International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Review of steady State Thermal Analysis of Piston Using Different Profile of Piston Head By Finite Element Analysis

RiteshTanwar[1], Prof. Rooesh Tiwari[2]

[1]M.Tech. Scholar,Department of ME,Sage University,Indore
[2]HOD &Professor,Department of ME,Sage University,Indore

ABSTRACT

The piston is the most critical component of the engine since it is exposed to heat and mechanical forces. The piston's job is to direct the rod's movement while conveying the gas pressure forces so that the volume within the cylinder may change. The piston in an engine is a reciprocating element that transfers thermal energy into mechanical energy. The piston is under thermo-mechanical strain, and cyclic thermal and mechanical loading has caused fatigue failure. To extend the life of the piston, further study has been conducted into improving the design and material of the piston.Concave and convex surfaces CATIA V5 was used to design the piston profile, and ANSYS 19.3 was utilised for the FEM study to optimise the piston's thermal behaviour. The piston was designed using aluminium alloy and grey cast iron.

Keywords: Piston, head, thermal analysis, CATIA V5, ANSYS, Thermal stresses.

NTRODUCTION

Because of the rising usage of vehicles, automotive components are in high demand these days. The growing demand is attributable to the components' greater performance and lower cost. To reduce the time it takes to launch new goods, R&D and testing engineers should build crucial components as quickly as feasible. This needs a thorough grasp of emerging technology as well as rapid incorporation into product development. In reciprocating IC engines, a piston is a component. The expanding gases' energy is converted into mechanical energy by the piston. The piston is seated in the cylinder sleeve or liner. Aluminum or cast iron alloys are widely used for pistons. Each piston has numerous metal rings surrounding it to prevent combustion fumes from bypassing the piston and to reduce friction. These rings serve as a seal between the piston and the cylinder wall, as well as reducing friction by reducing the piston-to-cylinder wall contact area. The piston should be stiff enough to minimise mechanical and thermal deformation, with adequate bearing surface to prevent excessive wear. Pistons are made with strength and thermal factors in mind. The piston pin's strength should be adequate to prevent shear failure. The piston is exposed to distortion during combustion, and the energy stored within the piston is used to determine the yield and failure conditions of a piston when subjected to static stress. Von misses result in The von Misses stress or equivalent tensile stress may be used to express creation, and the stress tensor can be used to get a scalar stress value.

FUNDAMENTAL OF PISTON

A piston is a metal cylindrical part that reciprocates within a cylinder and exerts force on the fluid inside. Pistons feature outside rings that keep oil out of the combustion chamber while keeping fuel and air in. Piston rings are found on most pistons used in cylinders. Two spring compression rings act as a seal between the piston and the cylinder wall, with one or more oil control rings underneath them. The piston's top surface might be smooth, bulged, or curved in any way. Forged or cast pistons are available. The piston's profile is typically rounded, although this may vary. The piston engine is seen in Figure 1. A piston is an important component of both piston engines and hydraulic pneumatic systems.

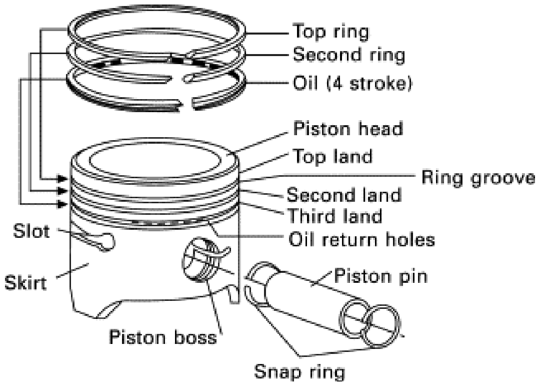

Fig. 1 Schematic diagram of piston.

LITERATUREREVIEW

In this section research papers are discussed related to the present work. Published papers are highlight in this section..

Vaishali R. Nimbarteet al. [1]The stress distribution of the piston under real engine conditions was researched and evaluated. Pressure, temperature, and thermo-mechanical analyses of the piston were carried out in their work. They employed operating gas pressure, temperature, and piston material qualities as parameters to study the piston. Boundary conditions were used to examine the piston, which included pressure on the piston head during operation and temperature distribution from the piston head to the skirt.

