The Influence of Bio Additive on the Various Compression Ratio with Diesel and Mahua Methyl Ester Biodiesel in DI Diesel Engine

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Abstract--- The increasing industrialization and modernization of the world lead to a steep rise in the consumption and demand for the petroleum based fuels every year. The present experimental investigation evaluates the effects of various compression ratio using blends of diesel fuel with 20% concentration of Methyl Ester of Mahua biodiesel blended with bio additive as an alternate fuel. Both the diesel and biodiesel fuel blend was injected at 23º BTDC to the combustion chamber. The experiment was carried out with three different compression ratio in DI diesel engine. Biodiesel was extracted from Mahua oil, 20% (B20) concentration with 3ml bio additive is found to be the best blend ratio from the earlier experimental study. The biodiesel B20MEOMBA3ml is tested with various compression ratio of 17.5, 16.5 and 15.5 respectively. The main objective is to obtain minimum specific fuel consumption, better efficiency and lesser Emission using bio additive blends with biodiesel when compared with baseline diesel. The results concluded that full load show an increase in efficiency when compared with diesel, highest efficiency is obtained with B20MEOMBA 3ml bio additive blend. It is noted that there is an increase in thermal efficiency as the compression ratio increases.

Keywords--- Methyl Ester of Mahua, Bio Additive, Compression Ratio, Performance, Emission.

I. Introduction

Energy is a primary source for economic development and social growth. The role of energy has got a direct impact on the growth of industries which contributes for the development of country's economy. In many countries, the diesel engines are widely used as prime movers in the field of power generation, agriculture and transportation. The rapid depletion of petroleum fuels and their ever increasing costs have lead to an intensive search for alternative fuels. Also there was a need to reduce the consumption of diesel fuel in the developed and in the developing countries. The sufficient amounts of energy resources are available which is essential to meet out our basic needs and thereby assuring a sustainable development [1]. The economic forecasting in the near future shall significantly depend on the long standing accessibility of energy in growing quantities from sources that are reliable, harmless and eco-friendly.

At present, the world is confronted with the twin crisis of fossil fuel depletion and environmental degradation which has put a limit in the use of conventional fuels. The search for alternate fuels for diesel engines has been intensified during the last few decades as substitute to fossil fuels. Countries like India which has strong agricultural resources can fulfil their energy requirements by focusing on the production of energy using the energy extract techniques from biofuels. Among the many alternative fuels, biofuels are considered as accessible and economical, which essentially plays a vital role for the development of industrialization. Many researches represented that there can be large potential work available in bio origin fuels. These biofuels can be used directly without any modifications made in the engine [2]. Some of the bio origin fuels are biodiesel, bio oil, bio gas, vegetable oil and alcohols, which can be used in the industries and in the transport sector as a replacement for existing fossil fuel. The bio fuels which are extracted from oil seed, crop and agricultural waste have less sulfur and more oxygen content. This research contributes an improvement for alternate resources, which reduces the emulating pollution. The objective of this study is to investigate the usage of biodiesel and bioadditive blended in order to reduce the emissions of all regulated pollutants from diesel engine. The analysis is further carried out with the effect of various compression ratio on engine for bio fuels.

II. Effect of Additives and Compression Ratio in Diesel Engine

Experimental investigation conducted on single cylinder CI engine with ferric chloride additive. The additive blends with used palm cooking oil and also blends with diesel separately in the proportion of 20 μmol per liter. This test was conducted at five different loads at constant speed. The results reported using the ferric chloride additive showed BTE decreased by 6% and SFC decreased by 6.3%, also ferric chloride additive added in biodiesel, the NOx emission was reduced and CO emission was higher. The smoke emission of ferric chloride additive was reduced by 52.6%, 26.6% and 6.9% correspondingly compared to diesel without ferric chloride additive in biodiesel [3]. Higher cylinder gas pressure, heat release rate and shorter ignition delay period were observed with FBC added biodiesel at these conditions.

