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Analysis on combustion geometry on different combustion chambers

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ABSTRACT

The present research work concentrates on combustion chamber geometry of single cylinder four stroke DI diesel engine with specification of 5.2kw, 1500rpm. The proper mixing of air and fuel in shorter time is essential to lessen the ignition lag phase. In order to get proper air fuel mixing, a systematic air movement also called swirl is essential, which produce higher relative velocity between fuel droplets and air. The spray cone of the injected liquid fuel gets disturbed because of air movement and turbulence inside the chamber. Since, the turbulence is mandatory for proper mixing and the fact that this could be achieved by the shape of the combustion chamber geometry.

KEYWORDS: *Nitrogen Oxide (NOx), Exhaust Gas Temperature (E.G.T), Carbon Monoxide (CO)*

I. INTRODUCTION

This system is having a hemi spherical shaped combustion chamber with single injector having three 0.3mm nozzles. In this chapter, four combustion chamber geometries (1) Toroidal, (2) Shallow Depth, (3) Re-entrant and (4) Double wedge shallow are considered for optimization. Computational Fluid Dynamics software Diesel-RK is used to model the combustion phenomenon in compression ignition diesel engine.

A four stroke, single cylinder, naturally aspirated, direct injection and water cooled diesel engine with a displacement volume of562 cc, compression ratio of 16.5:1 and rated power output of 5.2kW at 1500 rpm is used for conducting experiments. The engine is run at its rated constant speed of 1500 rev/min. Engine is coupled to an eddy current dynamometer which permit engine motoring either fully or partially. The engine and the dynamometer are connected to a control panel and is connected to a digital computer. The manufacturer supplied computer software is used for the test rig for recording the test parameters such as fuel rate, temperatures, air flow rate, load, brake power etc. From these data the engine performance characteristics such as brake thermal efficiency, brake specific fuel consumption, volumetric efficiency and mechanical efficiency are calculated. The calorific value and the density of the diesel fuel which is used for test are given as input to the computer software.

II. RESULTS AND DISCUSSIONS

In this investigation, four pistons of different configurations suitable to 5.2kw single cylinder four stroke DI diesel engine are considered. The hemispherical shaped geometry is taken as base engine combustion chamber geometry. In the present work, simulations are conducted to investigate the performance, emission and combustion characteristics using diesel fuel alone at different loads by using DIESEL -RK. The following graphs shows the results of different efficiencies, exhaust emissions, specific fuel consumptions and cylinder pressures for all combustion chamber geometries.

