Experimental Investigations on Modified Combustion Chamber Geometry in Diesel Engine

ShaikHussain, Sanam Ravi Teja

Abstract: Today the two disturbing conditions in front of the engineers worldwide are to decrease the utilization of conventional fuels and to downscale the ever rising environmental pollution.The performance characteristics and emission characteristics of single cylinder water cooled diesel engine with the effect of piston crown geometries such as HCC (Hemispherical combustion chamber) and RCC (Re-entrant combustion chamber) are evaluated. The tests are conducted with diesel and Rice Bran Methyl Ester and Diesel blends as fuels with different loading conditions. Rice bran methyl ester is prepared by using transesterification process. Without modifying the compression ratio and cylindrical volume of the engine the baseline hemispherical type piston is replaced with Re-entrant type piston. All the engine tests were conducted with diesel and 20% blend with diesel [RBOME20] indiesel engine with HCC and RCC. From the investigations it is observed that the brake point thermal efficiency is increased and specific fuel consumption proportion is decreased for re-entrant combustion chamber. Further thenormal pollutants emissions are reduced. But slightly increase in nitrogen oxides is detected compared to base fuel for re-entrant combustion.

Keywords: Diesel engine, biodiesel, re-entrant combustion chamber, Hemispherical Combustion chamber and Rice bran methyl ester.

I. INTRODUCTION

Conservation of energy and emissions have become of rising concern over last few decades. More stringent emission laws along with the need to conserve the limited resources of petroleum based fuels, engineers related are under notable pressure to enhance their energy efficiency and diminish the exhaust emission levels. In this circumstance, there has been developing the interest and immense research on the actions that take place in the IC engines and the alternative fuels such as biodiesel to supply a proper diesel oil use for the internal combustion engines. However the results of the first stage of this research plan and majority of the studies exploration on the performance of the biodiesel fuelled the diesel engine specified, reduces in power of engine and the thermal efficiency, raising in the specific fuel consumption and raising the in emissions especially NOx, when compared with theoperation ofstandard diesel.

The destitute performance of the biodiesel controlled diesel engines in comparison with the petroleum basedengines is mostly due to the changes in the properties of fuel, design of engine and operating parameter. The characteristics of p of the DI diesel engine are highly effects by the motion of air in the inner side of the cylinder. The mixing of air-fuel and the following combustion in the DI diesel engines are restrained by flow field inside the cylinder happened by the combustion chamber specifications. The motion of air in the diesel engine, in the course of compression stroke is causes by the combustion chamber. Hence, configurations of combustion chambers require a great attention to contact the global movements in the consumption of fuel, performance and emissions.

In this stage of exploratory work, without changing the engine's compression ratio, geometry of piston bowl was modified from the baseline HCC (Hemispherical Combustion Chamber) to the RCC (Re-entrant Combustion Chamber) by using rice bran oil methyl ester blended with diesel.

S. Jaichandar et al [8] (2012) investigates re-entrant combustion chambers for better air movement and charge mixing. However UBHC, CO and the smoke intensity in the modified engine partly increase with slow injection timing because of poor initial phase of combustion. The increased squish and swirl of the modified engine improves the charge mixing that which results in good combustion and increases temperature of combustion chamber and further increases NOx in modified engine.The biodiesel B20 obtains from Pongamia oil improves the combustion, performance and emission characteristics because of better mixing and enhanced combustion.[8]

II. MATERIALS AND METHODS

2.1 Preparation of Rice bran oil methyl ester (RBOME)

Rice bran oil was choose for this investigation and gets converted it into its methyl ester by trans-esterification. In this trans-esterification reaction, initially 250 ml of methanol was mix-up with the 150 ml of NaOH. The time taken for the reaction is six hours at 55˚C [1]. Then the mixture was kept for minimum eight hours at ambient temperature and then separates the settled glycerin. After decanting glycerol, the methylene esters get washed off with water. The characters of RBOME were found and compares with the diesel [3]. The comparison shows that the properties of rice bran oil methyl ester are relatively closer to diesel fuel properties.