This study investigated about the methyl ester of cotton seed oil production by transesterification process and blends with four different blends B5 to B20 in equally raised by 5%. An experiment is studied at constant speed in 1500 rpm with variable compression ratio (CR). The compression ratio of 15 and 17 were found better in performance characteristics with 5% blends. The oxides of nitrogen emission are higher in compression ratio 17 with B20 blend. Also reduction in carbon monoxide and smoke in all loads in higher compression ratio of 17 with B20 blend. They concluded B20 with higher compression ratio is suitable for diesel engine. [4]

Eknath studied about the two different biodiesel such as Jatropha and Karanja with Diesel in VCR diesel engine [5]. The experiments conducted with various compression ratios of 16 and 18. The longer ignition delay is noted in jatropha while compared to karanja, and higher viscosity is also noted in Jatropha. In both biodiesel B20 has showed lower exhaust gas temperature and lesser NOx.

In the present work the bio mileage is used as an additive with 20% of Methyl Ester of Mahua. The additive 3ml is blended with B20MEOM in order to increase the cetane number in biodiesel. This additive will gives better performance with biodiesel and less emission at different loads.

III. Experimental Setup

This experimental investigation is carried out in three different compression ratio with varying loads at constant speed of 1500 rpm. It is a four stroke, single cylinder, vertical, water cooled DI diesel engine. The test engine specifications were given in table 1. Both the diesel and biodiesel fuel is injected at 23ºBTDC. Biodiesel was extracted from Mahua oil used in 20% (B20) concentration with diesel. The bioadditive of 3 ml is added with B20MEOM and the experiment is conducted with 17.5, 16.5 and 15.5 compression ratio [6]. The physical properties of B20 Methyl Ester of Mahua are provided in table 2. Smoke density reading is identified by smoke meter in HSU. The emissions like hydrocarbon, carbon monoxide and oxides of nitrogen is measured using digas analyser from engine tail pipe. The engine is cooled by the flow water at constant rate for entire experiments. Engine load was applied by adjusting knob, which in turn connected to eddy current dynamometer.

Table 1: Details of Experimental Engine

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

In each load the performance parameter and emission parameter were measured [7]. The line diagram of the experimental system is shown in figure 1. The temperatures of the inlet and exhaust gas were measured by Chromel-Alumel K-type thermocouples. The combustion parameter like cylinder pressure and heat release rate is measured by using AVL combustion analyzer.

Table 2: Physical Properties in B20 MEOM

Test Property	B20 MEOM
Density at 15° C kg/m3	879.6
Kinematic Viscosity at 40°C	4.53
Flash Point (PMCC) °C, (min)	126
Pour point °C	5
Gross Colorific value k.cal/kg	9823

