Dr. K. Sreenivasa Reddy[1]

Breaking Barriers: Advanced Engine Solutions for a Greener Tomorrow

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Abstract

Diesel engines rely heavily on efficient combustion, which is significantly influenced by turbulence in the combustion chamber. Turbulence ensures proper mixing of air and fuel, leading to better combustion efficiency and reduced emissions. One crucial factor affecting turbulence is the design of the piston crown. By incorporating turbulent grooves on the piston crown, engines can achieve improved air-fuel mixing, resulting in enhanced combustion efficiency. Turbulent grooves on the piston crown play a vital role in breaking down fuel droplets into finer molecules, promoting better atomization and mixing with air. This design modification can lead to significant improvements in engine performance and emissions. Research has shown that pistons with specifically designed grooves can optimize turbulence, thereby enhancing combustion efficiency. Studies have indicated that pistons with three grooves exhibit superior performance in terms of combustion efficiency and emissions reduction. The incorporation of turbulent grooves, along with heat reservoirs, can further improve both combustion and thermal efficiencies. These design modifications represent effective strategies for maximizing fuel utilization and minimizing emissions in Diesel engines. The design of the piston crown, particularly the incorporation of turbulent grooves, is a critical factor in enhancing Diesel engine performance. By optimizing turbulence, engines can achieve better combustion efficiency, reduced emissions, and improved overall performance. Continued research and development in this area can contribute to more efficient and environmentally friendly Diesel engines.

Keywords: *Combustion Efficiency, Turbulent Grooves, Piston inserts, Limited Cooled Engines*

INTRODUCTION:

Scientists expressed that there would be a possibility of Performance improvement with enhanced mixing of air and fuel. But for the complete combustion of the diesel in the diesel engine it requires better turbulence in the combustion chamber. The turbulence within the existing combustion bowl of a direct injection (DI) diesel engine has a considerable bearing on the combustion characteristics and therefore on emissions and efficiency. In addition the gas velocities adjacent to the cylinder walls have a significant influence on convective heat transfer rates. The measurement of fuel and airflow in the DI diesel engine has provided a major challenge owing to restricted access to the combustion chamber. The flow patterns are normally divided into mean flow components, which are represented, by squish and swirl, and fluctuating flow components, which are referred to as turbulence. While it is possible to model the mean flow components fairly accurately, the subject of turbulence remains somewhat tenuous because of the lack of experimental data. In spite of its complexity, turbulence cannot be ignored when characterizing the flow processes in a diesel engine as it contributes significantly to heat transfer and to combustion. Tabaczynski [2] reported that two of the major features of turbulent flow were its definite structure in the flow field and its tendency to be governed by chamber geometry near top dead centre of compression. Turbulence models presently in use provide reasonable levels of accuracy in terms of expected trends. However, they generally employ procedures, which provide ensemble-averaged solutions and can only be validated by ensemble averaged velocity data.

LITERATURE:

The effect of turbulence for I.C engines in future, especially in diesel engines, has evoked considerable interest. Without Turbulence do not make good CI engine. Because of their high Auto ignition temperatures they can be ignited by providing higher temperatures in the combustion chamber. This tendency of turbulence that has been exploited in the development of the efficient Diesel engine. Most of the literature available deals with the use of insulation in diesel engines with normal compression ratio in different methods. In majority of the cases the performance is poor in the conventional diesel engines with some operational problems due to lack of turbulence. The low combustion efficiency in diesel engines will leads to problem of turbulence. All these problems can be

[1] [1]Professor, SRIT Proddatur, Kadapa (Dt), A.P.,India

avoided by providing turbulence in the combustion chamber.

METHODOLOGY:

Preparation of Regenerative surface:

To reduce the heat transfer, original Aluminium Piston plays a vital role which takes heat from the combustion chamber and delivers it to the fresh charge. This preheats the charge and increases the combustion efficiency. For the purpose of this, Aluminium Piston crown is replaced with Brass Piston Crown. In this research an air gap is provided between piston crown and skirt. The crown and skirt is allied with Proper gaskets. The air gap between the two components acts as an insulator for the heat transfer through the piston and further provides more heat in the chamber.

The following Fig: 1 shows the air gap. brass piston used in the experiment.

