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Analysis of Impact of Modified Piston

G. Sucharitha and Ramesh Rai

Abstract--- *The piston is a heart of the engine and its working condition is the most exceedingly bad one of the key parts of the engine in the workplace. A piston is a segment of responding piston responding pumps gas compressors and pneumatic chambers among other comparative systems. It is the moving part that is contained by a barrel and is made gas-tight by piston rings. In a piston, its motivation is to exchange force from growing gas in the barrel to the crankshaft through a piston bar and additionally associating pole connecting rod. The main objective is to investigate and analyze the behavior stress and structural analysis of modified piston at the real engine condition during the combustion process. This work advancement by utilizing finite element analysis to anticipate the higher stress and critical area is on the component.*

Keywords--- *Piston Mechanical, Fatigue Machines, Materials Survey.*

I. INTRODUCTION

The automotive piston is indeed a highly thermal mechanically loaded part that sometimes requires specific features and characteristics in order to improve its performance and thereby to reduce the polluting emissions. From a thermal cycle point of view during normal engine operation, a piston first gets heated by the combustion process and is cooled thereafter by engine oil rings and cylinder block.

1.1 Parts of the Internal-Combustion Engine and their Functions

The function of the mechanism of any engine is to provide a means whereby the heat energy of the fuel can be efficiently converted into useful mechanical work. The cylinder is usually made of hard close-grained cast iron and may be arranged horizontally vertically or at an angle to the vertical according to the type of engine. Pistons are usually made of a good grade of close-grained cast iron or aluminum alloy. In larger engines, cast steel is sometimes used.

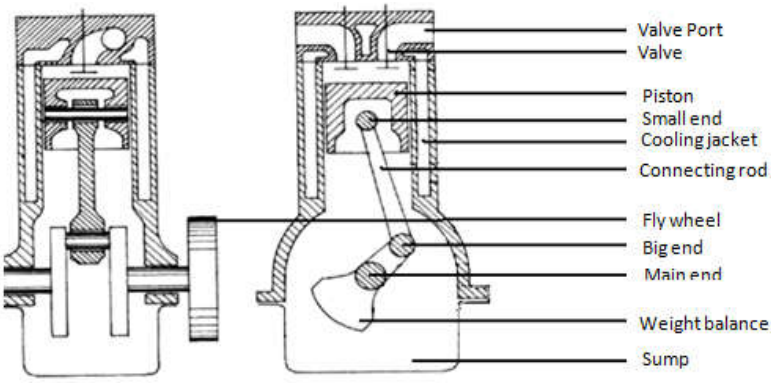

Fig. 1: Insight of a Single Cylinder Engine (Courtesy: SPR Ltd)

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a) Piston Ring

The piston ring is a split band that fits into a groove on the outer diameter of the piston in a reciprocating engine pressed against the wall of the cylinder by springs mounted in the inner "junk ring.

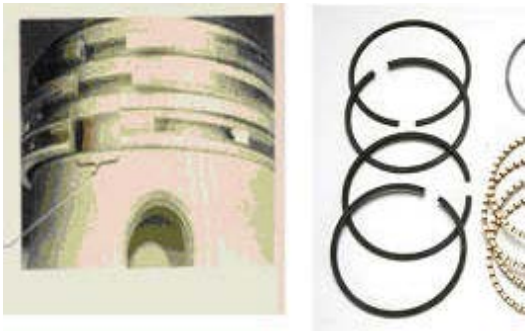

Fig. 2: Piston Ring

A ring groove is a recessed area located around the perimeter of the piston that is used to retain a piston ring. Ring lands are the two parallel surfaces of the ring groove which function as the sealing surface for the piston ring. A piston ring is an expandable split ring used to provide a seal between the piston and the cylinder wall. Piston rings are commonly made from cast iron.

b) Cylinder Liner

Cylinder liner a cylinder liner is a cylindrical part to be fitted into an engine block to form a cylinder. It is one of the most important functional parts to make up the interior of an engine. The cylinder liner serving as the inner wall of a cylinder forms a sliding surface for the piston rings while retaining the lubricant within. The most important function of the cylinder is the excellent characteristic as of the sliding surface and there are four necessary points which must be considered for the cylinder liner they are: 1. high anti-galling properties 2. Less wear on the cylinder liner itself 3. Less wear on the partner piston ring 4. Less consumption of lubricant. Fig 3. Cylinder liner the cylinder liner receives combustion heat through the piston and piston rings and transmits the heat to the coolant.