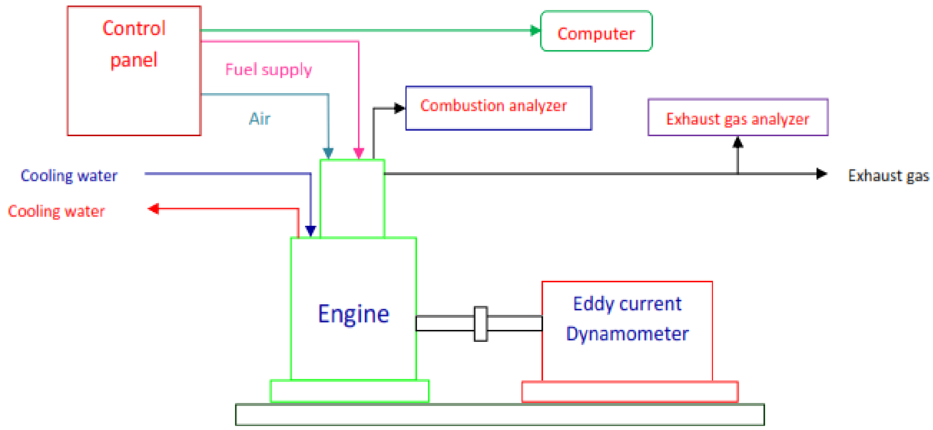

Figure 1: Line Sketch of Experimental System

IV. Results and Discussion

Performance Characteristics

The comparison of brake power and specific fuel consumption is shown in figure 2. The observation made from the graph shows specific fuel consumption (SFC) is decreased with increase in brake power of various compression ratio. The SFC for B20MEOMBA3ml blend fuel is 1% lower when compared to diesel at maximum value of load for compression ratio 17.5. The increase in specific fuel consumption is observed as compression ratio increases, due to better mixing of B20MEOMBA3ml at higher temperature causes complete combustion of fuel [8].

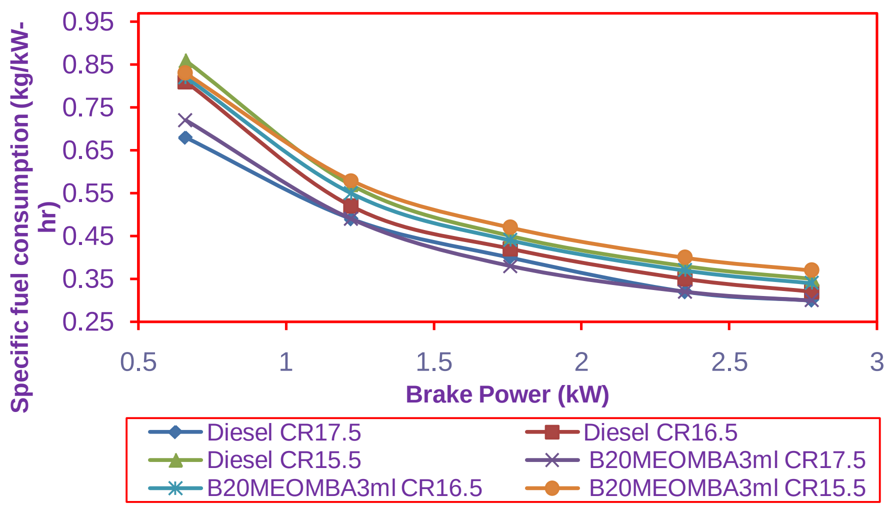

Figure 2: Specific Fuel Consumption with Brake Power (B20MEOMBA-CR)

The brake power with that of BTE is demonstrated in figure 3. It is noted from the plot 6.50 that when load value rises, BTE is also rises steadily. This is because of the rise in the value of load. There is an increase in brake power and thermal efficiency which also increases due to the heat formed in the cylinder. The experimental results plotted in the figure also demonstrates that the BTE obtained for compression ratio values of 16.5 and 15.5 for B20MEOMBA3ml blend was smaller than that of the compression ratio value of 17.5 both diesel and B20MEOMBA3ml. The brake thermal efficiency for diesel fuel and B20MEOMBA3ml at the maximum load is 28.18% and 27.99% in compression ratio 17.5. The higher CR such as 17.5 is remarkable change in the BTE. At CR value of 16.5, the BTE was 27.27% at the maximum load and for CR value of 15.5, the BTE was 26.05% at the maximum load.

