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To cite this article: S Sivaganesan *et al* 2017 *IOP Conf. Ser.: Mater. Sci. Eng.* **183** 012039

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

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**Abstract.** The present experimental investigation evaluates the effects of using blends of diesel fuel with 20% concentration of Methyl Ester of Jatropha biodiesel blended with various compression ratio. Both the diesel and biodiesel fuel blend was injected at 23° BTDC to the combustion chamber. The experiment was carried out with three different compression ratio. Biodiesel was extracted from Jatropha oil, 20% (B20) concentration is found to be best blend ratio from the earlier experimental study. The engine was maintained at various compression ratio i.e., 17.5, 16.5 and 15.5 respectively. The main objective is to obtain minimum specific fuel consumption, better efficiency and lesser Emission with different compression ratio. The results concluded that full load show an increase in efficiency when compared with diesel, highest efficiency is obtained with B20MEOJBA with compression ratio 17.5. It is noted that there is an increase in thermal efficiency as the blend ratio increases. Biodiesel blend has performance closer to diesel, but emission is reduced in all blends of B20MEOJBA compared to diesel. Thus this work focuses on the best compression ratio and suitability of biodiesel blends in diesel engine as an alternate fuel.

## 1. Introduction

The economy and the development of the country mainly depend on its energy resources. 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. 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 [1]. 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. 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 research is to investigate the usage of biodiesel 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.

## 2. Effect of compression ratio in diesel engine

This study reveals the natural aspirated, various compression ratio engine with different biodiesel blends (B10, B20, B30, B40, B60, B80 and B100). The test was conduct in no load to full load in all blends. All emission parameter such as HC, CO, and NO<sub>x</sub> were measured. The compression ratio was varied from 14 to 18 with equal interval of two. In higher compression ratio 18 the BTE was increased and lower in SFC. The results shown B20 biodiesel was superior in both performance and emission parameter in higher compression ratio of 18 compare to other compression ratio and other biodiesel blends [2].

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 [3].

The performance of DI compression ignition engine with blends of 5-carbon alcohol, rubber seed biodiesel and diesel at various compression ratio (CR) viz.16: 1, 17.5: 1, 19: 1. It proves that CR 17.5 is the best compression ratio for all the blends. The result shows that the emission is reduced except for NO<sub>x</sub> when compared with the diesel fuel. Finally concluded that emission was reduced in R10P10 blend at CR 17.5 and it is an eco friendly alternative fuel [4].

This experiment was tested in uneven firmness ratio engine (VCR) with methyl ester of jatropha oil (MEOJ) and diesel. The compression ratio was varied for 14, 16, 18 and 20. The BTE and BSFC were measured for performance parameter and CO, CO<sub>2</sub>, HC, NO<sub>x</sub> and smoke for emission parameter. It was noticed that higher CR, performance of engine increased apparently with less BSFC for biodiesel blends fuel. The emission was higher for CO and CO<sub>2</sub>, HC, NO<sub>x</sub> and smoke density emission is lower when CR is higher. The higher compression ratio of the combustion parameter is improved in biodiesel blends [5].

## 3. Experimental Setup

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 engine details were mention in table 1. The both diesel and biodiesel fuel was injected at 23°BTDC. Biodiesel was extracted from Jatropha oil used in 20% (B20) concentration with diesel in all compression ratios [6]. The physical properties in B20 MEOJ are provided 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.