III. Modeling of combustion chambers

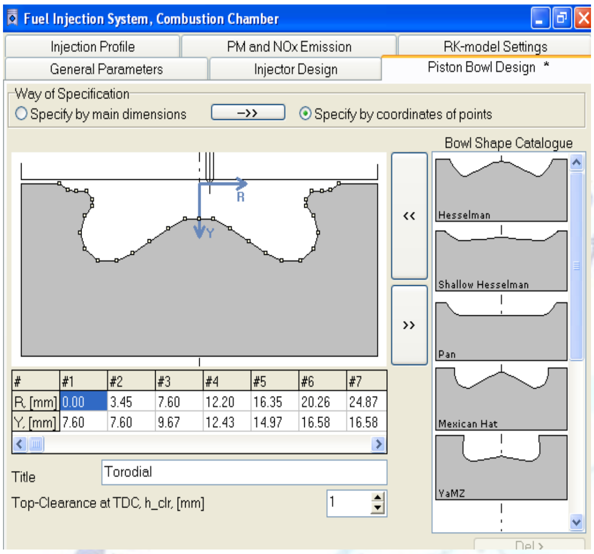

Fig 1.1: Modeling of Toroidal shaped chamber

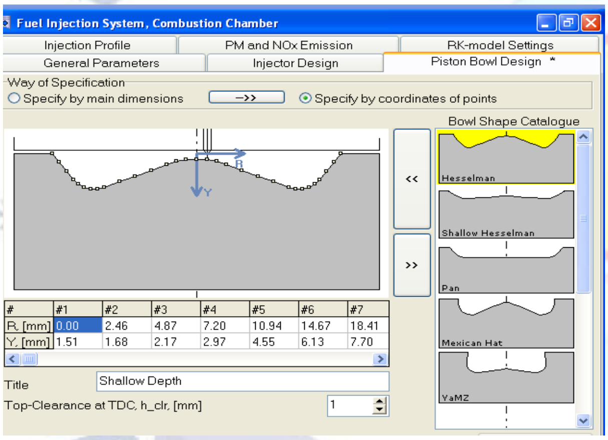

Fig 1.2: Modeling of shallow depth chamber

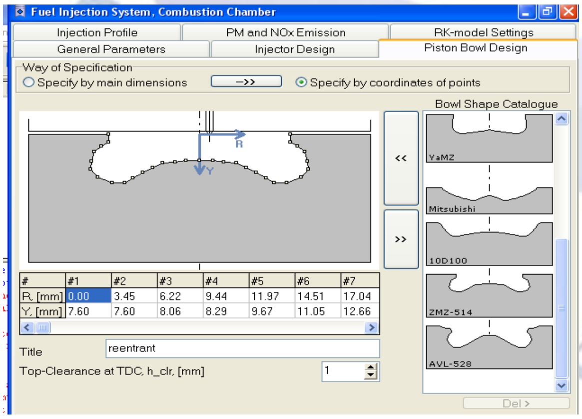

Fig 1.3: Modeling of Re-entrant shaped chamber

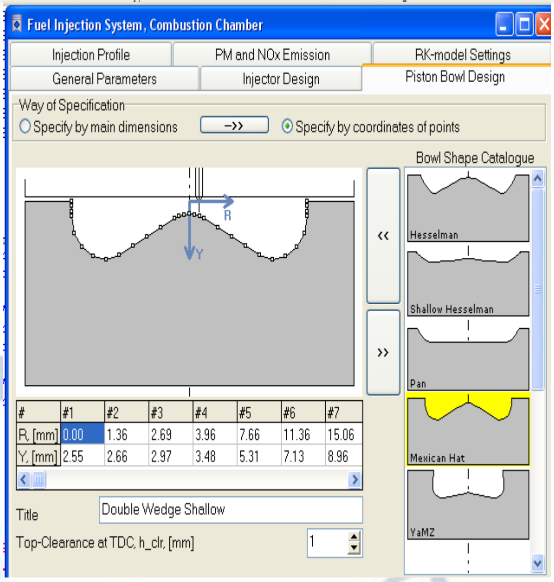

Fig 1.4: Modeling of Double Wedge shaped chamber

IV. Results of different piston geometry configurations

In the present work CFD simulations are carried out at different loads to study the performance, emission and combustion characteristics using diesel fuel. In this investigation, pistons of different configurations are used for analysis.

