A Review on the Suitable and Possible Combustion Chamber Geometries for Reducing the Emission of Poisonous Gases and for Minimum Fuel Consumption in CI Engines

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Abstract **–The big problem to use of CI Engine is there emission rate which is more than SI Engine. Many researchers today sort out this issue by studying the different geometries of Combustion Chamber (CC). Different parameters of suitable geometries were studied. The possible outcomes for actual implantation is checked. The results studied that the combustion bowl parameters could have a huge impact on the performance of CI engine. The most widely used CC is toroidal type.Some parameters bowl parameters, throat diameter and toroidal radius affect on performance of the combustion bowls. It was observed that the combustion bowl parameters, namely toroidal radius, central pip distance, and toroidal corner radius could have a effect on the emission magnitude. Based on analysis the optimistic geometries of it which are best and suitable for use which are studied and discussed.**

Keywords- **Combustion Chamber, Emission, pollution, combustion parameters**

I. Introduction

Around the globe the air pollution seriously affect the ecosystem and nature gets hampered. Many researchers adopt the different sources to reduce the emission of gases from the engine and improve their efficiency. Combustion Chamber geometry plays an vital role in this contrast. The CI engines have higher soot and NOx emission than SI engines. The two major fuel energy sources in the automobile sector are the petrol engine high-octane fuel and diesel engine high cetane based fuel. Among which the diesel engine has majorly used in the transportation sector, owing to the superior performance characteristics. Around 7 million people die each year from report said, as air pollution levels remain dangerously high in many parts of the world. [1] The harmful emission exhausted from the automobile sector has become a major threat to the human health, surrounding temperature, and its effect on the degradation of the heritage building and other living organisms.This warn the government bodies to focus on an over alternative energy source to sort out the limitation identified such a fuel crisis. [2]The engine modification consists the air motion by which the air enters the combustion zone, fuel injection pressure, and timing by which the fuel is exposed to the high-temperature air and combustion zone wall temperature; combustion bowl profile plays an vital role to enhance the engine behaviour in an optimized way.

Research in the era of CC has been carried out over the past five decades and the compression ratio of CC to 14 to 24: 1 is the result of natural breathing of engines. [3] The different combustion chamber were studied out of which the toroidal geometry is suitable one for CI Engine.[4] the two-sector version of the TRCC, it has Among the chambers considered TCC has the ability to reduce the carbon burn and thereby reduce the fuel-based emissions. Ability to maximize the turbulence kinetic energy and minimise the fuel deposit over the cylinder wall region. The research of this CC is to built least fuel consumption and better emission reduction excluding injection pressure and timing.

II. Different Geometries of the Combustion Chamber

A) Square combustion chamber: The square combustion chamber is shown in Figure 1, it is designed on the piston head. The air motion in the square CC is to air-fuel mixture and during compression creates a turbulence in CC mostly in corner areas.

B) Hemi-spherical combustion chamber: The name itself gives the idea of combustion chamber at the piston head or at the top of the piston. Figure 2 shows space which is close to half of ball (hemisphere) although in practice it generally less than half of that. HCC combustion chamber of the piston head was used in 1901. [5] In this combustion chamber, the ratio of depth to diameter could be different, but this does not give to the proper use of biodiesel fuel as a suitable combustion fuel. Therefore,rise in BSFC and reduces BTE when biodiesel is used as fuel in this type of combustion chamber.

Fig 1 Square Combustion Chamber [6]

Fig 3 Shallow depth Combustion Chamber

a) **b)**

Fig 2 (a) Hemispherical Combustion Chambers. (b) Piston crown in Cylinder head

C) Shallow depth CC combustion chamber: This type of combustion chamber is used more times in low-speed diesel engines, they are usually designed with a low-depth hole and a large diameter hole on the piston crown. The SCC efficiency in a combustion which uses biodiesel fuel is relatively better than HCC, as shown in Fig 3

D) Toroidal combustion chamber: [7]The air-fuel motion in Toroidal CC is better than any other, so the better air motion in this combustion chamber leads to favourable combustion. The TCC has a cone angle of 150 to 160 degree.The Toroidal CC is majorly used CC.