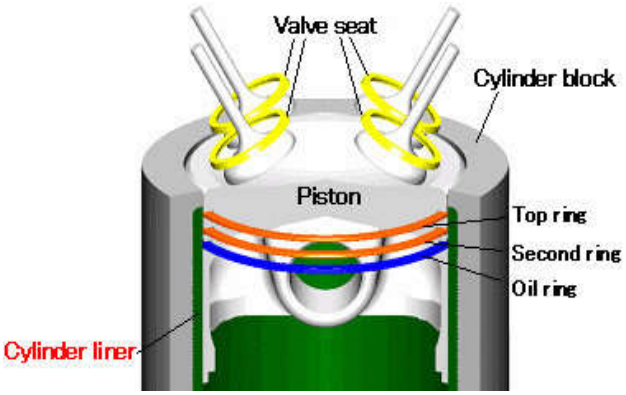

Fig. 3: Cylinder Liner

The cylinder liner prevents the compressed gas and combustion gas from escaping outside. it is necessary that a cylinder liner which is hard to transform by high pressure and high temperature in the cylinder.

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1.2 Piston Materials

Piston materials the most commonly used material for the piston of IC engines is al alloy and cast-iron. But al alloy is preferable in comparison of cast iron due to its lightweight. The heat conductivity of Al-alloy is four times that of cast iron. Aluminium pistons are made thicker which is necessary for strength in order to give proper cooling. Pistons are a group of engine ensembles made of cylindrical metal that exhibits vertical movement within the cylinder. Pistons are used in various machines like pneumatic and gas compressors pumps and reciprocating engines. The main function of a piston in a machine is to transfer force from the gas expanding in the cylinder to the crankshaft with the help of pistons or connecting rods.

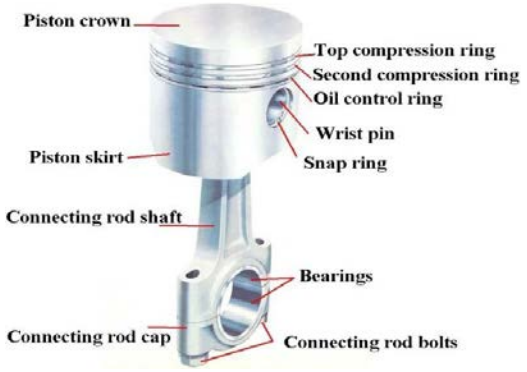

Fig. 4: Components of Piston

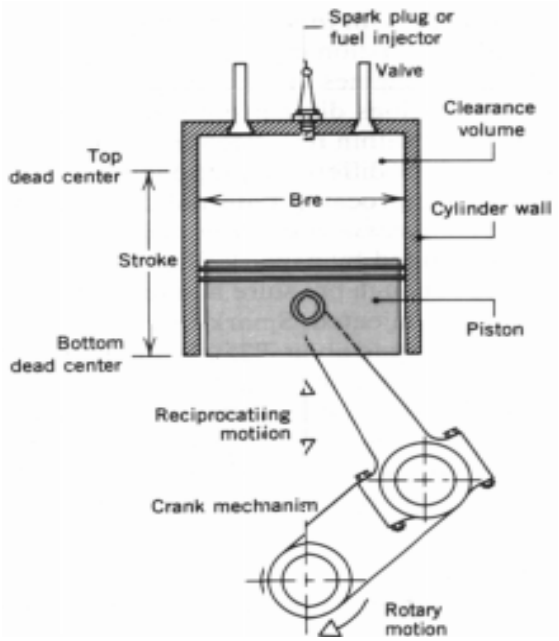

Fig. 5: Arrangement of Piston Cylinder

a) Factors Considered for Proper Functioning of Piston

1. The piston should have enormous strength and heat resistance properties to withstand gas pressure and inertia forces. They should have minimum weight to minimize the inertia forces.

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2. The material of the piston should have good and quick dissipation of heat from the crown to the rings and bearing area to the cylinder walls. It should form an effective gas and oil seal.
3. Material of the piston must possess good wearing qualities so that the piston is able to maintain sufficient surface-hardness unto the operating temperatures.
4. Piston should have rigid construction to withstand thermal mechanical distortion and sufficient area to prevent undue wear. it has even expansion under thermal loads so should be free as possible from discontinuities.