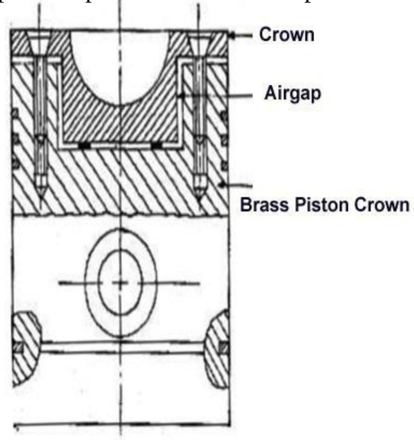


Fig:1 BRASS PISTON CROWN

WITH AIR INSULATION

Creation of turbulence for proper mixing:

Further the chamber temperature and combustion in the chamber depends on the turbulence generated in the chamber. So in this work an attempt is made with Two, Three and Four number of grooves on the brass crown piston and named as TG02, TG03 and TG04 respectively. The configurations of the brass pistons tried are shown in the following Fig. 2.

Fig. 2: TWO, THREE AND FOUR NUMBER OF GROOVES ON THE BRASS CROWN PISTON

RESULTS AND DISCUSSIONS:

Experimental study has been conducted on a single cylinder 4-stroke, water-cooled 3.64KW Kirloskar diesel engine by changing piston crown. The concentration of smoke is measured by Bosch smoke meter; Unburnt Hydrocarbons was measured with exhaust gas analyser. Air suction rate and exhaust air flow rates were measured with the help of an air box method. Temperatures at the inlet and exhaust valves are monitored using a thermocouple. Time taken to consume 20 cc of fuel and Engine RPM are measuredwith the help of digital stop watch and Tachometer respectively and the analysis of these results are as follows. The following Fig:3show the experimental set up.

Fig 3: Photographic view of experimental setup The notations are given below.

LC : Limited Cooled Engine-Brass piston with 2mm air gap

TGO2: Limited Cooled Engine-Brass piston with Two Turbulent Grooves **TGO3:** Limited Cooled Engine-Brass piston with Three Turbulent Grooves **TGO4:** Limited Cooled Engine-Brass piston with FourTurbulent Grooves

The experimental investigations are carried out on all these different engine configurations and the processed results are presented in the form of graphs.

Brake Thermal Efficiency:

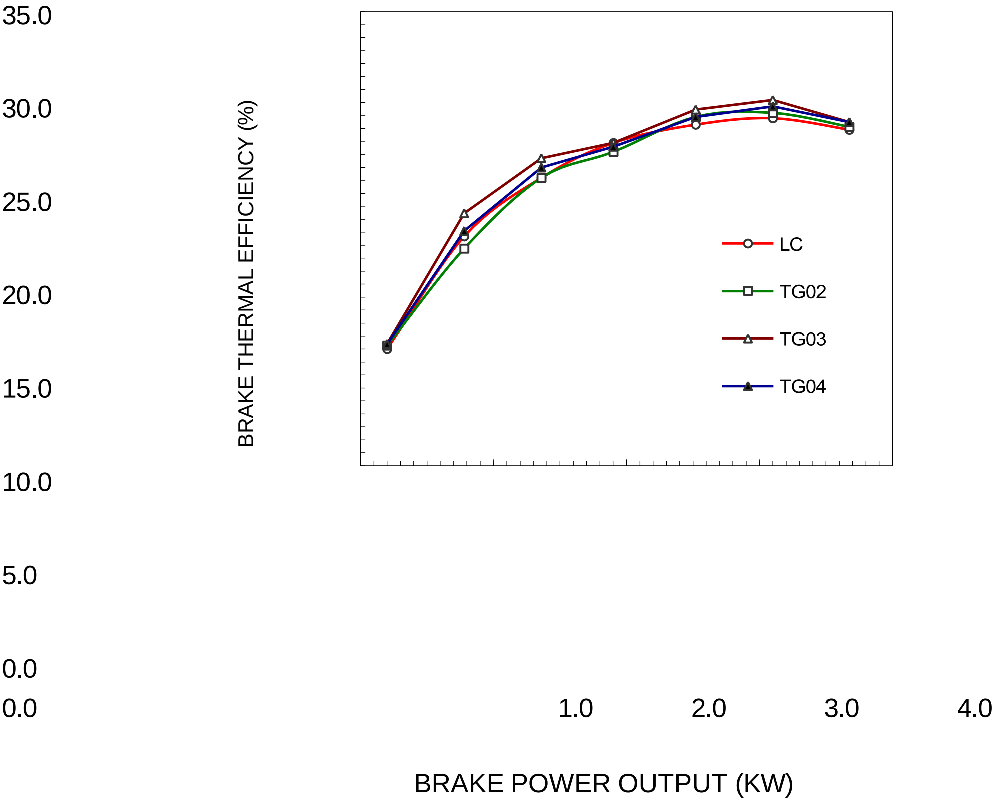


Fig:.4 COMPARISON OF BRAKE THERMAL EFFICIENCY FOR FOUR CONFIGURATIONS

Fig:4 depict the variation of brake thermal efficiency with various turbulent Grooves. TG03 configuration gives higher efficiency over wide range of operation. The study suggests that the Three