[8] Fig.4 Toroidal Combustion Chamber

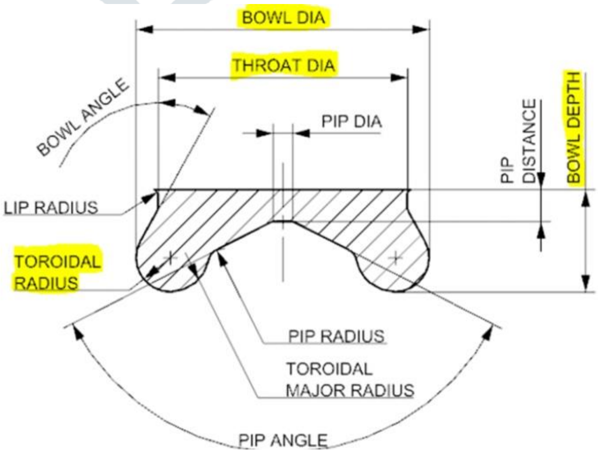

Fig.5 Different Parameters of TCC

III. Combustion bowl parameters and nomenclature:

[9] CI engine combustion is a multiterms system; the operation mainly deals with the operating condition, fuel specification, combustion chamber design, and injection system parameters.Of these, combustion chamber plays a major role to obtain maximum air fuel mixing, good combustion, and subsequent emission characteristics. Re-entrant piston come top among other bowl designs owing to its superior performance and with minimum emission norms that are also evident from the literature surveyed. Figure 5 illustrates the various bowl parameters of re-entrant piston bowl. The combustion bowl parameters are bowl diameter, bowl depth, pip diameter, pip distance, pip angle, throat diameter, toroidal radius, bowl angle, and lip radius.

Aspect Ratio:-Bowl depth / Bowl Diameter

Re-entrancy Ratio:-Throat Diameter /Bowl Diameter

Bore to Bowl Ratio:-Bowl Diameter /Bore Diameter

IV. The Effect of Combustion Chamber Geometry on Combustion, Performance and Emissions

[10] With the reference of this content the effect of various CC geometries on the different criteria of the CI engines (combustion, performance and emission parameters) are studied. The effect of the engine piston bowl area on the combustion performance of pollutants gases examined. The different volume of the piston bowl was considered and 20%, 30%, 35% and 40% of the total area of the piston. The tests were conducted with a single-cylinder CI engine with a compression ratio of 10: 1 in 1500 rpm with full open throttle and the results were studied. It was observed that an rise in the piston bowl above 30% of the piston area gives instability in the combustion. However, a significant increase was observed in the brake thermal efficiency power in the ratio of equivalence between 0.7 and 0.9 for the piston bowl of 30%. The emission level of piston bowl was 30%, compared with 20%, 35% and 40%, respectively. There was increase in NO emission in the piston bowl 30% and 25% compared to 30% and 40%. In short, the 30% piston bowl improved combustion performance and reduced emissions.

V. Study Of Different TCC structures:-

[11] The base re-entrant CC for reference, the researchers had studied the design parameters keenly for better understanding. For the base combustion chamber they had chosen, they got the aspect ratio, re-entrancy ratio, and bore to bowl ratio to be 0.351, 0.830, and 0.60, respectively.

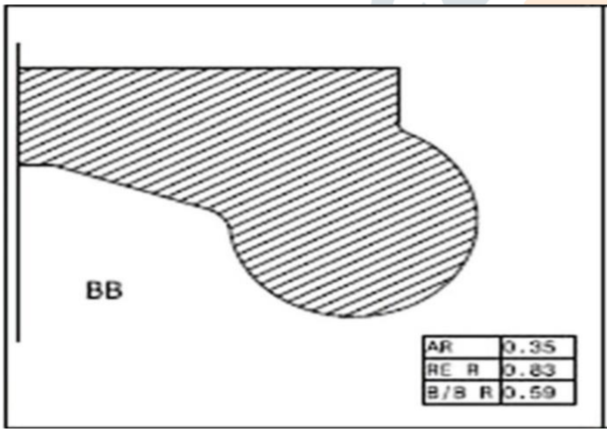

Fig.6 Base Combustion Bowl (BCC)

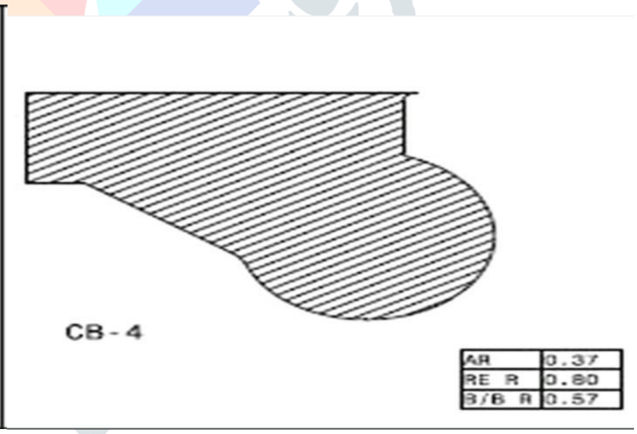

Fig.7 Suitable and optimistic geometry from BCC

VI. Methodology of Research:-

[12] The researcher simulated on software CONVERGE simulation package that can simulate three-dimensional, compressible or incompressible, and chemically changing transient fluid flows in complex geometries with stationary as well as moving surfaces. It is a more powerful tool for rapidly and correctly simulating all internal combustion engine types, namely spray simulation, aerodynamic simulation, and combustion simulation. For the current study, the researchers have focused on the combustion simulation of only compression and expansion strokes.

