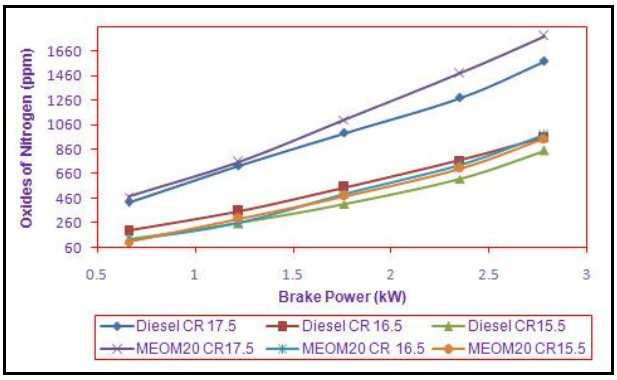

Figure 6 oxide of nitrogen with brake power

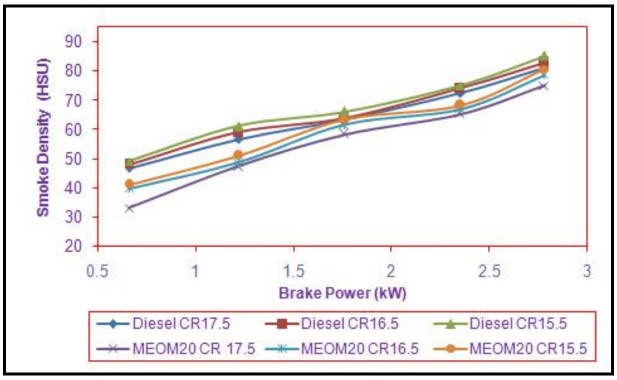

Figure 7. Smoke density with brake power

4.3 Combustion analysis

4.3.1 Cylinder pressure:

Impact of various compression ratio on cylinder pressure and crank angle fuelled with diesel and B20 MEOM fuel is as plotted in figure 8. From the plots, it is shown that the lower compression ration delay period is increasing for both diesel and B20 MEOM blends. The compression ratio of 16.5 and 15.5 has lower peak pressure for all fuels, this causes longer ignition delay. The higher cylinder pressure is found in diesel and followed by B20 MEOM at 17.5 compression ratio. Combustion in later stages was more erratic in the case of both diesel as well as B20 MEOM blend which may have lead to higher exhaust temperatures[13].

4.3.2 Heat release rate:

Impact of various compression ratio on heat release and crank angle fuelled with diesel and B20 MEOM fuel is plotted in figure 9. In lower compression ratio, there is a decrease in oxygen amount in air fuel ratio, it results in lesser temperature for the period of combustion. The ignition delay period is shorter for higher compression ratio of 17.5 in both diesel and B20 MEOM, this causes higher heat release rate to be attained. In lower compression ratio of 16.5 and 15.5, poor air fuel mixture is obtained. The poor mixture is leads to incomplete combustion and lower heat produced in the combustion chamber[14-15]. The lower NOx is found in lower compression ratio, this arise because of lesser oxygen content. It leads to improper burning and lower temperature.

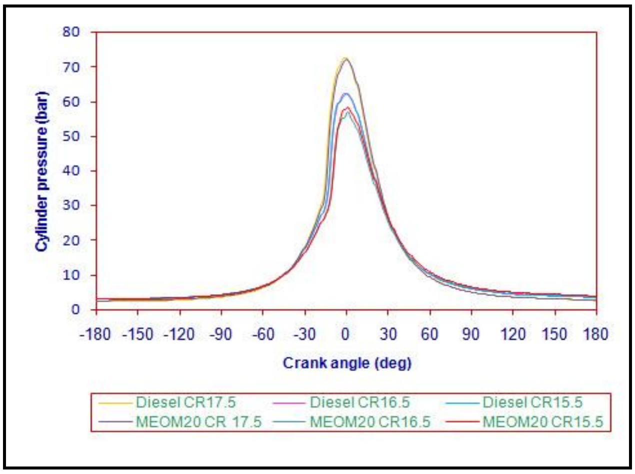

Figure 8 Cylinder pressure with crank angle

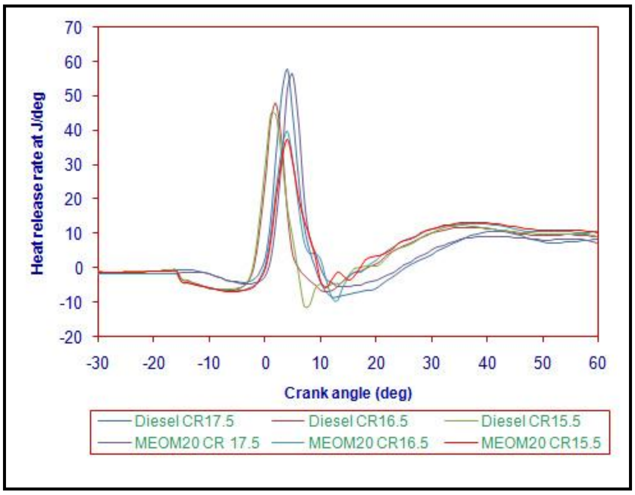

Figure 9. Heat release rate with crank angle

5. Conclusion:

The analysis is carried with diesel and B20 MEOM at three different compression ratios, the conclusion were made as given below. The lower specific fuel consumption is obtained in higher compression ratio. At higher compression ratio, the specific fuel consumption is reduced by 16.6% for diesel and 13.6% for B20MEOM. The maximum brake thermal efficiency for diesel is 28.18% and 28.04 % for B20MEOM at higher compression ratio in higher load condition. CO is higher at minimum load in higher compression ratio and lower at maximum load in lower compression ratio. With decrease in compression ratio, HC emission also increases for both diesel and B20 MEOM. At full load condition with 16.5 and 15.5 compression ratio, HC emissions differs from 34 to 43 ppm and 38 to 51 ppm for diesel and B20 MEOM respectively. The smoke density is lesser for B20 MEOM blend at all compression ratios compare with diesel fuel. The higher cylinder pressure is found in diesel followed by B20 MEOM at 17.5 compression ratio. The ignition delay period is shorter for higher compression ratio 17.5 in both diesel and B20 MEOM, this causes higher heat release rate to be attained.

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