**Table 1.** Details of Experimental Engine

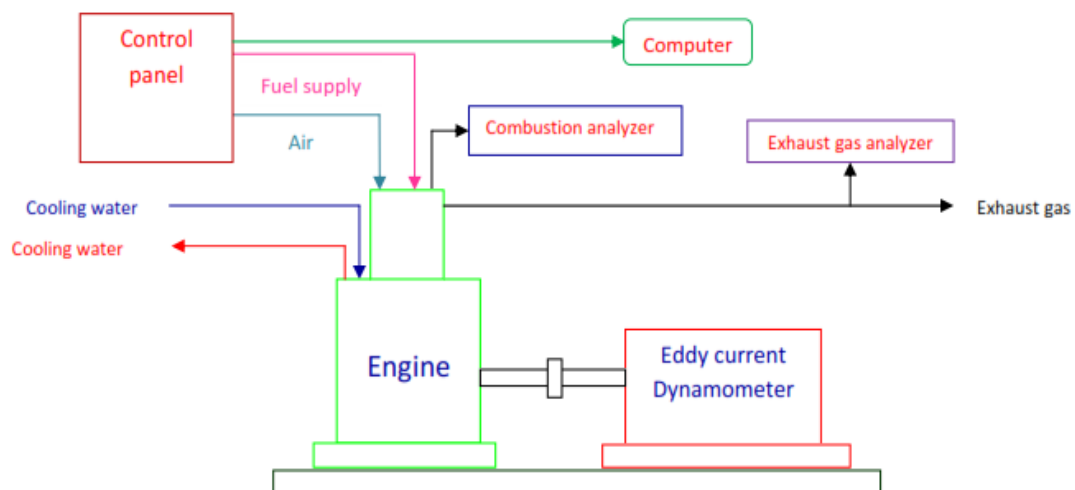
Manufacturer	Kirlosker TV – I
Category	Vertical cylinder, DI diesel engine, VCR engine
Number of cylinder	1
Bore X Stroke	87.5 mm X 110 mm

Compression ratio	17.5
Speed	1500 rpm
Rated brake power	5.2 kW
Cooling system	Water cooling
Injection timing	23°BDTC

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 [7]. The experimental system sketch is plotted in figure 1. The inlet and exhaust gas temperature were measured by Chromel-Alumel K-type thermocouples. The combustion parameter was measured by combustion analyzer.

**Table 2.** Physical Properties in B20 MEOJ

Test Property	B20 MEOJ
Density at 15° C kg/m <sup>3</sup>	868.2
Kinematic Viscosity at 40°C	4.36
Flash Point (PMCC) °C, (min)	138
Pour point °C	5
Gross Colorific value k.cal/kg	10280