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The test fuels were prepares with RBOME blends RBOME20 and diesel. Originally, the experiments were conducted in a baseline engine mounted with HCC piston using RBOME20 and diesel with customary injection timing and injection pressure ant the outcomes were compared with diesel. Finally, with RBOME20 and diesel on a modified engine mounted with RCC piston at variable load and the obtained results were compared with again with the diesel fuel.

2.2 Experimentation

The engine designated for experimentation was single cylinder DI and four strokes, water cooled diesel engine and the engine can resist the higher pressures and is vastly used in agricultural sector and in industries. The details of the engine specifications are represented on the table. The engine runs at rated speed of 1500 rpm, compression ratio of 16:1 and rated power output of 3.7kW. The engine had a hemispherical shaped open type combustion chamber with overhead valve arrangement and operates with push rods and camshaft. [4]

Without changing the compression ratio the hemispherical piston is modified into re-entrant type piston and the modified combustion chamber geometry is shown in (Figure3) with HCC. Then, the experiments were conducts by using RBOME biodiesel and diesel fuel to study the hemispherical and re-entrant combustion chamber shapes as in Figures 2. Then, the results were used to substantiate the performance and radiation characteristics of the engine. The emissions at exhaustion analyzed by krypton 290 gas analyzer

Table.1 Specifications

S. No.	Details	Specifications
1	Power	3.7kW
2	Speed	1500 rpm
3	Compression Ratio	16:1
4	Connecting rod length	230 mm
5	Stroke Length	110 mm
6	Cylinder Bore	80 mm
7	No. of Cylinders	1
8	Stroke type	4
9	Indicator Used Type	Cylinder Pressure
10	Dynamometer Type	Swinging field type
11	Cooling Type	Water
12	Speed Type	Constant

