INVESTIGATION ON THE PERFORMANCE OF SINGLE CYLINDER DI DIESEL ENGINE WITH VARIOUS GROOVED PISTONS

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Abstract— Internal combustion engines have been relatively inexpensive and reliable source of power for applications ranging from domestic use to large scale industrial and transportation applications for most of the twentieth century. DI Diesel engines, having the benefit of a higher thermal efficiency than all other engines, have served for both light- duty and heavy-duty vehicles. In DI diesel engines, swirl can increase the rate of fuel-air mixing. Swirl interaction with compression induced squish flow increases turbulence levels in the combustion bowl, promoting mixing. It is evident that the effect of geometry has a negligible effect on the airflow during the intake stroke and early part of the compression stroke. But when the piston moves towards Top Dead Centre (TDC), the bowl geometry has a significant effect on air flow thereby resulting in better atomization, better mixing and better combustion. In CI engine piston shapes on crown is flat and concave combustion chamber, with this geometry we have been running the engine. But here air fuel ratio mixture cannot mix properly. To avoid this we make piston geometry changes. The main object of this project is to investigate the performance technique to enhance the air swirl to achieve betterment in engine performance and emission in a direct injection (DI) single cylinder diesel engine. In order to achieve the swirl intensities in the cylinder, changes on the piston crown has been selected. To increase the swirl, series of experiments to be conducted with Elliptical groove piston(EGP), Tangential groove piston (TGP) and Rhombus groove piston (RGP)and compare the results with normal piston values.

Index Terms—DI Engine, Piston head grooves and Performance.

I. INTRODUCTION

An internal combustion engine is defined as an engine in which the chemical energy of the fuel is released inside the engine and used directly for mechanical work, as opposed to an external combustion engine in which a separate combustor is used to burn the fuel. The internal combustion engine was conceived and developed in the late 1800s. It has had a significant impact on society, and is considered one of the most significant inventions of the last century. The internal combustion engine has been the foundation for the successful development of many commercial technologies. For example, consider how this type of engine has transformed the transportation industry, allowing the invention and improvement of automobiles, trucks, airplanes and trains.

It is well known that in DI diesel engines swirl motion is needed for proper mixing of fuel and air. Moreover, the efficiency of diesel engines can be improved by increasing the burn rate of fuel air mixture. This can be achieved in two ways; one by designing the combustion chamber in order to reduce contact between the flame and the chamber surface, and two by providing the intake system so as to impart a swirl motion to the incoming air. The swirl ratio and resulting fluid motion can have a significant effect on air-fuel mixing, combustion, heat transfer, and emissions. When the piston moves close to the top dead centre [TDC], the variation of swirl ratio depends on the shape of the combustion chamber. For combustion chamber bowl-in piston, the gases are squished in to the piston bowl when the piston moves close to TDC. The momentum of inertia of gases decreases abruptly, leading to the increase of swirl ratio. This increase in large scale flow speed contributes to the fuel spray being spread out which accelerates the processes of the fuel-air mixing and rate of combustion in diesel engines. The effect of swirl on combustion and emissions of heavy duty-diesel engines has been investigated and suggested that optimum level of air swirl that minimizes soot depends on engine running conditions. It has recognized that over-swirling causes centrifugal action which directs the fresh air away from the fuel, resulting in complete combustion and there by soot formation. The interaction between the swirl motion and the squish flow induced by compression increases the turbulence levels in the combustion bowl, promoting mixing and evaporation of fuel. In diesel engine, fuel is injected at the end of compression stroke, followed by the entry of compressed air tangentially into the injected fuel spray and then it mixes with air. In order to achieve the swirl intensities in the cylinder, changes on the piston crown has been selected. To increase the swirl, series of experiments were conducted like 4 tangential grooves piston, 9 elliptical grooves piston, 6 rhombus grooves piston and compare the results with normal piston.

II. DESIGN OF GROOVES ON PISTON CROWN

The in-cylinder air motion in internal combustion engines is one of the most important factors controlling the combustion process. It governs the fuel-air mixing and burning rates in diesel engines. In this present work the experimental investigation of air swirl in the cylinder upon the performance and emission of a single cylinder diesel direct injection is presented. This intensification of the swirl is done by the cutting grooves on the crown of the piston, by three different configurations of TGP4, EGP9, RGP6 and normal pistons are investigating the performance of the diesel engine. Experiments are carried out on a diesel engine using Modified different configuration piston which is a four stroke single cylinder air cooled and constant speed engine. Performance parameters such as brake power, specific fuel consumption and Thermal efficiency are calculated based on experimental analysis of the engine. It is evident that the effect of geometry has a negligible effect on the airflow during the intake stroke and early part of the compression stroke. But when the piston moves towards Top Dead Centre (TDC), the bowl geometry has a significant effect on air flow thereby resulting in better atomization, better mixing and better combustion. The geometry of the piston heads are shown in figure below.