Grooves provided on the Piston Crown increases turbulence and in turn increases the brake thermal efficiency of the engine. The brake thermal efficiency is around 26.5% for the TG03 configuration at full load. So the brake thermal efficiency of TG03 is increased by about 2.31% compared to Limited Cooled at Full Load.

Exhaust Gas Temperature:

Fig:5 shows exhaust gas temperatures with brake power output. Generated temperature is more for TG03 at full load and lower over a wide range of operations. The temperature for brass piston is 518.7^{0}C and for TG03 it is 327.6^{0}C at full load. Further the grooves on the piston crown generate the turbulence in the combustion chamber and increase the combustion efficiency. So the Exhaust temperature of TG03 is decreased by about 36.84 % compared to Limited Cooled at Full Load.

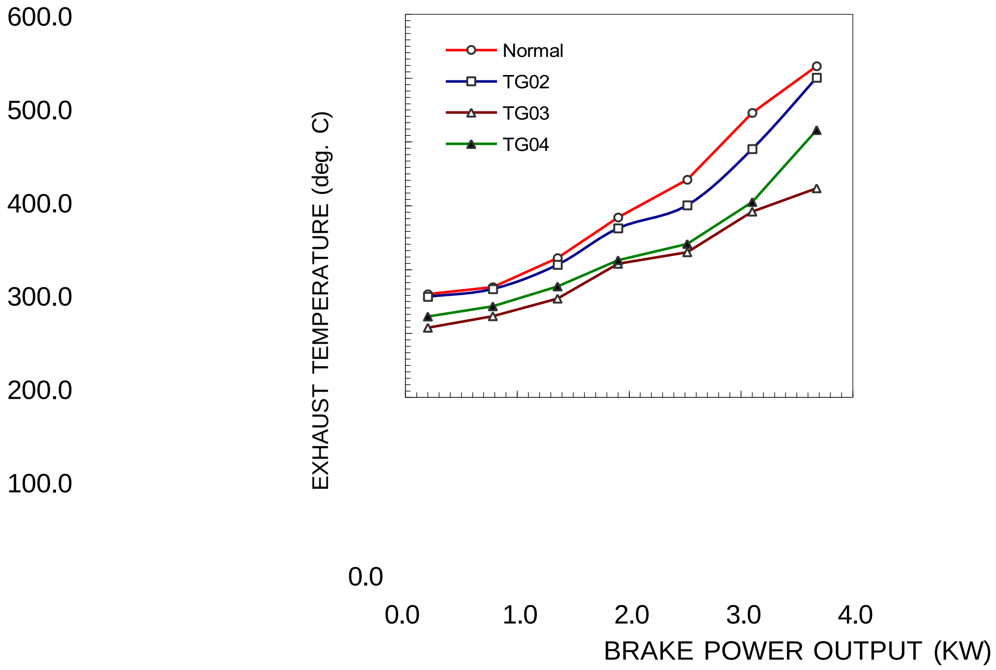
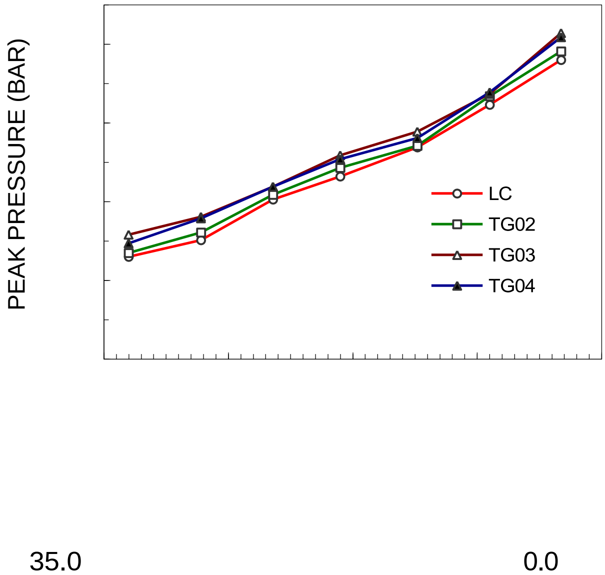


Fig:5 COMPARISON OF EXHAUST TEMPERATURE WITH POWER OUTPUT FOR...

