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A Review on Thermal Design Analysis of Piston Using RSM Method

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***Abstract*- A piston is a component of reciprocating IC-engines. Piston is the component which is moving that is contained by a cylinder and was made gas-tight by piston rings. A mathematical model is formulated based on the simulation result values of total deformation, stress and first ring groove temperature. The Piston during the working condition exposed to the high gas pressure and high temperature gas because of combustion. At the same time it is supported by the small end of the connecting rod with the help of piston pin (Gudgeon pin). The gas pressure given 20 Mpa is applied uniformly over top surface of piston (crown) and arrested all degrees of freedom for nodes at upper half of piston pin boss in which piston pin is going to fix. The statistical ''Design-Expert 8.0.7.1" software has been used to study the regression analysis of simulation data and to draw the response surface plot. The statistical parameters were estimated by using ANOVA. The objective of the study is to minimize themass. The optimum combination of the influencing parameters for the mass can be found using Response Surface Method.**

***Keywords*- Piston , reciprocating IC-engines, mathematical model, temperature, gas, combustion, piston pin , connecting rod , gas pressure, crown, ring temperature.**

I.INTRODUCTION

A piston is a component of reciprocating IC-engines. Piston is the component which is moving that is contained by a cylinder and was made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in the cylinder to the crankshaft via a piston rod. Nowadays Piston mainly endures the cyclic gas pressure and the inertial forces at working and this working condition may cause the fatigue damage of piston. Piston in an IC engine must possess the good mechanical and thermal characteristics.

Generally pistons are made of Al alloy and cast iron. But the Al alloy is more preferable in comparison of cast iron because of its light weight which suitable for the reciprocating part. There are some drawbacks of Al alloys in comparison to cast iron that are the Al alloys are less in strength and in wearing qualities. The heat conductivity of Al is about of thrice of the cast iron. Al pistons are made thicker which is necessary for strength in order to give proper cooling.

Pistons are designed with features which perform specific functions during engine operation. The piston head or crown receives the majority of the initial pressure and force caused by the combustion process. The piston pin area is exposed to a significant amount of force due to rapid directional changes.

It is also subjected to thermal expansion caused by the transfer of heat from the head to the body of the piston. The piston pin area is subject to more thermal expansion than other areas of the piston. This occurs from the thermal expansion properties of cast aluminum alloy and the mass in the piston pin area.

Some pistons are cast and machined at the factory into a cam ground (elliptical shape). An elliptical shape is an oval shape in which one-half is a mirror image of the other half. These piston shapes provide an advantage in conforming to the ever-changing dimensions of the cylinder bore.

The piston is designed to be an elliptical shape when cold. As the engine reaches operating temperature, the piston pin bore area expands more than other thinner areas of the piston.

At operating temperature, the piston shape becomes a circular shape, which matches the cylinder bore for improved sealing and combustion efficiency.

II. LITERATURE REVIEW

Zhaoju et. al. (2019) calculated the temperature field distribution of the highly intensified diesel engine piston in static compression state and the thermo-mechanical coupling stress and compared with only consider the mechanical load, the results showed that the mechanical load is the major stress.

Mishra (2019) evaluated the strength of reciprocating piston, the simultaneous effect of all these forces should be considered, while simulating through finite element

method. With effect of all these forces, the currently considered piston of Gray Cast Iron, aluminum alloy and Metal-Metric-Composite (Si-C) are given four different crown shapes for optimization of material and crown geometry for better strength.

Krishnan et al. (2017) they studied approximately using light-weight materials, which include advanced ultra-high tensile strength steels, aluminum and magnesium alloys, polymers, and carbon-fiber strengthened composite materials.

Sinha et. al. (2017) analyzedpiston numerically with FEA software named ANSYS Workbench to assess its thermo mechanical capability under a predefined thermal and structural load.

Gopal et. al. (2017) studied a mechanism of the Piston, Connecting rod and Crank shaft of a four wheeler petrol engine. The components of the assembly have to be inflexible and the assembly has to move as a mechanism.