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Fig. 1 (TGP 4)

Fig. 2 (EGP 9)

Fig.3 (RGP 6)

III. EXPERIMENTAL SETUP AND PROCEDURE

The experiments are conducted on 5 BHP KIRLOSKAR single cylinder, 4-stroke, water cooled conventional diesel engine. The specification engine given below.

ENGINE SPECIFICATIONS

Type	Four stroke single cylinder diesel engine water cooled compression ignition engine
Make	Kirloskar
Rated power output	5 HP [3.68 KW]
Bore & stroke	80mm & 110mm
Compression ratio	16.5 : 1
Engine displacement	553cc
Starting	By hand cranking

IV. RESULTS AND DISCUSION

The experiments are conducted for normal piston; tangential groove piston, elliptical groove piston and rhombus groove piston by varying load are shown in the following graphs.

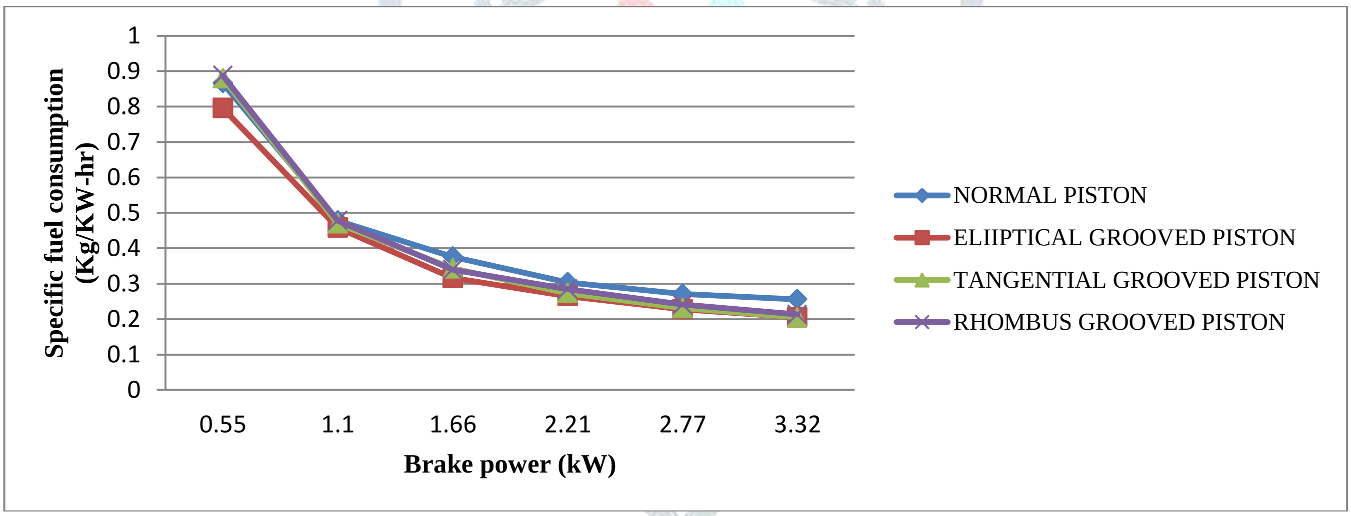

Fig.4 Specific fuel consumption vs Brake power

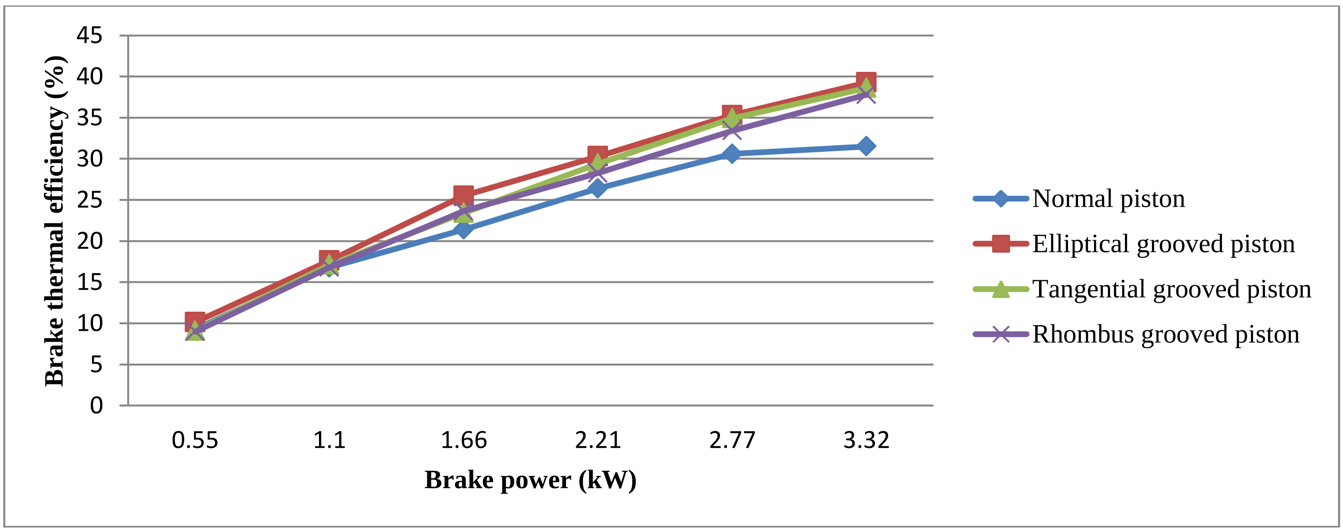

Fig.5 Brake thermal efficiency vs Brake power