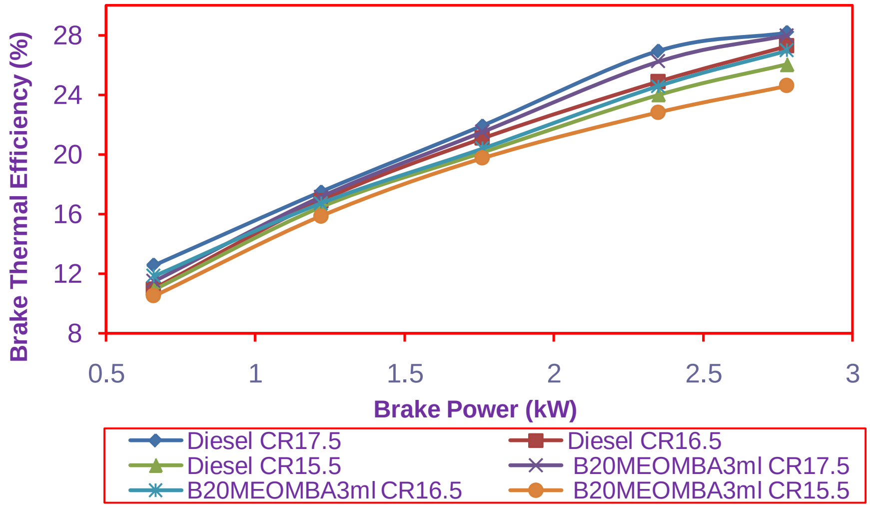

Figure 3: Brake Thermal Efficiency with Brake Power (B20MEOMBA-CR)

Emission Characteristics

Smoke density is commonly related with soot development. It is also coupled with less cylinder temperature and imperfect fuel burning. The deviation of the smoke density versus brake power is represented in figure 4. The smoke density increase gradually with a steady increase in the value of engine loads. The quantity of fuel consumed per unit time rises as the amount of load increases and subsequently the density of smoke also increases [9]. It is noted clearly from the plot that the smoke density is increasing for diesel at all loads for compression ratio 16.5 and 15.5. This is due to the incomplete combustion that happened because of the improper mixing in lower compression ratio. Smoke density is reduced at all loads for B20MEOMBA3ml blends at compression ratio 17.5.

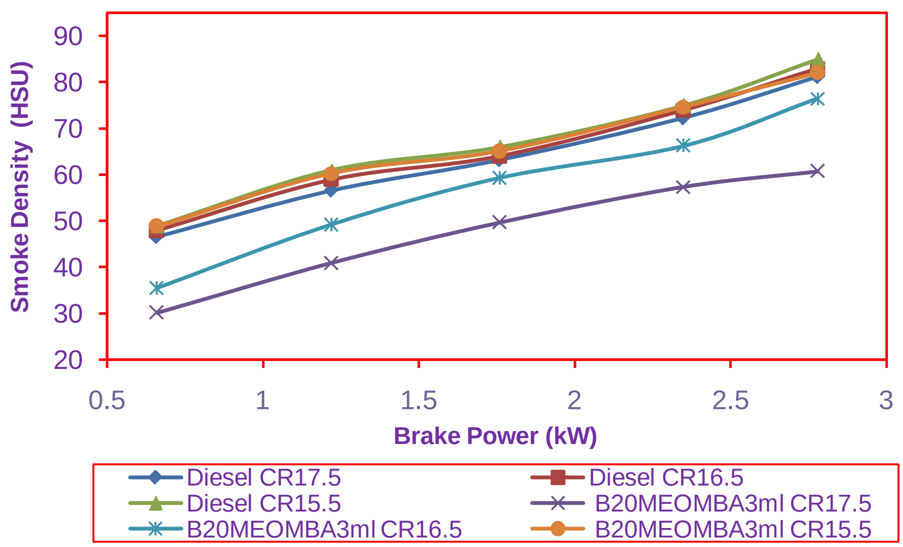

Figure 4: Smoke Density with Brake Power (B20MEOMBA-CR)

The difference in NOx emission with engine brake power is given in figure 5. Oxide of Nitrogen is produced as an effect of the oxidation of nitrogen in the atmosphere all through the burning of the air fuel combination in the ignition unit. The major aspect to make it possible and speed up the reaction between O_2 and N_2 to is temperature, resulting in high NO_x creation. The NOx emission of all compression ratio for the B20MEOMBA3ml blend was higher while compared to diesel fuel. This is due to bio diesel and bio additive are having higher oxygen content [11]. The NOx emission of diesel was decreased at lower compression ratio 16.5 and 15.5. The possible reason could be lesser in cylinder pressure and rate of heat release helps to reduce the temperature in the cylinder and thus reduces the NOx emission.