Shehanaz et. al. (2017) investigated thermal analyses on a piston, made of Cast Aluminum alloy and titanium alloy. Then, structural analyses are performed on piston of titanium alloy &Aluminum alloy material by means of using ANSYS workbench.

Sathish (2016) evaluated the stress distribution on the four stroke engine piston by using FEA. The finite element analysis is performed by using FEA software. The couple field analysis is carried out to calculate stresses and deflection dueto thermal loads and gas pressure.

Pandey et. al. (2016) investigated design, evaluation and optimization of 4 strokes S.I. Engine piston, which is strong and lightweight the usage of finite element analysis with the help of ANSYS Software. Solid Model of piston has been made the use of ANSYS 16.2

Geometric module and Thermo-Mechanical (Static Structural Analysis+ Steady-State Thermal Analysis) analysis is achieved to analyze stresses, general deformation and factor of safety distribution in numerous parts of the piston to understand the impact due to gasoline strain and thermal versions using ANSYS 16.2.

Rao et. al. (2016) analyzed the piston model by the use of unigraphics and outcomes are proven by fabricating piston by way of vortex approach the usage of aluminum primarily based mmc containing 5, 10, 15, wt. % and fly ash particulates of 53micro meter. Here we used stir casting method to get appropriate form and complexity. And after casting suitable machining is completed to the component to get the desired form.

Srinadh et. al. (2015) designed a piston for 1300cc diesel engine vehicle and brought three exclusive profile rings. A 2D drawing is constituted of the calculations. The piston and piston rings have modeled the use of Pro/Engineer software program.

The pressure and displacement are analyzed for the piston and piston rings by making use of stress on it in the Structural analysis.

Prasanth et. al. (2015) they conducted a thermal evaluation of piston by way of the use of Hybrid steel matrix.

Singh et. al. (2015) they studied the stress variations and thermal stresses of three various aluminum alloys piston by using finite element method (FEM). The parameters used for the simulation are performing gas pressure, temperature and material behaviors of piston.

The conditions used for the investigation of these pistons belong to four stroke single cylinder engine of Bajaj Kawasaki motorcycle.

According to Chaple and Deshamukh (2014) Computer aided engineering (CAE) tools allow engineers to design product and to simulate these designsfor residual stress, structural response, pre-processing and post processing fatigue and similar effects on themachine component.

Tamrakar et. al. (2014) performed design optimization of piston by using global sensitivity studyalong with finite element analysis through PRO-E. First a piston has been modeled and thenfinite element analysis has been performed to know about the structural and thermal loadingeffects.

Vibhandik et. al. (2014) studied that design analysis and optimization of piston and deformation of its thermal stresses using CAE tools, he had selected I.C. engine piston from TATA motors of diesel engine vehicle. He had performed thermal analysis on conventional diesel piston and secondly on optimized piston made of aluminum alloy and titanium alloy material

Kurbet's (2013) studied related to the working of theengine parts, the piston is considered as main source of thevibration and noise the emphasis is on the piston vibration andto find out the various methods to predict mechanical noiseproduced by the primary and secondary motion of the enginepart

III. CONCLUSION

After going through literature review of various authors it can be concluded that, Al–Si based alloys have been widely used in automotive piston and other thermal applications because of good mechanical and thermal properties, lightweightstructures, environmental and other attractive properties.

But to manufacturing the automotive piston the basic Al-Si alloys are unbeneficial and may not fulfil the basic requirements of piston. And produced various unwanted stresses in components during the manufacturing.

By controlling the exhaust gas temperature, catalytic converter life span can be improved. The heat transfer in exhaust arrangement directly influences the functions and the discharge characteristics of the internal combustion engine.

For improvement in the performance of an engine, it is necessary to control the temperature in automotive exhaust system. To calculate the temperature impact and heat switch to the engine piston crown it become concluded that spatial and time averaged combustion side boundary situation is a most favourable and suitable treatment technique inside engineering approximations.

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