**Figure 1.** Line Sketch of Experimental System

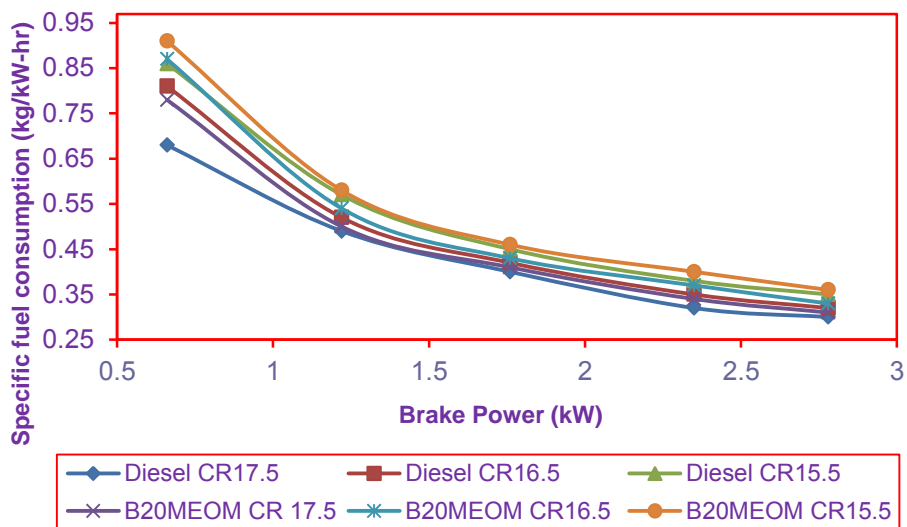
## 4. Results and Discussion

### 4.1 Performance characteristics

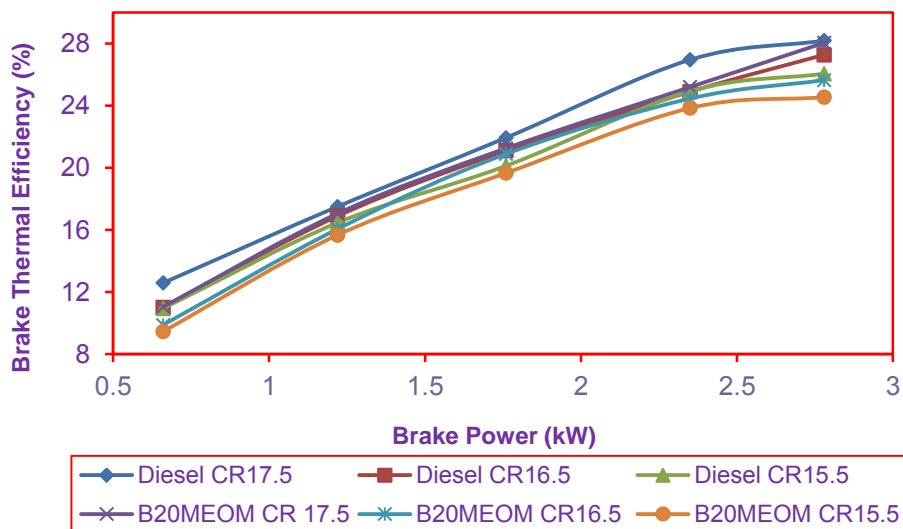
The different compression ratio on SFC for the blend of B20 MEOJ and diesel fuel is reported in figure 2. Among the three compression ratio tried, it was observed that specific fuel consumption is

least at 17.5 for both diesel and B20 blends. This is due to improvement in physical properties of MEOJ oil. It is concluded that the higher compression ratio shows better results [8].

The difference of BTE with different loads in various compression ratio with blend of B20MEOJ is shown figure 3. From the figure, higher BTE is obtained in higher compression ratio of 17.5 in diesel and B20MEOJ blends the maximum BTE was 28.18 and 28.04% respectively, hence it was predicted that there was a marginal improvement on performance while increasing the compression ratio [9].



**Figure 2.** Specific fuel consumption with Brake Power (B20MEOJ-CR)



**Figure 3.** Brake thermal efficiency with Brake Power (B20MEOJ-CR)

*4.2 Emission characteristics*

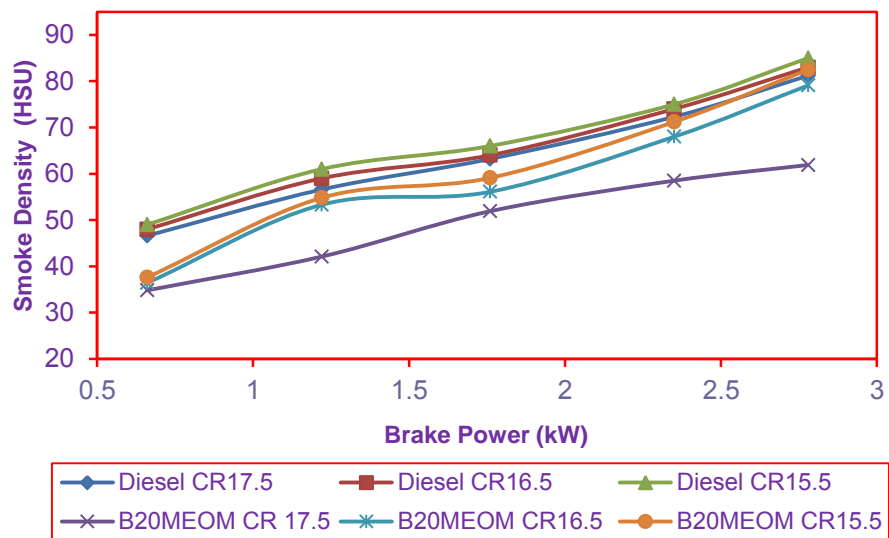
The difference in smoke density in diesel and B20 blends of MEOJ oil at compression ratio of 17.5, 16.5 and 15.5 is depicted in figure 4. For the B20 blends of MEOJ the 17.5 compression ration

resulted in the lowest smoke density over the entire output range. All biodiesel blends lower smoke density in all compression ratio is compared with diesel [10].