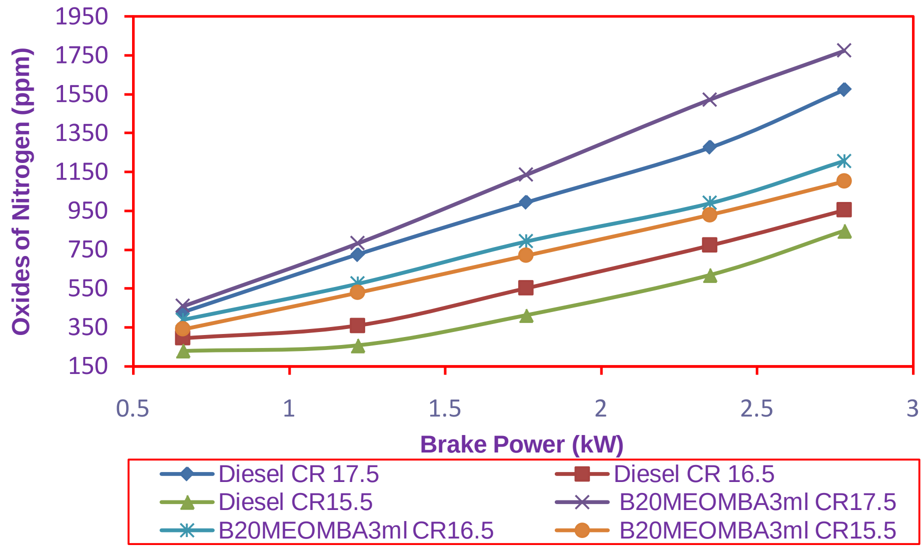

Figure 5: Oxides of Nitrogen with Brake Power (B20MEOMBA-CR)

Hydrocarbon emission with reference to brake power for all the blends of B20MEOMBA3ml and diesel is plotted in figure 6. The deviation of hydrocarbon emission is determined by load and composition of fuel of the engine. HC emission is mainly because of the incomplete burning. HC emission of compression ratio 17.5 for diesel fuel varied from 19 ppm (at low load) to 27 ppm (at maximum load). The change in hydrocarbon emission for sole diesel fuel for compression ratios of 16.5 and 15.5 was from 20 ppm at low load to 34 ppm at maximum load and 35 ppm at low load to 43 ppm at maximum load respectively. Hydrocarbon emission for B20MEOMBA3ml is 30 ppm at maximum load at compression ratio is 17.5 ppm. Hydrocarbon emission is lower for B20MEOMBA3ml blends in all compression ratios are compared with diesel fuel.

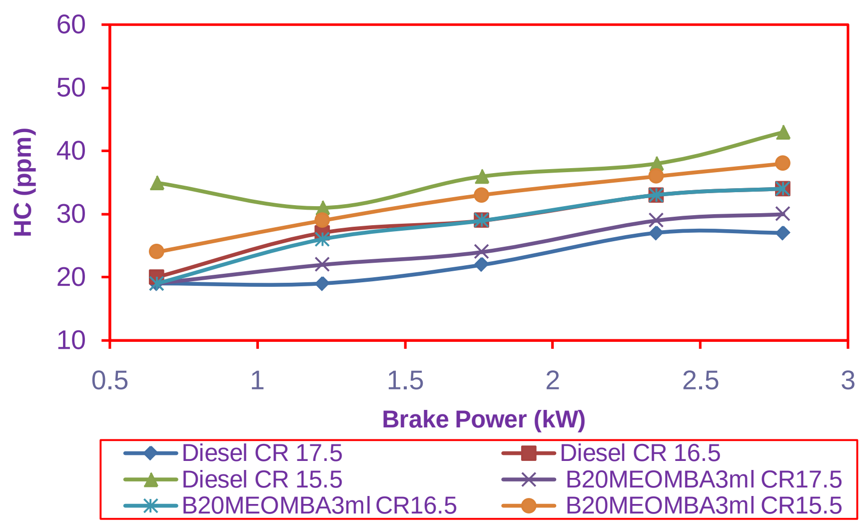

Figure 6: Hydro Carbon with Brake Power (B20MEOMBA-CR)