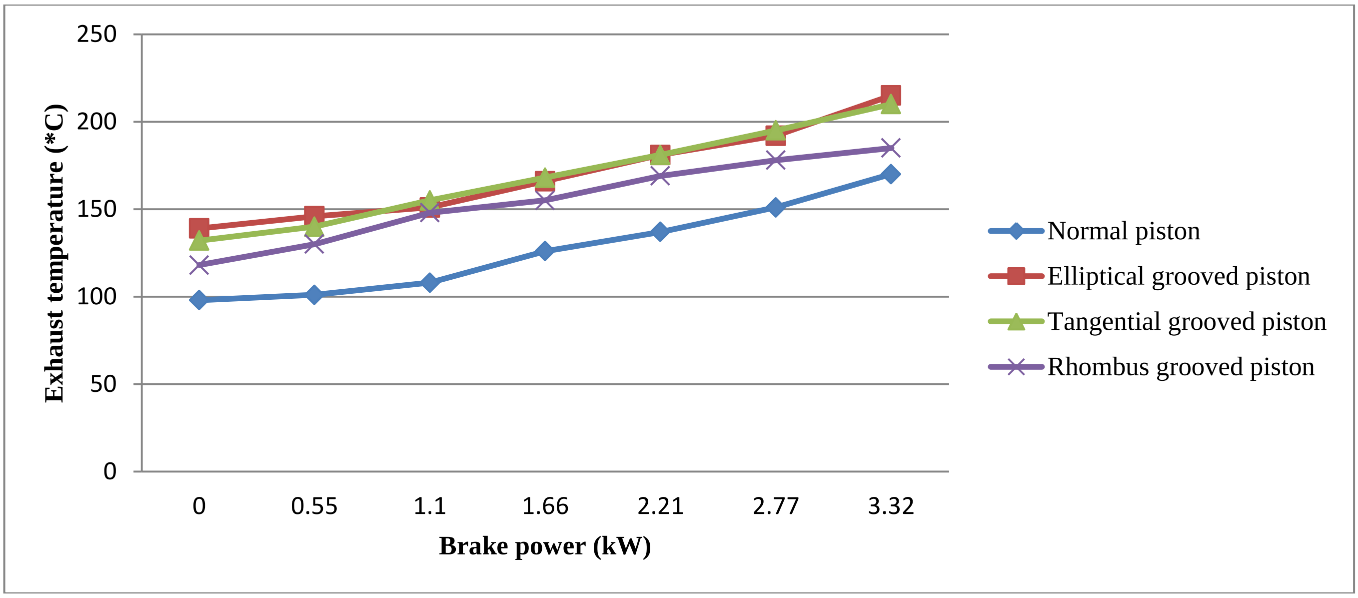

Fig.6 Exhaust temperature vs Brake power

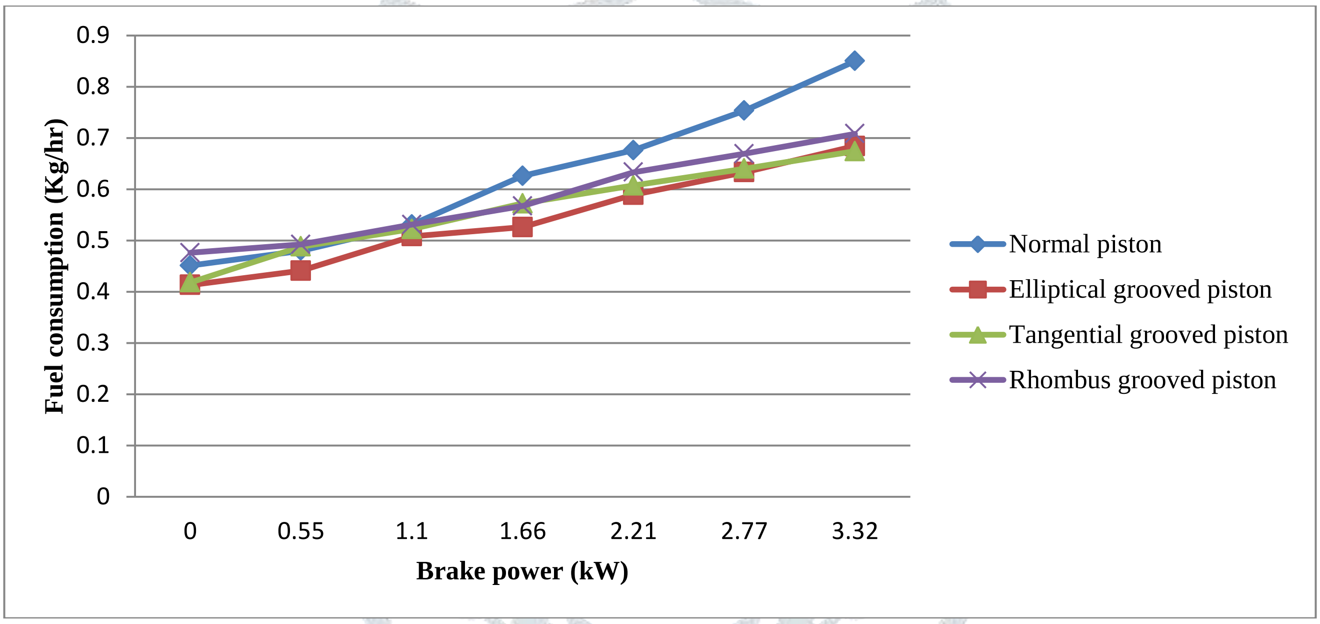

Fig.7 Fuel consumption vs Brake power

From the Fig.4, it is absorber that the specific fuel consumption of grooves pistons are less as compare to normal piston by increase brake power. The specific fuel consumption of TGP less as compare to other groove pistons.
From the Fig.5, it is absorber that the Brake thermal efficiency of grooves pistons are more as compare to normal piston by increase brake power. The Brake thermal efficiency of EGP more as compare to other groove pistons.
From the Fig.6, it is absorber that the exhaust temperature of grooves pistons are more as compare to normal piston by increase brake power. The exhaust temperature of EGP more as compare to other groove pistons.
From the Fig.7, it is absorber that the fuel consumption of grooves pistons are less as compare to normal piston by increase brake power. The fuel consumption of TGP less as compare to other groove pistons.

V. CONCLUSION

The geometry of the piston is modified by accommodating grooves in the piston crown to induce turbulence by means of swirl motion of charge. Based on the experimental work on a single cylinder diesel engine with swirl inducing pistons the following conclusions are drawn.

- The maximum increase in brake thermal efficiency for EGP, TGP and RGP compared to normal piston was found to be 24.6%, 22.57% and 20.03% respectively.
- The reduction in the brake specific fuel consumption for EGP, RGP and TGP compared to normal piston was found to be 24.87%, 24.27% and 20.18% respectively
- The exhaust gas temperature is found to be 170 ^{0}C for normal piston and 215^{0}C for EGP, 210^{0}C for TGP and 185^{0}C for RGP. There is an increase in exhaust gas temperature obtained for groove pistons are more.

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