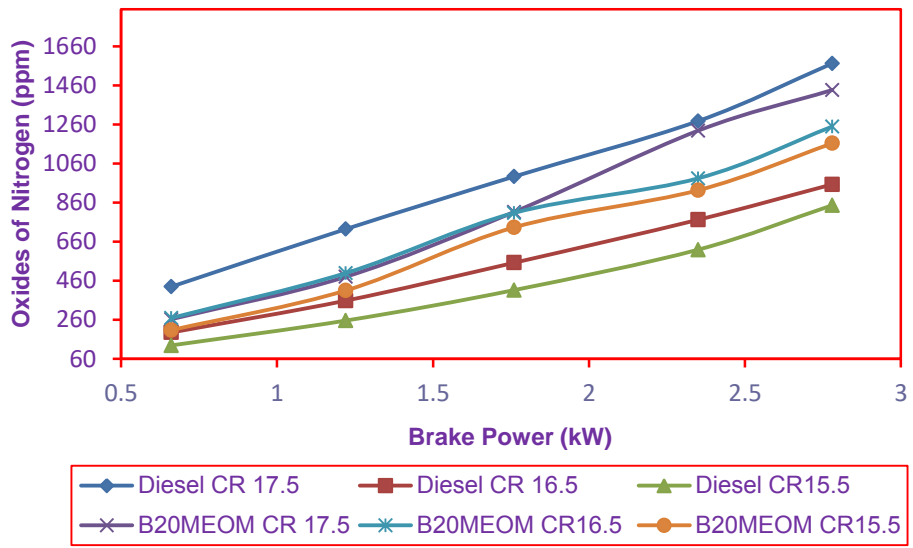
The differences in NO<sub>x</sub> emission with different loads at different compression ratio is exhibited in figure 5. For all the blends NO<sub>x</sub> emission is raising with rising of loads. In compression ratio of 15.5, the NO<sub>x</sub> emission is optimum over the entire output range with diesel. The corresponding NO<sub>x</sub> values at maximum output are 846 ppm. Diesel at 15.5 compression ratio is the overall optimum combination for lower NO<sub>x</sub> emission.

The Hydro Carbon emission for B20 blends of MEOJ and diesel at various compression ratio (CR) effects plots in figure 6. The HC emission increase or decrease is based on the CR value. Normally if the CR value is increased, the HC emission reduced. At full load with the CR of 17.5, the HC for B20 is 33ppm while compared to other compression ratio. During the end of the compression stroke the air temperature gets higher, this enhance the complete burning and reduction HC emission [11].

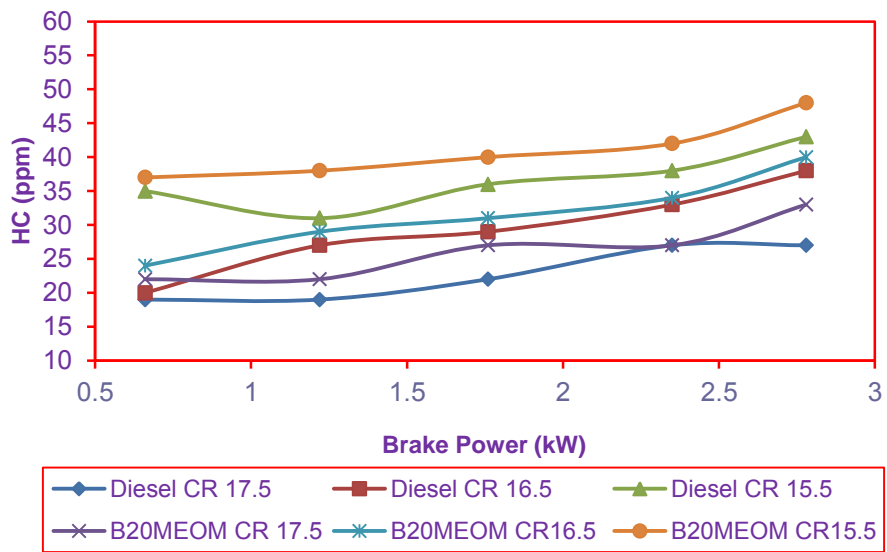
The difference of Carbon monoxide emission for B20 blends of MEOJ and diesel fuel with various CR is indicated in figure 7. It is noted that the increase of CR value with decrease of Carbon monoxide emission. At full load with the CR value of 17.5, the Carbon monoxide emission for B20MEOJ is 0.07 % and 53% decreasing of Carbon monoxide emission is achieved. The reason is entire burning of the fuel takes place during combustion (Eliana Weber de Menezes et al. (2006)).