1.3 Different Types of Pistons Design

HCCI stands for homogenous charge compression ignition is an engine combustion. The design of pistons is important for engine performance. Pistons must have low friction to improve engine performance and fuel economy. The profile of the piston cavity and the configuration of the nozzle also play significant roles in engine combustion fuel emission and the fuel consumption. The design of the piston cavity nozzle design piston bowl type and the in-cylinder charge air is all important parameters that affect engine performance. The geometry of the piston cavity and various dimensions such as the pipe region torus radius impingement area and the cavity lip area affect the formation of emissions in engine combustion. Research has shown that combustion chambers with optimal shapes help reduce emissions during engine combustion.

a) Square Bowl Piston Design

As its name suggests this piston is a modified version of the bowl piston. it has a square bowl space on its top this shape has a direct influence on the rate of heat released especially with HCCI engines. As a matter of concern most HCCI combustion is limited to load as a result of high pressure and fast combustion; thus, the speed of combustion can reduce the load range. Therefore, square bowl pistons produce micro-turbulence derived from rounded corners which account for the superior air-fuel mixing.

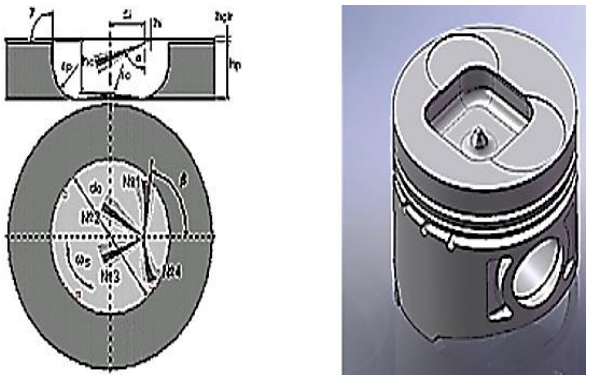

Fig. 6: Square Bowl Piston Design

b) Bowl Piston Design

Bowl piston design bowl pistons are applied to minimize compression ratios due to the additional blow combustion volume. They can be used on supercharged or turbocharged engines to eliminate detonation that is the spark knock under the boosted conditions of the two designs. Bowl pistons have compact combustion chambers and

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fast combustion rates figure shows a sample bowl piston used in a diesel engine in which the bowl is utilized to confine the gasoline spray for good and fast combustion.

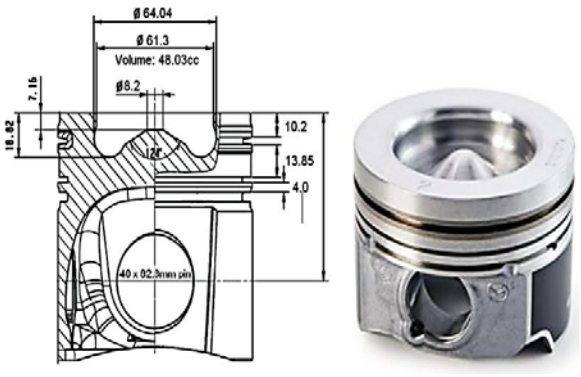

Fig. 7: Bowl Piston Design

c) Dome Piston Design

Dome piston design the dome piston has the additional volume on the top compared to flat pistons whose tops are flat as shown in the figure. The extra volume is for improving the compression ratio of the piston and consequently improving performance. However, inefficiency in the cylinder surface design and highly domed pistons cause inefficient combustion and slow burning rates of the air-fuel mixture. Convexity is used to develop and improve optimum chamber shape with a high compression ratio and efficient combustion rate.