Peak Pressure:



BRA1K.0E POWER2.0OUTPUT (3K.0W)

4.
0

Fig:6 COMPARISON OF PEAK PRESSURE WOTH…

The peak pressure variation with power output is shown in Fig:6. the rise in Maximum cycle pressure is noticed in TG03. For the standard engine the peak pressure increases from 48 Kgf/cm^2 at no load to 73 Kgf/cm^2 at full load. For TG03 configuration, the peak pressure increases from 50.8 Kgf/cm^2 at no load to 75.9 Kgf/cm^2 at full load.

Hydrocarbon Emissions:

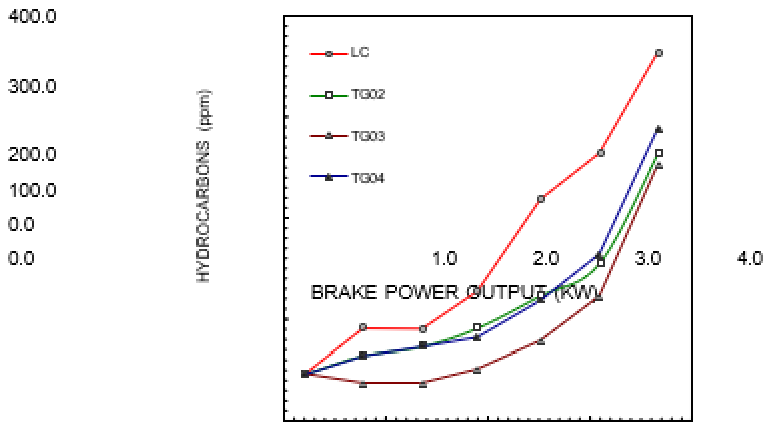


Fig:7 COMPARISON OF HYDROCARBONS WITH POWER OUTPUT FOR FOUR CONFIGURATIONS

Fig: 7 depict the amount of unburnt hydrocarbons present in the exhaust gas. Lean mixing, burning of lubricating oil, and wall quenching are the sources of emissions in Diesel engine. . Because of better turbulence, Hydrocarbon emission formation is found to be less in all the turbulent grooved engines. From the graph it is observed that maximum reduction is with TG03 due to its properties and turbulence generated. The reduction is about 30.5 % compared to BP at the rated load.

Carbon monoxide Emissions:

Carbon monoxide levels in the exhaust of base engine and all the four configurations are shown in Fig:8 Because of better turbulence, carbon monoxidelevels are lower. Lowest carbon monoxideemissions are observed in the case of TG03 configurations, the reduction is about 29.5% by volume at rated load. Compared to part loads, the reduction is more at higher loads.

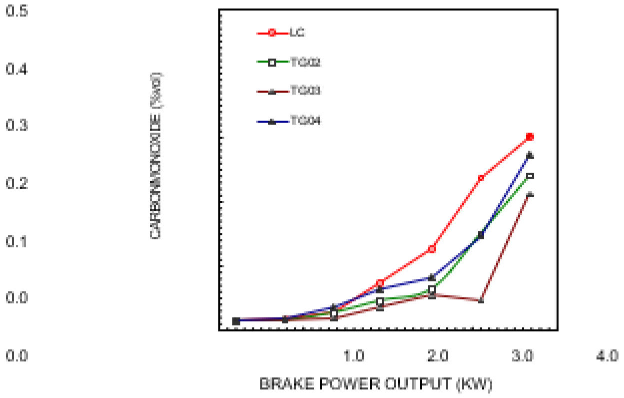


Fig:8 COMPARISON OF CARBONMONOXIDE WITH POWER OUTPUT FOR FOUR CONFIGURATIONS

CONCLUSIONS:

1. The brass piston material acts as an insulator with its lower thermal conductivity. With this the heat generated will be stored and supplied back to the incoming fresh charge. This completes the combustion process and increases the exhaust gas temperatures and brake thermal efficiency.
2. There is increase in combustion efficiency when used with turbulent piston. By Considering emissions & efficiency, the three turbulent piston crowns gives better results than others.
3. The Low temperature of the exhaust indicates the better combustion due to better turbulence.
4. Maximum reduction of Hydrocarbons is with TG03 due to its properties and turbulence generated. The reduction is about 30.5 % compared to BP at the rated load.
5. Lowest carbon monoxide emissions are observed in the case of TG03 configurations, the reduction is about 29.5% by volume at rated load.

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