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PERFORMANCE AND EVALUATION ON FOUR STORKE SINGLE CYINDER DI DIESEL ENGINE WITH TRAPEZOIDAL GROOVES ON PISTON CROWN

Dr. R. GANAPATI
Associate Professor,
Mechanical Engineering Department,
ANURAG Engineering College, Kodada, Telangana, India.

Dr. B. OMPRAKASH
Assistant Professor,
Mechanical Engineering Department,
JNTUA College of Engineering, Ananthapuramu, A.P, India.

***Abstract*: Diesel engines play a vital role in the power generation, transportation, marine applications etc. Intensive research efforts are ongoing for improving combustion efficiency, fuel consumption and exhaust emissions from diesel engines. To increase the combustion efficiency, turbulence plays a very important role in the combustion phenomenon of C.I engine. Hence even a small increase in the combustion efficiency will result in greater advantage. The turbulent motion of the mixture intensifies the better mixing. The turbulence can be increased by suitable designing of combustion chamber, which involves the geometry of cylinder head, inlet manifold and piston crown. In the present work, the experimental investigation of air swirl in the cylinder upon the performance and emission of a single cylinder direct injection diesel engine is presented. Turbulence is created in the engine cylinder by cutting trapezoidal grooves on the piston crown, three different configurations of the piston i.e. ,in the order of 2, 4, 8 are used to intensify the swirl for better mixing of air and fuel. A series of experiments are conducted on four stroke single cylinder direct injection diesel engine with grooved piston and compared with that of normal piston. Performance parameters such as brake power, specific fuel consumption, and thermal efficiencies are calculated based on the experimental analysis of the diesel engine .Emissions such as carbon dioxide, carbon monoxide, unburnt hydrocarbons, and NO_x are measured.**

KEYWORDS: **Trapezoidal Grooved Piston (TGP), single cylinder 4-stroke diesel engine, Air swirl, Piston crown**

I.INTRODUCTION

Internal combustion engines are the engines which burn the fuel inside it and produce the energy. Of all the engines the direct injection diesel engines have their own importance because of their higher thermal efficiencies than all the others. They can be used for both light-duty and heavy duty vehicles. It is well known that in DI diesel engine swirl motion is required for proper mixing of air and fuel. However, the efficiency of the diesel engines can be increased by increasing the burn rate of fuel air mixture. The swirl can be generated in the diesel engine by modifying the 3 parameters in engines, they are the cylinder head, the piston i.e., modification of the combustion chamber and the inlet manifold. The in-cylinder fluid motion in internal combustion engines is one of the most important factors in controlling the combustion process. It governs the air-fuel mixing and rate of burning in diesel engines. Therefore better understanding of fluid motion is critical for designing the engines with the most desirable operating and emission characteristics.

When the piston moves close to the top dead centre [TDC], the variation of swirl depends on the shape of the combustion chamber. The effect of swirl on combustion and emission of heavy duty- diesel engines has been investigation by Benajes et al. And suggested that the optimal level of swirl that minimizes soot depends on engine running conditions.

To reduce the emissions coming the engines exhaust, manufacturer try to design the best combustion chamber and other level. At the design of combustion chamber geometry to reduce the NO_x many researchers studied the different piston bowl geometry. Cao Li et al reported NO and CO emissions are lower for changing the piston geometry as comparison to normal piston geometry.

II.LITERATURE REVIEW

K. Hemachandra Reddy, C. EswaraReddy, C.V.Subba Reddy et.al.(2012)[1]: "effect of tangential grooves on piston crown of direct injection diesel engine with blends of cotton seed oil methyl Easter" .This paper presents about direct injection diesel engines are in service for both heavy duty vehicles, light duty vehicles not only in the field of agriculture and transport sectors, but also stationary engines consume maximum percentage of petroleum based fuels and have the evident benefit of higher thermal efficiency than all other engines. In this, experiments are conducted on D.I diesel engine with three different tan-