FIGURE 2.1: Experimental setup

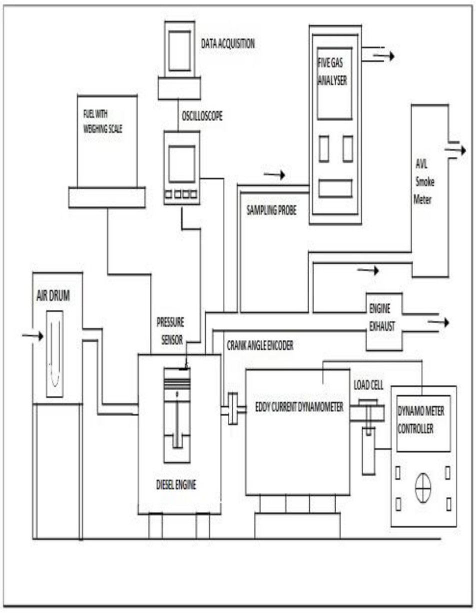

FIGURE 2.2: ExperimentalBlock

(a) **(b)**

FIGURE 2.3(a) Hemispheric Combustion Slot
(b) Re-entrant Combustion Cavity

1. RESULTS AND DISCUSSION

3.1 Brake Thermal Efficiency:

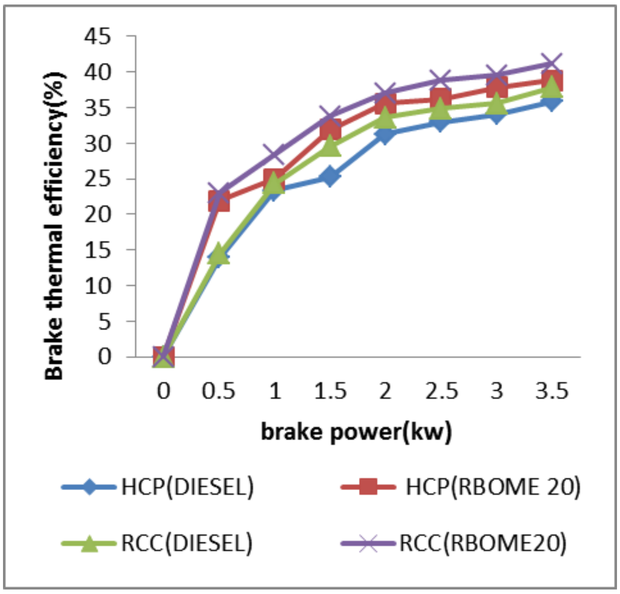

FIGURE 3.1: BP Vs Brake point thermal efficiency

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Figure 3.1 describes the comparison of brake point thermal efficiency with brake point power for standard diesel and rice bran oil methyl ester for both of the combustion chambers. The BTE of B20 with baseline engine having HCC is higherin comparison with diesel. Whereas the engine is operates at constant injection timings and RBOME has little ignition delayed. Hence combustion gets initiated before TDC. By this there is increase in heat losses and hence lowers the BTE of engine and increases compression. The BTE for RCC with RBOME20 is complex compared with baseline engine at all the loads. This is due to the greater mixture formation of RBOME20 with air that results in finer air motion in RCC piston, which causes the better combustion of RBOME20 and hence the BTE is increased. The brake thermal efficiency of RCC is about 2.7% more when fuelled with RBOME20 than standard diesel.

3.2 Brake Specific Fuel Consumption:

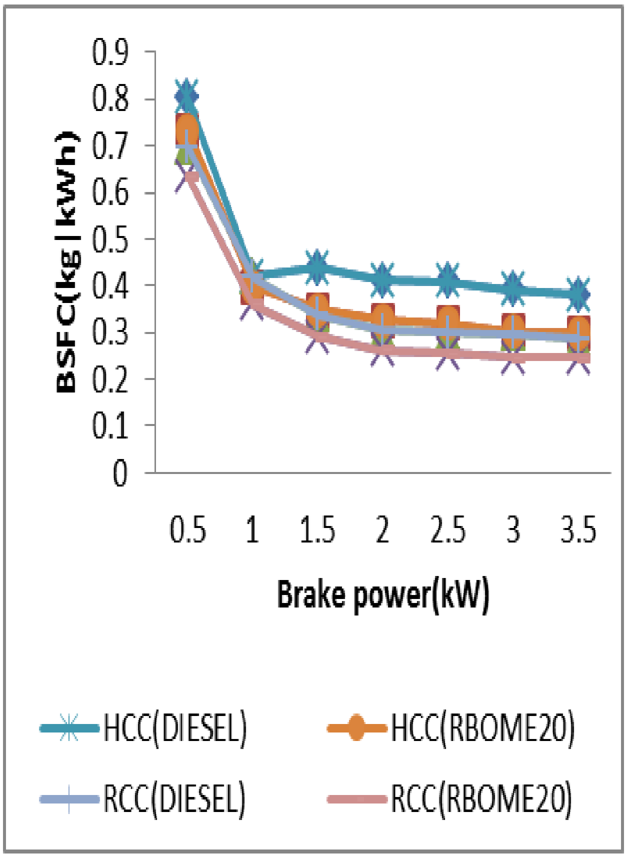

FIGURE 3.2: BP Vsspecific fuel consumption at brake pt.

The comparison of BFSC for tradiltional engine and modified new engine operated with standard diesel and ROME20 are shown in Figure 3.2. The BSFC for RCC is (0.252 kg/ kW-hr). This is lower than hemispherical combustion chamber with RBOME20 fuel under full load conditions. This attributes to greater combustion of RBOME20 because mixing of air and fuel results in turbulent kinetic energy (TKE) and improves in swirl velocity. The BSFC for RCC withRBOME20 is lower compared to conventional engine and is about 4.96%at rated load operation of the engine.