For the modelling process of mathematical tratment for the in-cylinder flow, three major equations, namely conservation of mass, momentum, and energy, have been considered. For gas simulation, B Redlich–Kwong (Redlich and Kwong 1949) equation is used. A interference between pressure, temperature, and volume of gasses were considered.In the Parcel simulation type, which makes use of diesel fuel with 736 K temperature, was considered for the simulation. In all around the world transport simulation parameters considered are Prandtl number—0.9 and Schmidt number—0.78. The flow of compressible gas flow solver and incompressible liquid flow solver were studied.

VII. Result and Discussion:-

A) [13]Base bowl analysis data

Parameters

Performance characteristics

Peak FP (bar) 59.42

Peak ROHR (J/°) 63.11

Combustion characteristics

IMEP (bar) 7.43

ISFC (gm/kW h) 199.87

Emission characteristics

HC (ppm) 86

CO (ppm) 0.676

NOx (ppm) 687.7

Soot (g/h) 6.38

B)Suitable And Possible Geometry Parameters:-

Performance characteristics

Peak FP (bar) 60.90

Peak ROHR 69.01

Combustion characteristics

IMEP (bar) 7.66

ISFC (gm/kW h) 194.01

Emission characteristics

HC (ppm) 36.8

CO (ppm) 0.025

NOx (ppm) 700

Soot (g/h) 4.1

VIII. Major aspect to Improve Combustion, Efficiency and Emission Reduction:-

In this content we gives the methods that resolved the problems that produced in the cold start(initial) and the release of emission gases and the analysis of the combustion engine chambers:

A)More injection inlets in initial start: More injection point systems with different injection abilities were used to improve CI engine performance. The two phenomenon one is Shooting flame and other is pressure inside combustion chamber gives pressure more-injection strategy is better than single injection under initial start conditions. The pressure change inside the combustion chamber with the more-injection strategy is almost two times as likely as single-injection cases [14].

B)Exhaust Gas Recirculation (EGR): the percentage of the engine's exhaust gases to the intake valves of the cylinders to reduce emissions, it was found that the use of EGR more than 20 to 40 percent of the engine output volume minimised the smoke mass in the combustion chamber. Increased EGR also reduced greenhouse gas emissions. To obtain smoke and NOx information at three levels of EGR, 0.2, 0.3 and 0.4, the result is that using higher EGR values reduces NOX. [15]

C) Pressure sensor: The one of the important parameter pressure inside the cylinder is most valuable signals used to detect combustion in IC motors. The pressure sensor has more response speed, light weight, minimum size and less sensitivity to surrounding conditions. They are majorly used to determine pressure inside the cylinder of the engine combustion chamber using a pressure sensor, gives the digital signal processing of the pressure inside the cylinder for combustion detection in the combustion chamber of the HCCI engine**.**

IX. Conclusions:-

The different geometries of CC are studied from which suitable geometry is selected by researchers which can be used in practical applications of CI Engine:

1. The given content gives good geometry for spraying fuel strategies gives effect such as squish, swirl, tumble, and turbulence for analysing of combustion, performance and emission.

2. The different research on the geometrical parameters and structure of the combustion chamber with the different modified Combustion Chamber in three cases, the Toroidal Re-entrant Combustion bowl(TRCC), the shallow depth Re-entrant combustion chamber (SRCC) and hemispherical combustion chamber (HCC) in the SRCC and HCC has a less cylinder pressure than that of TRCC and combustion delay for TRCC.Also, the Break Specific Fuel Consumption for TRCC was more favorable. They also gives the following results regarding the gases emission: The hydrocarbons emissions (HC) for TRCC and SRCC is reduced compared to HCC. CO emission from the engine with SRCC and HCC having more than Toroidal Combustion Chamber. Exhaust gas emissions for TRCC was lower than others. EGR system was proposed to solve this problem.
3. By analysing the various geometries of the piston bowl, the TRCC model was more useful for factors such as turbulence, swirl kinetic energy and rotation in the compaction stage and the quality of air motion in the combustion chamber was reduced, respectively, by HCC<SRCC< TRCC

Toroidal Geometry has more advantages than other geometry which are given below as follows:

1. The ratio Bore to bowl diameter played a vital role in combustion,emission and performance characteristics,in the performance characteristics increased IMEP and lower ISFC values were obtained for the lower bore to bowl ratio and vice versa. Based on the this characteristics, combustion chambers with minimal bowl diameter and bore to bowl ratio are identified as there as on behind the yield of higher indicated mean effective pressure and lower indicated specific fuel consumption. It could be further concluded that combustion bowl parameters such as bowl depth, bowl diameter, toroidal radius, and throat diameter played a crucial role in determining the performance characteristics of the combustion bowls.
2. Also on the combustion characteristics, combustion bowls with minimum throat diameter gives higher peak firing pressure considering to the presence of the combustion within the certain zone and its other combustion bowls gave higher peak rate of heat release compared with the base bowl. It was studied that the combustion chamber parameters, namely throat diameter and bowl depth, had an effect on the combustion analysis.

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