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gential grooved pistons and cotton seed oil methyl esters blended with diesel in various proportions. The effect of three different sizes of tangential grooves on piston crown on the performance and emission characteristics are studied.
C R Rajashekhar, Sudeep Kumar, Veeresh M Kodekal,[2]: **"**Studies on induced turbulence combustion on performance and combustion characteristics of bio-diesel fuelled C.I engine" this paper presents about the effects of modification of piston in C.I engine. For inducing the turbulence in the combustion chamber, a rotating blade had been placed on the piston crown. The oscillation of the connecting rod causes the blade to rotate by an angle of 60^o. This arrangement induces the turbulence in combustible mixture during combustion, by which better combustion can be achieved.
VaibhavC.Bhatt , V.Y.Gajjar ,K.K.Araniya et.al.(2014) [3]**:** **"**A review on performance and exhaust emission characteristics of a diesel engine by changing piston geometry" this paper gives the basic idea about the effects of air swirl in the cylinder on its performance and exhaust emission of single cylinder direct injection diesel engine. In order to achieve the different swirl intensities in the cylinder, three design parameters have been changed i.e., the cylinder head, piston crown and inlet duct.
S.L.V.Prasad, V.Pandurangadu et al. (2011) [4] made investigated experimentally the factor that the effected performance of diesel engine. It is quite well known that a properly designed intake manifold is vital for the optimal performance of an I.C.Engine. This a method of increasing the performance of a Diesel engine without any major modification. This paper aims at studying the effect of air swirl generated by directing the air flow in intake manifold on engine performance. The turbulence was achieved in the inlet manifold by grooving the inlet manifold with a helical groove of size of 1mm width and 2mm depth of different pitches to direct the air flow. The tests are carried with different configurations by varying the pitch of the helical groove from 2 mm to 10 mm in steps of 2 mm inside the intake manifold. In this paper clearly observed the results are compared with normal engine (without helical groove). The results of test show an increase in air flow, increases the brake thermal efficiency, mechanical efficiency and decrease in HC and Co emissions.
BhanuPratap Patel , I J Patel , G P Rathod et al. (2014) [5] **:** **"**effect of spiral grooves in piston bowl on exhaust emissions of direct inject ion diesel engine". In present time developed country are used from small to largest diesel engine as a power plant for different purpose like generation electricity and transportation. These engines consume in heavy quantity fuel per hour, where these engines produce the bulk power as well as there also produce the different types of toxic gases that harmful our human beings and environment. At this time both type of country try to reduce the harmful gases from diesel engine. In present scenario many technology are used to reduce the toxicity of exhaust gases EGR(exhaust gas recirculation) is one of them. Where EGR reduces the toxicity of exhaust gases and fuel consumption as well as reduce the power of the engine which is not good at any level. In this present experimental to reduce the NOx, HC, CO, and CO_2 some modification has been done in piston bowl by cutting three spiral grooves on inner surface of hemispherical bowl and slight increasing in bowl diameter. The spiral grooves increases the capacity and slight reduce the compression ratio as well as make homogeneous mixing of air and fuel.

G.Buscaglia, E.Dari, O.Zamonsky et al. (2004) [6] made suitable modifications simulations mixture formation and combustion in a Gasoline Direct Injection (GDI) engine were studied. A swirl-type nozzle, with an inwardly opening pintle, was used to inject the fuel directly in a 4 stroke, 4 cylinder, 4 valves per cylinder engine. The atomization of the hollow cone fuel spray was modeled by using an hybrid approach validated at first in a quiescent chamber at ambient pressure and temperature, comparing numerical penetration and spray shapes with the experimental ones.

III.MODIFIED PISTON

Fig 1: TGP 2 Fig 2: TGP 4

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Fig 3: TGP 8

TGP 2- Trapezoidal grooved piston with 2 grooves
TGP 4- Trapezoidal grooved piston with 4 grooves
TGP 8- Trapezoidal grooved piston with 8 grooves

Above showed pistons are the modified pistons with trapezoidal grooves on the piston crown. figure 1 shows that the making of 2 grooves i.e., TGP 2 and similarly fig 2 & fig 3 shows the TGP 4 and TGP 8 respectively. the trapezoidal grooves are placed on the piston crown for homogeneous mixing of air and fuel by enhancing air swirl within the combustion chamber which decreases the compression ratio and its effects on performance and emissions are observed.