3.3: Carbon Monoxide Radiations

Figure 3.3 shows the comparison of carbon monoxide emissions of HCC and RCC combustion chambers by using standard diesel and RBOME20 in respect of brake power. The Carbon monoxide emissions for both HCC and RCC combustion chambers are reduced with RBOME 20 compared to standard diesel. The CO emissions are further reduced with RCC combustion chamber compared base engine from no load to specific r load operations because of greater movement of air in RCC and oxygen proportion in the RBOME that leads to better fuel combustion. The amount of reduction in Carbon monoxide emission for RBOME20 with RCC is 33.2% when compared with standard diesel engine.

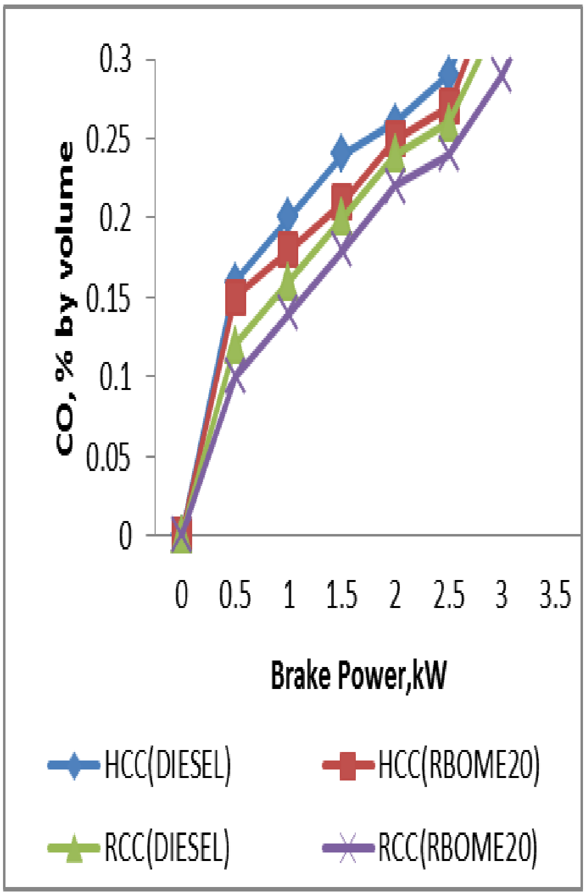

FIGURE 3.3: BP Vs Carbon monoxide emission

3.4 Hydrocarbon Emissions:

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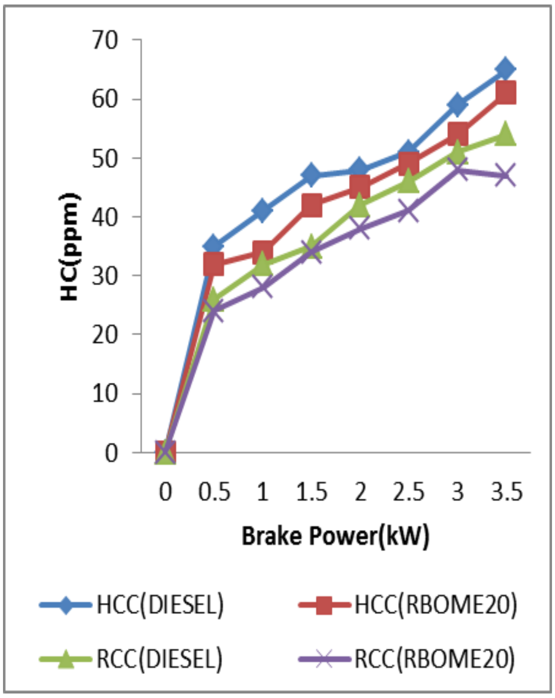

FIGURE3.4 BP Vs Hydrocarbon emissions

In Figure 3.4 shows that, the comparison of hydrocarbon emissions for both combustion chambers HCC and RCC operated with RBOME20 and standard diesel. HC radiations were decreases at full loads of HCC and RCC combustion fuelled with RBOME20 instead of standard diesel. But, it is observed that RCC emits low level of Hydrocarbons that compares with HCC. This is because of better combustion of RBOME20 as results of superior swirl motion of air in RCC along with oxygen in RBOME20 which leads to the unique air-fuel mixture. There is a decline of 16.6% HC radiations for RCC with RBOME20 and 23.07% with standard diesel compared to base engine.