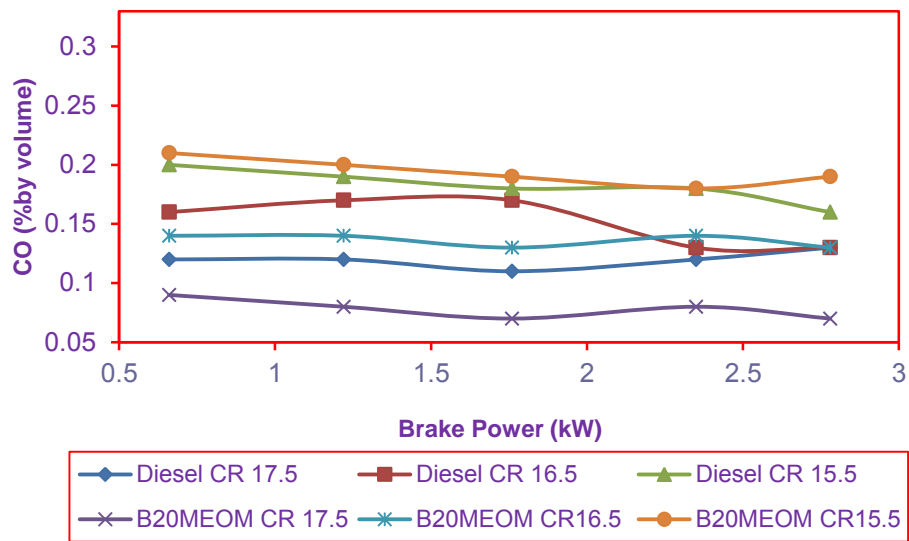
**Figure 4.** Smoke density with Brake Power (B20MEOJ-CR)



**Figure 5.** Oxides of Nitrogen with Brake Power (B20MEOJ-CR)



**Figure 6.** Hydro carbon with Brake Power (B20MEOJ-CR)



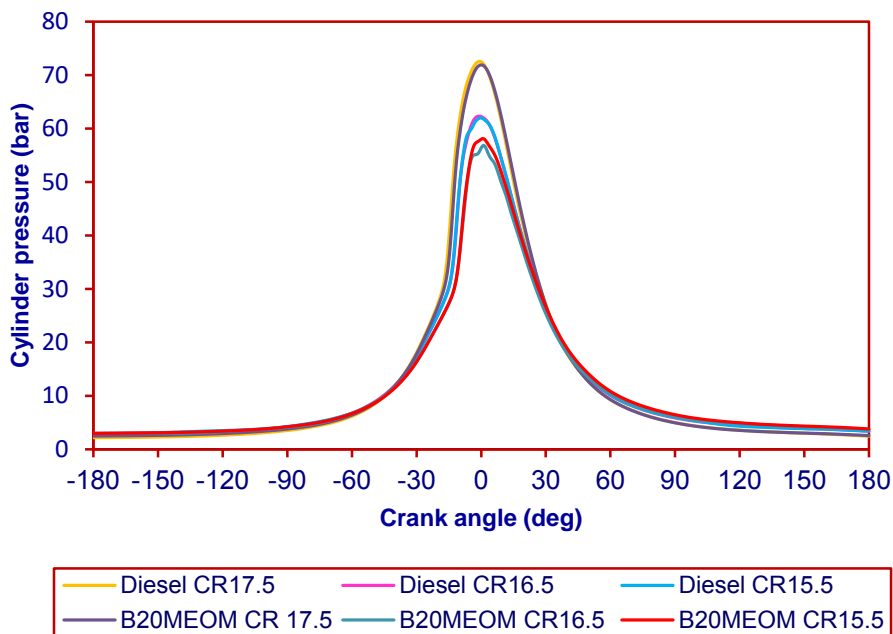
**Figure 7.** Carbon monoxide with Brake Power (B20MEOM-CR)