KethavathVishalet al [2]worked on the piston design and analysis. The design, analysis, and manufacturing procedures of pistons were investigated here. The goal of the study was to quantify piston transient temperature at different places on the piston from cold start to steady state and compare the findings to those of finite element analysis.

Amit B. Solankiet al. [3]presented the design study and optimization of a hybrid piston for a 4 stroke single cylinder diesel engine producing 10 HP (7.35 kW). The piston crown was made of high-strength cast steel, while the piston wall was made of a light alloy like aluminium alloy. They studied the stress distribution of the piston and the real engine state throughout the combustion process using FEM. The strains caused by combustion were taken into account in order to prevent the piston from failing.

Dr. L.N. Wankhade et al. [4]a piston's upper surface was examined to see how much stress and heat was present there. The structural model of the piston would be generated using CATIA V5 software. Then they loaded the CAD model into the Hyper Mesh for geometry cleaning and meshing purpose.

MuhammetCerit [5]engine piston with a partial ceramic coating on the spark ignition (SI) spark plug. He evaluated the effects of coating thickness and breadth on temperature and stress distribution and performed a comparison with data from an uncoated piston. He saw the coated surface temperature rise with increasing the thickness in a decreasing pace. The surface temperature of the piston was raised to 82°C with a coating thickness of 0.4 mm.

M. Martin et al. [6]The computational and experimental evaluation of the impact of a partial thermal barrier coating on the temperature distribution of the piston and the cold start HC emissions from a spark ignition (SI) engine. They did thermal analysis for both regular and coated pistons by utilising ANSYS. They employed a single cylinder, water cooled SI engine for both regular and coated casings. An examination of their data revealed an increase in air-fuel mixture temperatures in the crevice and wall quenching regions of up to 100°C on the coated piston portion. Thus, cold start HC emissions dramatically drop compared to the normal engine without any compromise in engine performance. When compared to a conventional engine, the maximum reduction in HC emissions was 43.2%.

Shuoguo Zhao [7]provided a structural study of the piston in 2012. He studied the piston with Pro-E software to enhance and optimise the structure of the piston. There are two processes in the analysis of the piston carried out by Aditya Kumar Gupta et al. They were Designing and Analysis.

DeovratVibhandik et al. [8]examined the behaviour of the combustion engine pistons which were manufactured of various sort of materials under thermal stress. Geometrical model of the piston was generated using CAD software. The model was created using a real-life TATA MOTORS four-stroke diesel engine piston as a starting point.

K VenkateswaraRaoet al. [9]created a 5B.H.P diesel engine piston. Pro-E was used to create a 3D model of the piston. They utilised Cast Aluminum, Aluminum MMC and Brass as piston material. The strength of the piston was evaluated structurally by applying pressure to three different materials. The piston's heat transfer rate and temperature distribution were studied using thermal analysis.

KethavathVishalet al [10]spent time working on piston design and analysis. The design, analysis, and manufacturing procedures of pistons were all examined in this setting. Research goals included measuring piston transient temperature at different locations throughout its length from cold start to steady state and comparing those findings with those obtained by finite element analysis.

M. Cerit et al. [11]The computational and experimental evaluation of the impact of a partial thermal barrier coating on the temperature distribution of the piston and the cold start HC emissions from a spark ignition (SI) engine. They did thermal analysis for both regular and coated pistons by utilising ANSYS. They employed a single cylinder, water cooled SI engine for both regular and coated casings. An examination of their data revealed an increase in air-fuel mixture temperatures in the crevice and wall quenching regions of up to 100°C on the coated piston portion. Thus, cold start HC emissions dramatically drop compared to the normal engine without any compromise in engine performance. When compared to a conventional engine, the maximum reduction in HC emissions was 43.2%.

P. Carvalheira et al. [12]examined the performance of an engine piston made of two different materials. One of the materials was Aluminium Alloy A390-T5 and another was Ductile Iron 65-45-12. They examined the two materials with the aid of Finite Element Analysis (FEA) and identified the most suitable material for piston. To anticipate the thermal and mechanical loads on the piston, a number of FEA were done and thus they optimised the piston form.