IV.EXPERIMENTAL WORK

Experiment is carried out in diesel engine with the following engine specifications as shown in table 1

TABLE I
ENGINE SPECIFICATIONS

Specifications	Item
A V 1	Kirloskar Diesel Engine Model
3.68KW	Engine Power
80 mm	Cylinder bore
110 mm	Stroke length
1500 rpm	Engine speed
16.5:1	Compression ratio
553 cc	Swept volume
Four	Stroke
Rope Brake Type	Dynamometer
190 bar	Injection Pressure

Procedure:

The experiments are performed on D.I. diesel engine at constant speed 1500rpm by using pure diesel. In the first phase data recorded with standard piston and in the second phase data recorded by changing the modified piston (TGP 2, TGP 4 & TGP 8) respectively. The power of the engine is measured by using the rope brake dynamometer that is coupled with engine and engine exhaust emissions are measured by gas analyzer at different load. The performance and emission characteristics are compared with standard piston results.

V.RESULTS AND DISCUSSIONS

1.Load vs Brake specific fuel consumption

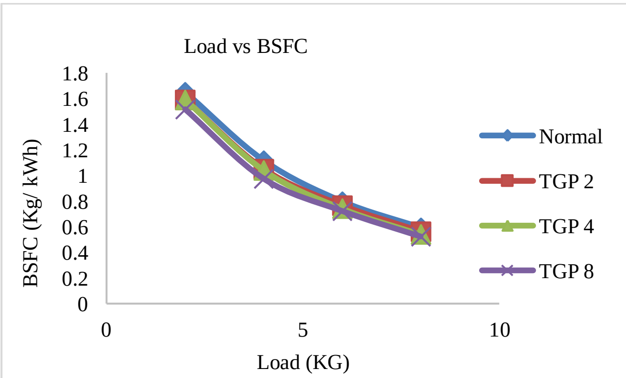

Fig: 2Load vs Brake Specific Fuel Consumption

The variations of brake specific consumption with load as shown in fig 2.The brake specific consumption for TGP 2, TGP 4 and TGP 8 at max load are 0.562kg/kW-hr ,0.541kg/kW-hr and 0.523kg/kW-hr respectively, whereas for normal piston it is 0.592kg/kW-hr. It is observed that the TGP 8 has lowest brake specific consumption 11.6% when compared to normal piston. This is because of complete combustion of charge in the combustion chamber due to the enhancement of air swirl.

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2. Load vs Brake thermal efficiency

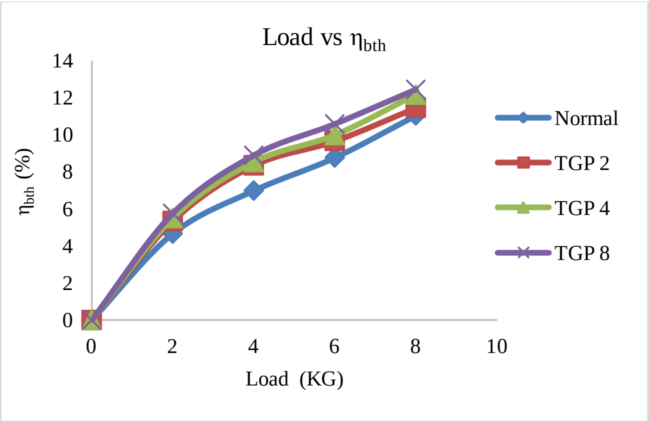

Fig: 3 Load vs Brake Thermal Efficiency

The variations of brake thermal efficiency with load as shown in fig 1.The brake thermal efficiency for TGP 2, TGP 4 and TGP 8 at max load are 11.45% ,12.15% and 12.43% respectively, whereas for normal piston it is 11.03%.the brake thermal efficiency is increased by 12.6% for TGP 8 when compared to normal piston. This increase in brake thermal efficiency might be due to the turbulence created in the engine cylinder by enhancement of air swirl.