3.5 Nitrogen oxide Emissions:

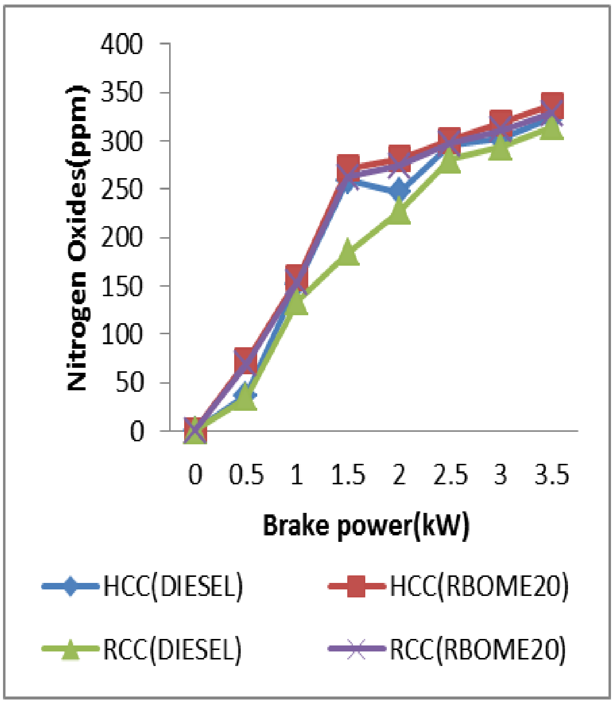

FIGURE 3.5 BP Vs Nitrogen oxide emissions

Figure 3.5 showsnitrogen oxide emissions with brake power for baseline engine HCC and modified RCC with fuelled RBOME20 and standard diesel. The NO_x emissions for RBOME20 were higher for RCC than baseline engine. The NO_x emissions increased by 7.2% for RBOME20 with RCC compares with HCC. The reason for increasing in nitrogen oxide emissions is due to greater combustion temperature by formation of unique mixture that results in the upgraded combustion. For RBOME20 with RCC, the NO_x emission is 488 ppm and for that of base fuel is 445 ppm at full load conditions.

III. CONCLUSIONS

The investigates are conducted onfour stroke water cooled diesel engine withsingle cylinder two piston bowl geometries such as Hemispherical and Re-entrant. The performance and emission physiognomies ofbiodiesel fuelled DI diesel engine are determined. From the investigation the following conclusions are drawn:

- ✓ Based on performance and emission characteristics RBOME gives better Brake thermal efficiency, less fuel consumption and reduction in CO and unburnt HC radiations and slightly intensifies in NOx emissions for Re-entrant than compared to base engine(hemispherical).
- ✓ The brake point thermal efficiency of RCC is about 2.7% more when fuelled with RBOME20 than standard diesel.
- ✓ Enhanced air motion in re-entrant combustion chamber enhances the air fuel mixture formation increases BTE simultaneously reduces BSFC IN comparison with hemispherical combustion chamber. Better combustion because of better mixing of air and fuel in re-entrant that gives greater thermal efficiency for RBOME20.
- ✓ The CO, unburnt HC,CO2 were lesser for re-entrant than hemispherical by using RBOME20 because enhanced the mixing of air and fuel and greater presence of oxygen is more in RBOME20 and gives better combustion compares with hemispherical.
- ✓ NOx emissions are increased for re-entrant due to greater combustion temperature by formation of a mixture better than earlier one and accessibility of oxygen in RBOME that results in the upgraded combustion than HCC.
- ✓ The experimental results show that the re-entrant combustion chamber geometry performs a significant role that decides the swirl and turbulence in cylinder.
- ✓ The results indicates that the RCC combustion chamber with RBOME 20 as fuel can be used in existing diesel engines without any modifications.

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