Conclusion

Impacts on piston strength can be seen in piston materials, which have a significant effect in engine performance. The piston crown's bottom surface shows the greatest amount of stress in both materials, which is to be expected. The top of the piston is made of aluminium alloy and grey cast iron, which absorbs the maximum amount of displacement. Due to the thermal conductivity of the piston materials, the maximum heat flux is absorbed by both piston materials, resulting in the highest maximum temperature. As a result, new materials and a variety of design and analysis tools can be used to enhance study. Concave pistons exhibit greater stresses and overall deformations than convex pistons in the designs for which analysis are performed. Concave or cup-shaped pistons in diesel-fueled, large-sized IC engines are hence justified.

References

1. Ajay Raj Singh , Dr. Pushpendra Kumar Sharma. "Design, Analysis and Optimization of Three Aluminium Piston Alloys Using FEA", Int. Journal of Engineering Research and Applications www.ijera.comISSN : 2248-9622, Vol. 4, Issue 1,Version 3, January 2014, pp.94-102

2. Shuoguo Zhao , "Design the Piston of Internal Combustion Engine by Pro\ENGEER" 2nd International Conference on Electronic & Mechanical Engineering and Information Technology (EMEIT-2012),zhaoshuguo@yahoo.com.cn

3. Aditya KumarGupta ,Vinay Kumar Tripathi ."Design Analysis and Optimization of Internal Combustion Engine Piston using CAE tool ANSYS"Aditya Kumar Gupta Int. Journal of Engineering Research and Applications www.ijera.comISSN : 2248-9622, Vol. 4, Issue 11(Version - 5), November 2014, pp.04-10

4. S. Srikanth Reddy, Dr. B. SudheerPrem Kumar "Thermal Analysis and Optimization of I.C.Engine Piston Using Finite Element Method" International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization)ISSN: 2319-8753. Vol. 2, Issue 12,December2013

5. YaochenXu ,Mo Yang."Structure Design and Simulation of Titanium Engine Piston Based on Thermal-Mechanical Coupling Model" This work was carried out at the Department of Mechanical Engineering, Bleking Institute of Technology, Karlskron, Sweden under the supervision of Dr, Mats-Walte and doctoral student Massimo Panarotto. October 2012.

6. S. Bhattacharya, A. Basu, S. Chowdhury, Y.S. Upadhyaya "ANALYSIS OF PISTON OF TWO STROKE ENGINE" IJRET: International Journal of Research in Engineering and Technology. eISSN: 2319-1163 | pISSN: 2321-7308

7. Shuoguo Zhao , ―Design the Piston of Internal Combustion Engine by Pro\ENGEER‖ 2nd International Conference on Electronic & Mechanical Engineering and Information Technology (EMEIT-2012),zhaoshuguo@yahoo.com.cn

8. Aditya KumarGupta ,Vinay Kumar Tripathi .―Design Analysis and Optimization of Internal Combustion Engine Piston using CAE tool ANSYS‖Aditya Kumar Gupta Int. Journal of Engineering Research and Applications www.ijera.comISSN : 2248-9622, Vol. 4, Issue 11(Version - 5), November 2014, pp.04-10

9. S. Srikanth Reddy, Dr. B. SudheerPrem Kumar ―Thermal Analysis and Optimization of I.C.Engine Piston Using Finite Element Method‖ International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization)ISSN: 2319-8753. Vol. 2, Issue 12,December2013

10. YaochenXu ,Mo Yang.―Structure Design and Simulation of Titanium Engine Piston Based on Thermal-Mechanical Coupling Model‖ This work was carried out at the Department of Mechanical Engineering, Bleking Institute of Technology, Karlskron, Sweden under the supervision of Dr, Mats-Walte and doctoral student Massimo Panarotto. October 2012.

11. S. Bhattacharya, A. Basu, S. Chowdhury, Y.S. Upadhyaya ―ANALYSIS OF PISTON OF TWO STROKE ENGINE‖ IJRET: International Journal of Research in Engineering and Technology. eISSN: 2319-1163 | pISSN: 2321-7308

12. Dr. L.N. Wankhade, VivekZolekar. ―Finite Element Analysis andOptimization of I.C. Engine Piston Using RADIOSS and OptiStruct‖ Altair Technology conference, 2013 India