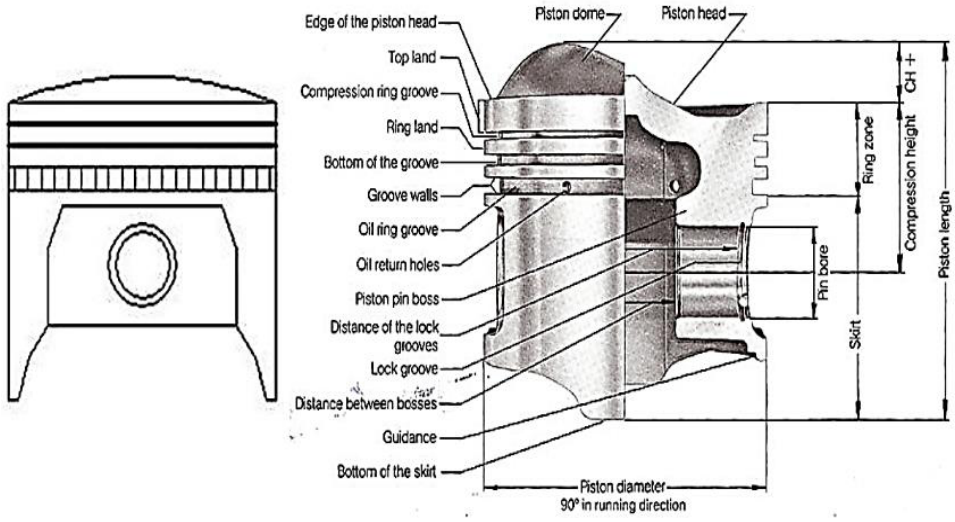

Fig. 8: Dome Piston Design

d) Flat-Top Piston Design

This piston is commonly used in mass-produced engines. They are easy to develop which keeps the cost of the engines low. Some flat top pistons have material extracted from the top to ensure the valves do not hit the pistons during the opening and closing of the intake and exhaust valves. This improves their compression ratios by allowing the pistons to rise higher into the head of the cylinders. The last decade has seen advancements in piston technology.

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Fig. 9: Flat -Top Piston Design

e) Two Stroke Piston

In a two-stroke HCCI engine, a flat-top piston can also be used. The combustion chambers steep roofs yield greater clearance volume creating a lower compression ratio when using a flat piston. This choice of piston design reduces the compression ratio to a minimum of about 9:1.

Fig. 10: Two-stroke Piston

f) Four-Stroke Engine Pistons

This piston design with a bowl on top is important in directing the fuel going to the piston during late injection timings. Furthermore, the crown piston is slightly raised for the increased compression ratios that are typical for gasoline based HCCI engines. for gasoline-based HCCI engines, higher compression ratios become useful in overcoming the disadvantages caused by the reduction of firing frequency compared to engines with the two-stroke.

Fig. 11: Four-stroke Piston

II. LITERATURE SURVEY

Andersson, Peter, Tamminen, Jaana, Sandstrom, CarlErik.

There is never the best piston ring or the best piston ring assembly which can meet all the demands of the different operating conditions so for different operating conditions different material different shapes & different coatings piston rings are used. The material of the ring should be capable of resisting fracture even in extremity conditions. The material of the ring should be elastic and corrosion resistance to serve its purpose inappropriate way. Ring material should also have good thermal conductivity to conduct heat from the piston to the cylinder walls. Material & shape of the ring should be such that it should withstand the mechanical stresses due to combustion of fuel as well as the thermal stress due to heat generation in the cylinder. ring shape should provide minimum friction between ring and liner.

A.V. Sreenath and N. Raman

Studies the conformance between the liner and rings of an internal combustion engine and found that it depends upon mainly on the linear wear dimensional loss during running-in. running-in wear studies using the factorial design of experiments on a compression ignition engine showed that at certain dead center locations of piston rings the linear wear of the cylinder liner increases with increase in the initial surface roughness of the liner.

Wakuri, Y., Hamatake, T., Soejima, M., Kitahara, T.

The friction force is considerably affected by the oil starvation. As the average and cyclic change of oil film thickness becomes smaller the friction force of the piston ring assembly becomes larger noticeably.

Peter Andersson, Jaana Tamminen, Carl-Erik Sandstrom. Piston ring tribology in 2002

The material of the ring should be capable of resisting fracture even in extremity conditions. The material of the ring should be elastic and corrosion resistance to serve its purpose inappropriate way. Ring material should also have good thermal conductivity to conduct heat from the piston to the cylinder walls. Material & shape of the ring should be such that it should withstand the mechanical stresses due to combustion of fuel as well as the thermal stress due to heat generation in the cylinder. Ring shape should provide minimum friction between ring and liner.

MS Motor Service International GmbH_ Piston Rings for Combustion Engines_2nd Edition 01.2010_

Nowadays coating for the ring is being used widely to improve the properties of the piston rings normally used coating materials are chromium molybdenum titanium and their alloys. Chromium is used where the wear rate of the piston ring is high and corrosion atmosphere is present. Molybdenum coating is used where the problem of scuffing is there. Flame spraying process or plasma spraying is employed for coating of molybdenum. Molybdenum also gives the advantage of porous structure on the face of the ring resulting in accumulation of lubrication oil on surface permitting the ring to run in extreme operating conditions.

III. CONCLUSIONS

This literature review presented some issues related to the effects of different piston crown designs in one HCCI engine. The direction of the piston is crucial to overall engine performance and efficiency. Innovations in engine

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technology employ designs that drive better performance for HCCI engines. Piston design is important for the best engine performance. Researchers strive to achieve successful piston design for HCCI gasoline-based combustion engines to eliminate various failure modes such as structural failure unusual noise and skirt scuffing. Pistons play an especially crucial role in engines. The designs and geometry of pistons contribute to overall engine performance.

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