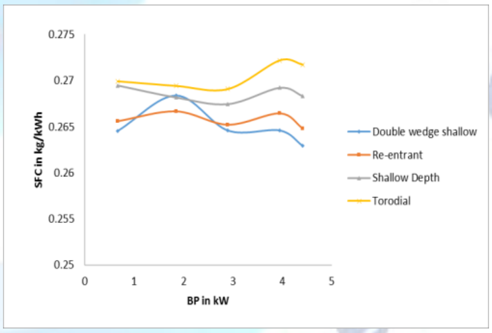

Fig2.1: Variation of SFC vs. BP

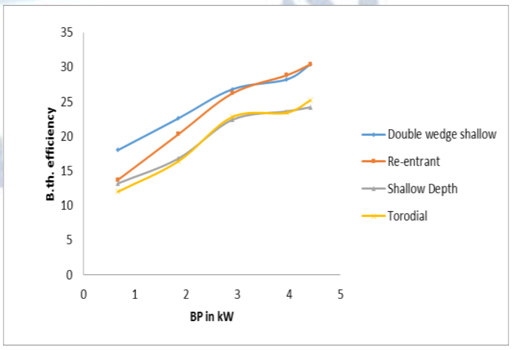

Fig 2.2: Variation of B.th Efficiency vs. BP

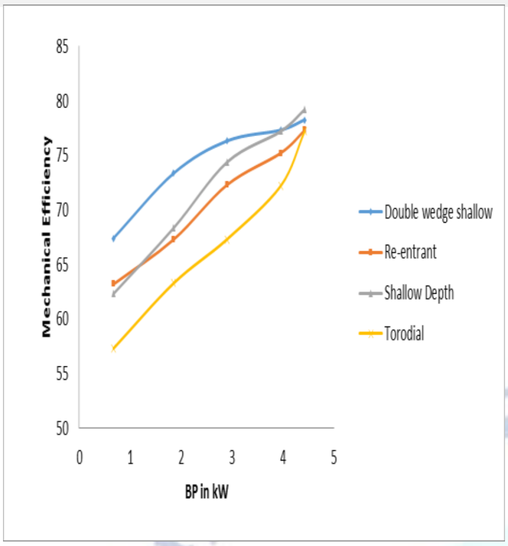

Fig 2.3: Variation of Mechanical Efficiency vs. BP

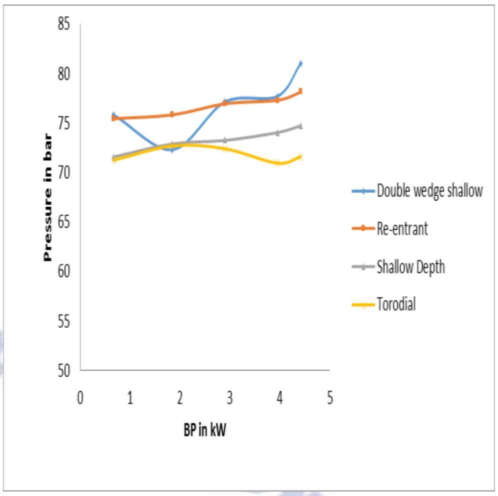

Fig 2.6: Variation of Pressure vs. BP

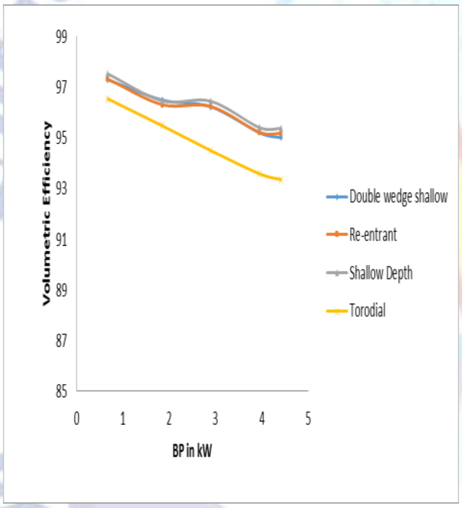

Fig 2.4: Variation of η_{vol} vs. BP

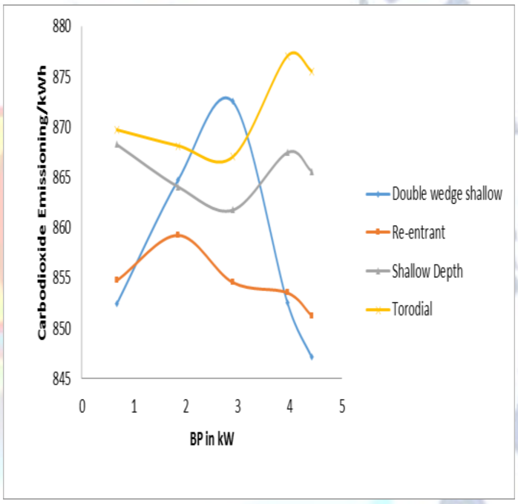

Fig 2.7: Variation of CO2 vs. BP

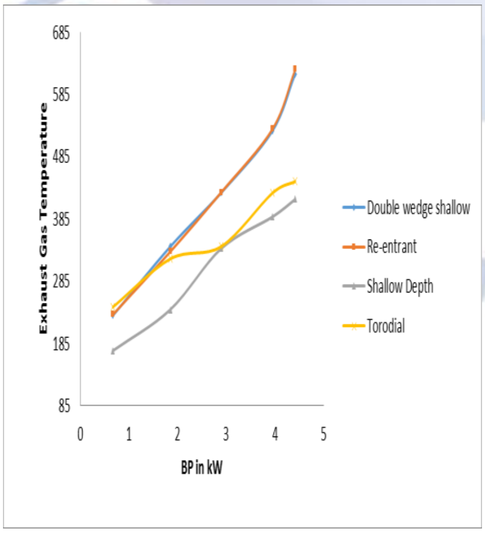

Fig 2.5: Variation of E.G.T vs. BP

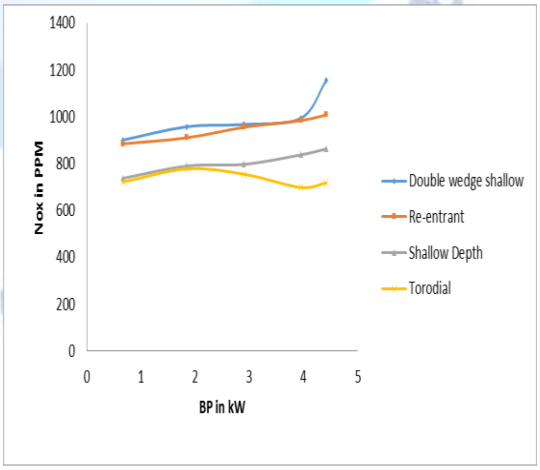

Fig 2.8: Variation of NOx vs. BP

IV. Conclusion

In view of the petroleum reserves deficit critical environmental concerns and huge usage demand an attempt is made in to investigations on the combustion chambers geometry of diesel engine. It is learnt that a suitable modification in the piston bowl which enhances the air fuel mixture turbulence in the cylinder is provided superior quality of combustion parameters and emissions hence in this research work a set of four configurations of combustion chamber geometries have been used to enhance afore said parameters. In this connection the performance emission and combustion characteristics are calculated by using a validated Diesel RK CFD technique. In this work the following significant observation are made and are presented as conclusions of the investigations related to the Diesel engine available in Department of mechanical engineering (J.N.T.U.H) collage of engineering.

The variation of mass of exhaust gas at 100% load are 0.0075g/sec, 0.008g/sec, 0.0084g/sec, 0.0087g/sec for shallow depth, Re-entrant, Double wedge shallow and Torriodal geometries respectively whereas 0.006g/sec for Hemispherical geometry.

The indicated mean effective pressure are 7.35 bar, 7.45 bar,7.54 bar and 7.58 bar for Toroidal, shallow depth, Re-entrant ,and Double wedge shallow combustion chamber geometries. A maximum pressure is observed with double wedge shallow geometry compared to other pistons. For different load conditions the pressure obtained is minimum for Torroidal shape combustion chamber. After ignition the cylinder pressure rapidly increases when there is a slight increase in combustion pressure caused by injection later then the TDC.