3. Load vs Mechanical efficiency:

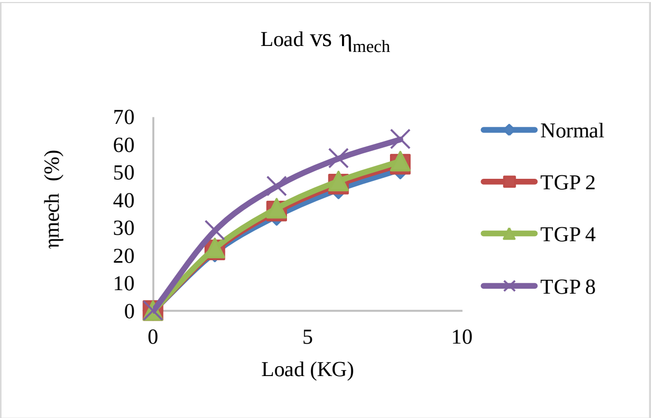

Fig: 4 Load vs Mechanical Efficiency

The variations of mechanical efficiency with load as shown in fig 3.The mechanical efficiency for TGP 2, TGP 4 and TGP 8 at max load are 52.8% ,53.9% and 61.9% respectively, whereas for normal piston it is 51.08%.It is observed that TGP 8 has the highest mechanical efficiency of 21.1% when compared to normal piston. This is because of complete of charge in the engine cylinder by liberating maximum energy due to the enhancement of air swirl in the combustion chamber.

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4. Exhaust emissions of nitrogen oxides:

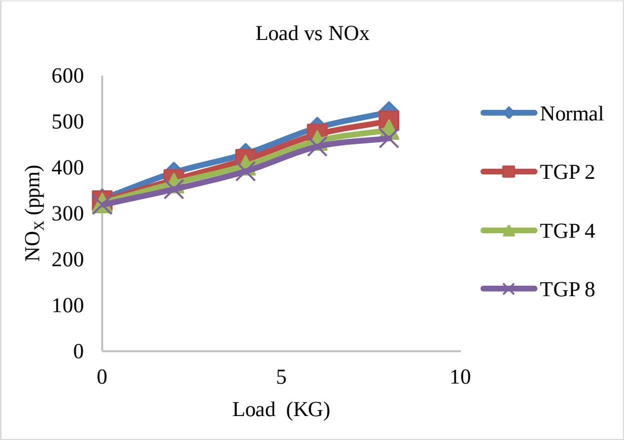

Fig: 5 Load vs NO_X

The comparison of NOx emissions with load for different configurations of pistons as shown in fig 6 .The NOx emissions for TGP 2, TGP 4 and TGP 8 at max load are 501ppm ,482ppm and 463ppm respectively, whereas for normal piston it is 521ppm.The NOx emission are lower of 11.1% for TGP 8 when compared to normal piston. This may be due to decrease in the combustion duration because of homogeneous mixing helps to decrease the peak temperature.

5. Exhaust emissions of hydrocarbon emissions:

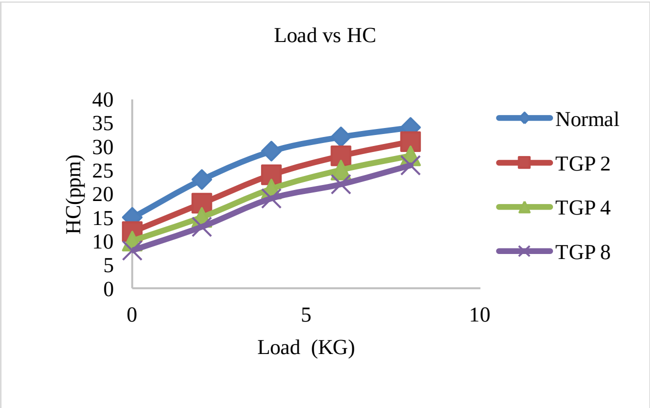

Fig: 6LoadvsHC

The comparisons of hydro carbon emissions with load as shown in fig 5.The HC emissions for TGP 2, TGP 4 and TGP 8 at max load are 31ppm, 28ppm, and 26ppm respectively, whereas for normal piston it is 34ppm.The HC emissions are lowered by 23.5% for TGP 8 when compared to normal piston. It is obvious that hydrocarbon emission decreases with increase in turbulence.