The comparison of CO emission and loads is mentioned in plot in figure 7. CO is primarily because of air-fuel correspondence ratio and in-cylinder temperature. The CO emission is changed (at low load) from 0.12 % vol to 0.13 % vol (at maximum load) for diesel at compression ratio 17.5. The results revealed that carbon monoxide emission is increased with decrease in compression ratio. The CO emission is lower in B20MEOMBA3ml compared to diesel. This may be because of the high carbon content of B20MEOMBA3ml at higher blends which leads to poor burring. The CO is also lower in greater compression ratio. This is probably due to complete combustion that takes place because of the better mixing in higher compression ratio [12].

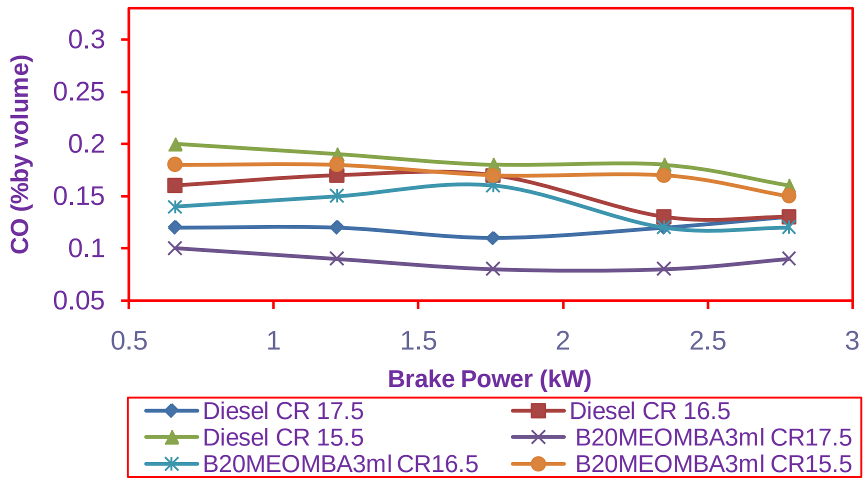

Figure 7: Carbon Monoxide with Brake Power (B20MEOMBA-CR)

Combustion Characteristics

The cylinder pressure with regard to crank angle for both diesel and various blends of B20MEOMBA3ml at peak brake power of the engine is exhibited in figure 8. The combustion is depicted by the oxidation process in the beginning, establishing a nucleus of flame, the heat liberated then increases the temperature and pressure of the air mass until the burning air charge pressure which exceeds the normal process. It is observed from the graph, compression ratio 16.5 and 15.5 of all the blends of B20MEOMBA3ml is lower compared to that of the diesel fuel and B20MEOMBA3ml at compression ratio 17.5. This higher compression ratio does not show any remarkable variation in the in-cylinder pressure at diesel and B20MEOMBA3ml. This is due to a change in the delay period which enhances the rate of pressure that rise during the combustion [13].