The mechanical efficiency obtained at rated load is 76%, 77%, 78.2% and 79% for Torroidal, Re-entrant, Double wedge, and Shallow depth geometries respectively. The mechanical efficiency obtained is maximum with Shallow depth chamber comparatively other configurations. This is due to the impingement of fuel on the piston walls lead to minimum. This is almost equal to hemispherical geometry. This is because of reduced heat losses in the engine.

It is observed that the volumetric efficiency is gradually decreased with increase in engine output however the maximum volumetric efficiency of 96% is observed with shallow depth combustion chamber geometry. This is because of systematic controlled enhancement of swirl during suction stroke which lead in controlling volumetric efficiency also. The minimum volumetric efficiency is observed for Torriodal shape piston geometry. This is because of heat loss to incoming air.

The exhaust gas temperatures at rated load is 3870c 3880c 5890c 589.40c for shallow depth, Torroidal, Double wedge shallow and Re-entrant combustion chamber geometries respectively.

The variation of exhaust emission CO2 at rated load is 847 g/kw-hr, 852g/kw, 865 g/kw, 876 g/kw for Double wedge shallow depth, Re-entrant, Shallow depth, and Torriodal shapes respectively but at various load conditions the Re-entrant combustion chamber geometry is reported less in CO2 percentage.

The variation of NOx at rated load is 630 ppm, 700 ppm, 820 ppm, 900 ppm for Torroiadal Shallow depth, Re-entrant and Double wedge shallow depth combustion chamber respectively.

The comparison revels that re-entrant combustion chamber geometry is the best among the selected geometry configurations. It exhibits lower emissions, lower specific fuel consumption rate, improved performance compared to other shapes.

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