#### 4.3 Combustion characteristics

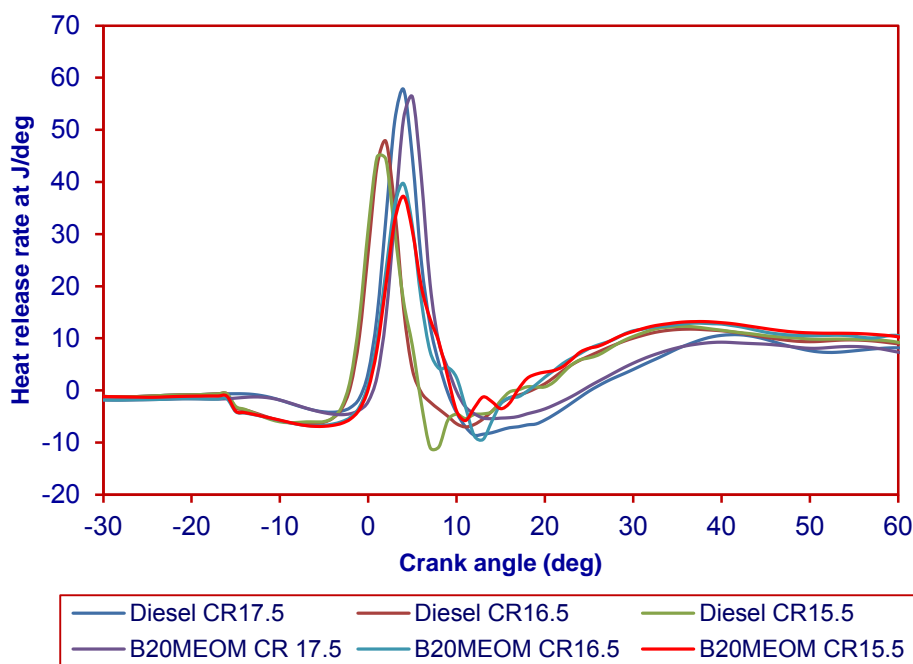
Cylinder pressure with crank angle of B20 blend of MEOJ and diesel fuel with different compression ratio at maximum load is depicted in figure 8. The maximum cylinder pressure is obtained in diesel compared to B20 blend of MEOJ for entire range of load operation. During the increase in the compression ratio the combustion that occurs before the top dead center as a result rapid pressure rise will take place [12].

Comparison of heat release at different compression ratio with B20 blend of MEOJ, and diesel fuel at maximum load is plotted in figure 9. At compression ratio of 17.5, the heat release rate of B20 blend MEOJ and diesel fuel are 57.75 J/degree and 49.87 J/degree respectively. However the heat release rate is increased in diesel fuel while compared to B20MEOJ. The reason for this is due to the increase in the combustion that takes place during the diffusion phase [13].





**Figure 8.** Cylinder pressure with Crank angle(B20MEOJ-CR)



**Figure 9.** Heat Release rate with Crank angle (B20MEOJ-CR)

### 5. Conclusions

It was observed that among the three compression ratio specific fuel consumption is least at 17.5 for both diesel and B20 blends. The higher BTE is obtained in higher compression ratio of 17.5 in diesel and B20MEOJ blends. The compression ratio 17.5 resulted in the lowest smoke density over the entire

output range. All biodiesel blends emit lower smoke density in all compression ratio when compared with diesel. The NO<sub>x</sub> emission is reduced in compression ratio of 15.5. When the CR value is increased, the HC and Carbon monoxide emission reduced. The maximum cylinder pressure is obtained in diesel compared to B20 blend of MEOJ and the heat release rate is increased in diesel fuel while compared to B20MEOJ. The results concluded that the compression ratio 17.5 with B20MEOJ biodiesel blend is the best compression ratio in terms of performance, emission and combustion when it is compared with baseline diesel.

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