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6. Exhaust gas emissions of carbon monoxide:

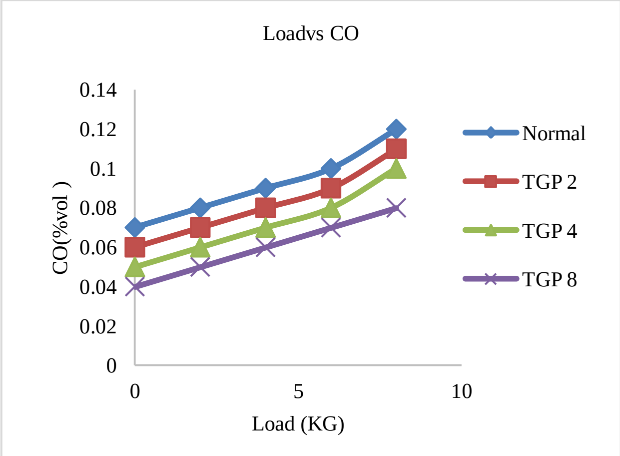

Fig: 7 Load vs CO

The variations of CO with load as shown in fig 4. The CO emissions for TGP 2, TGP 4 and TGP 8 at max load are 0.11%, 0.1% and 0.08% by volume respectively, whereas for normal piston it is 0.12% by volume. The CO emissions are lowered by 33% for TGP 8 when compared to normal engine. By increasing the turbulence in the combustion chamber the oxidation of CO is improved which in turn reduces the CO emissions.

7. Load vs Exhaust gas temperature

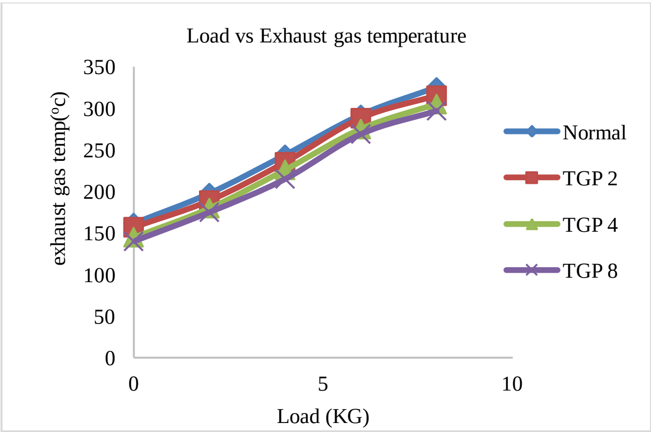

Fig: 8 Load vs exhaust gas temperature

The variations of exhaust gas temperature with load as shown in fig 7. The exhaust gas temperatures for TGP 2, TGP 4 and TGP 8 at max load are 315^{o}c,305^{o}c and 297^{o}c respectively, whereas for normal piston it is 325^{o}c.It is observed that TGP 8 has lowest exhaust gas temperature of 8.61% when compared to normal piston. Lower exhaust gas temperature for TGP 8 is due to low operating temperature in the combustion chamber resulted by the swirl created in the combustion chamber.

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VI.CONCLUSION

From the investigation, it is clear that out of all pistons configurations tested in single cylinder direct injection (DI) four stroke diesel engine, piston with grooves i.e. TGP 8 gives better performance in all aspects. The following conclusions are drawn at max load i.e. at 8kg load when compared to normal engine.

- The brake thermal efficiency is increased by 12.6%
- Fuel consumption for TGP 8 configuration is lowest among all piston configurations.
- The improvement in mechanical efficiency is about 21.1%.
- The maximum reduction in CO emissions is about 33%.
- The hydrocarbon emissions are reduced by 23.5%.
- The reduction in NO_x emissions is about 11.1%.
- The reduction in exhaust gas temperature is about 8.61%.

VII.SCOPE OF FUTURE WORK

The present work can be extended by varying the number of grooves on the piston crown and the engine can be tested for better performance with various alternative fuels also.

VIII ACKNOWLEDGMENT

Dr. GANAPATI RAMAVAT, working as a Associate Professor in the department of Mechanical Engineering, ANURAG Engineering college, Kodad, Telangana, INDIA. I completed my Ph.D in I.C. Engines from JNT University, Anantapur, Andhra Pradesh. I published 17 articles in various nationaland international conferences and 6 research papers invarious national and international journals.

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