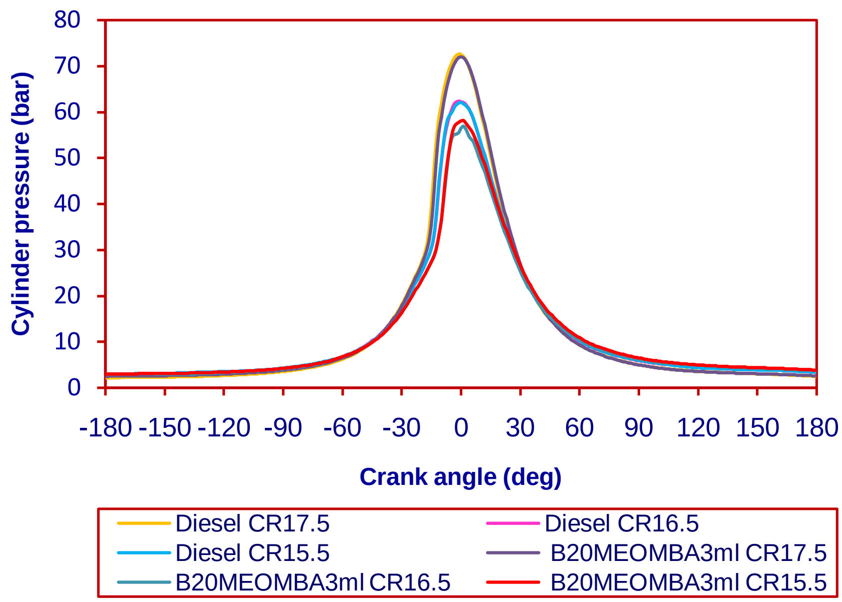

Figure 8: Cylinder Pressure with Crank Angle (B20MEOMBA-CR)

The rate of heat release for sole fuel and all the blends of B20MEOMBA3ml for the value of maximum load condition are shown in figure 9. It is analyzed from the plot that the rate of heat released in the case of

B20MEOMBA3ml blend at compression ratio 17.5 shows about 58.37 J/degree which was higher than that all other blends of B20MEOMBA and diesel. This is due do more oxygen content in B20MEOMBA blends.

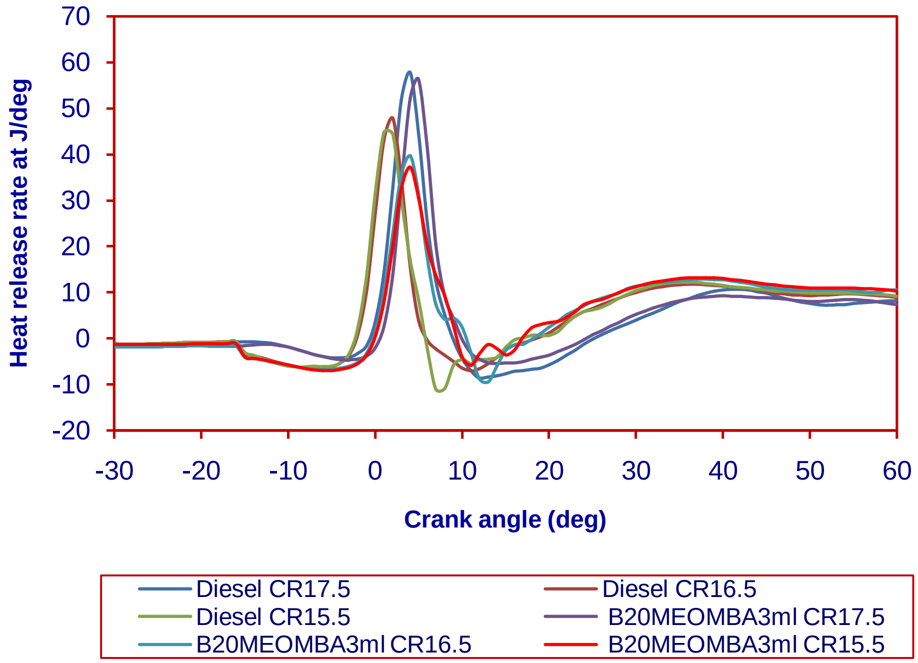

Figure 9: Heat Release Rate with Crank Angle (B20MEOMBA-CR)

V. Conclusion

The specific fuel consumption (SFC) is decreased with increase in brake power of various compression ratio. The SFC for B20MEOMBA3ml blend fuel is 1% lower when compared to diesel at maximum value of load for compression ratio 17.5. The higher CR such as 17.5 gives remarkable change in the BTE. Smoke density is reduced at all loads for B20MEOMBA3ml blends at compression ratio 17.5. The NOx emission of diesel was decreased at lower compression ratio 16.5 and 15.5. Hydrocarbon emission is lower for B20MEOMBA3ml blends in all compression ratios are compared with diesel fuel. The results revealed that carbon monoxide emission is increased with decrease in compression ratio. The CO emission is lower in B20MEOMBA3ml compared to diesel. It is observed that the cylinder pressure in compression ratio 16.5 and 15.5 of all the blends of B20MEOMBA3ml is lower compared to that of the diesel fuel and B20MEOMBA3ml at compression ratio 17.5. The rate of heat released is increased in B20MEOMBA3ml blend at compression ratio 17.5 when compared with all other blends. From the above study it is found that B20MEOMBA3ml with compression ratio 17.5 is the best optimum blend for diesel engine.

References

[1] Hashimoto, N., Ozawa, Y., Mori N., Yuri, I. and Hisamatsu, T. Fundamental combustion characteristics of palm methyl ester (PME) as alternative fuel for gas turbines. *Fuel* **87** (15) (2008) 3373–3378.

[2] Valente, O.S., da Silva, M.J., Pasa, V.M.D., Belchior, C.R.P. and Sodre, J.R. Fuel consumption and emissions from a diesel power generator fuelled with castor oil and soybean biodiesel. *Fuel* **89 (12)** (2010) 3637–3642.

[3] Kannan, G.R., Karvembu, R. and Anand, R. Effect of metal based additive on performance emission and combustion characteristics of diesel engine fuelled with biodiesel. *Applied Energy* **88** (11) (2011) 3694–3703.

[4] Anand, R, Kannan, G.R., Reddy, K.R. and Velmath, S. The Performance and Emissions of a Variable Compression Ratio Diesel Engine Fuelled With Bio-Diesel From Cotton Seed Oil. *ARPN Journal of Engineering and Applied Sciences* **4** (9) (2009) 72-87.

[5] Eknath, J.R.R. and Ramchandra, J. Effect of Compression Ratio on Energy and Emission of VCR Diesel Engine Fuelled With Dual Blends of Biodiesel. *Journal of Engineering Science and Technology* **9** (5) (2014) 620-640.

[6] Sivaganesan, S. and Chandrasekaran, M. The Influence of Bio Additive on the Compression Ignition Engine with Diesel and Mahua Methyl Ester Biodiesel. *International Journal of Chemical Sciences* **14** (4) (2016) 3097-3106.

[7] Karthick, D., Dwarakesh, R. and Premnath, R. Combustion and Emission Characteristics of Jatropha Blend as a Biodiesel for Compression Ignition Engine with Variation of Compression Ratio. *International Review of Applied Engineering Research* **4** (1) (2014) 39-46.

[8] Wang, X., Di, C.S. and Di, Y. and Huang, Z. Diesel engine gaseous and particle emissions fueled with diesel–oxygenate blends. *Energy* **94** (2012) 317–323.

[9] Burnwal, B.K. and Sharma, M.P. Prospects of biodiesel production from vegetable oils in India. *Renewable and Sustainable Energy Reviews* **9** (4) (2005) 363–78.

[10] Kadarohman, A., Hernani, Khoerunisa, F., and Astutia, R.M. Potential Study On Clove Oil, Eugenol And Eugenyl Acetate As Diesel Fuel Bio-Additives And Their Performance On One Cylinder Engine. *Transport* **25** (1) (2010) 66–76.

[11] Kadarohman, A., Rohman, I., Kusrini, R. and Astuti, R.M. Combustion characteristics of diesel fuel on one cylinder diesel engine using clove oil, eugenol, and eugenyl acetate as fuel bio-additives. *Fuel* **98** (2012) 73–79.

[12] Keskin, A., Guru, M. and Altıparmak, D. Influence of metallic based fuel additives on performance and exhaust emissions of diesel engine. *Energy Conversion and Management* **52** (2011) 60–65.

[13] Karthick, D., Dwarakesh, R. and Premnath, R. Combustion and Emission Characteristics of Jatropha Blend as a Biodiesel for Compression Ignition Engine with Variation of Compression Ratio. *International Review of Applied Engineering Research* **4** (1) (2014) 39-46.