International Journal of Research Publication and Reviews

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

A Review of Analysis and Performance of I.C. Engine Piston with Coating Material using CATIA and ANSYS software

Hem Narayan Shah and Dr. Shrihar Pandey

Department of Mechanical Engineering, Eklavya University, Damoh (M. P.), India

ABSTRACT

A piston is a component of IC engines. A cylinder confines the moving part, which is sealed by piston rings. In an engine, a piston rod and/or connecting rod transfer force from the expanding gas in the cylinder to the crankshaft. The piston, as an important component of the engine, is subjected to cyclic gas pressure and root stress during use, which can cause fatigue damage to the piston, such as piston side wear, piston head/crown cracks. etc. According to research, the highest stress occurs at the top end of the piston and stress concentration is a major cause of fatigue failure. The main objective of this research is to look at the analysis of pistons with design changes to reduce volume and improve efficiency. This required a thorough thermal analysis. The investigation focuses on dynamic, model and transient thermal analysis. This research focuses on the analysis and optimization of materials in pistons.

KEYWORDS- I.C. Engine piston; CATIA software; ANSYS software:

1 INTRODUCTION

A piston is a component of IC engines. It is the moving part that contains the cylinder and is sealed by the piston rings. In an engine, its purpose is to transmit the force of the expanding gas in the cylinder through the piston rod and/or connecting rod to the crankshaft. And this working condition can cause piston fatigue damage, such as piston side wear, piston head/crown cracking, etc. Investigations show that the highest stresses appear at the top end of the piston and stress concentration is a major cause of fatigue failure.

On the other hand, piston overheating can only happen when something burns or scratches the oil film that exists between the piston and the cylinder wall. Understanding this, it is not difficult to see why oils with exceptionally high film strength are so desirable. Good quality oils can provide a film that will withstand the extreme heat and pressure loads of a modern high horsepower engine. Thermal analysis is a branch of materials science where the properties of materials are studied as they change with temperature. The FEM method is commonly used for thermal analysis.

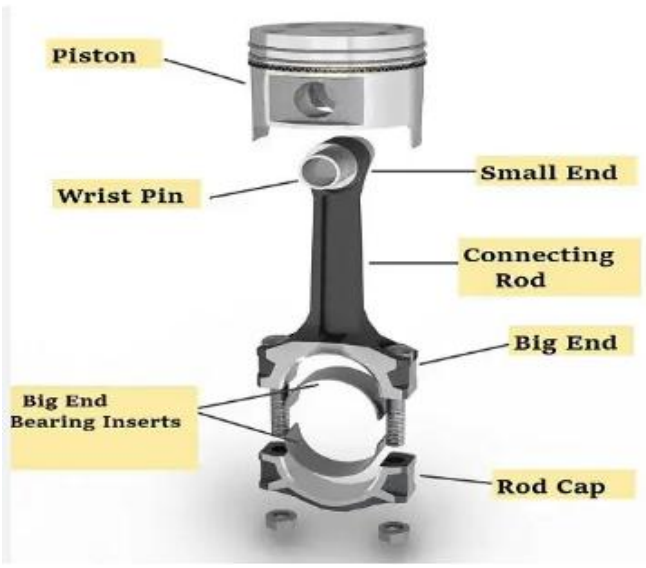

Figure 1 I.C. Engine piston with assembly

Figure 1 I.C. Engine piston

Due to the complex working environment for the piston; On the one hand, FEA for pistons has become more difficult, on the other hand, although there are many proposed methods to implement the ideal design, it is not easy to determine the ideal parameters. In this study, the piston is used in a low speed, rated speed gas engine. To improve engine dynamics and economy, it is important to implement optimization for the piston.

2 LITERATURE REVIEW

Many research articles have been published around this research work. Among these, specific articles are reviewed to form the basis of this work for a comparative study of piston materials, namely Aluminum 4032, Carbon Graphite and Tungsten. It became necessary to calculate the temperature distribution of the piston to control the thermal stress and distortion within acceptable levels. Temperature distribution allows the designer to optimize the thermal aspects of the piston design at low cost. Srinath et al. concluded that Zamak has low deformation and high heat flow properties compared to other materials such as cast iron and aluminum. According to their results, pistons with Zamak have a higher heat flux value than conventional materials. SiC-reinforced ZrB2 composite pistons have lower deflection than aluminum alloy and gray cast iron for the applied temperature and pressure. It is also observed that the stresses for all the materials are within the permissible limits for the respective materials. Aluminum silicon carbide has less deformation, lower stress and better temperature distribution than aluminum [1-4]. Due to the high pressure and high temperature combustion of fuel inside the engine cylinder, the engine runs with increased load and speed. High thermal and structural stresses on the piston are generated inside the engine cylinder and if these stresses exceed the designed values, piston failure occurs [5].

Krishna Dutta Pandey etc. [6] compared structural steel and graphite for piston materials using FEA. Their analysis shows that graphite is a better piston material because of its better thermal behavior and lower weight. The results show that pistons made of carbon graphite have higher heat transfer. Carbon graphite is lighter than 2618 aluminum alloy, as well as having a lower coefficient of thermal expansion. Kumar et al. Conducted static structural analysis, steady temperature analysis and transient temperature analysis of AL-4032 aluminum alloy piston using ANSYS. It is confirmed that the main factor of piston failure is induced voltage. Changes in temperature and heat flux over time are determined in transient analysis. Maximum displacement is observed above aluminum alloy and gray cast iron pistons. The maximum temperature found in the piston is due to the thermal conductivity of the material and the maximum total heat flux absorbed by both materials of the piston. Thus, further research can be done with better materials [7-9]. The total heat flow is different for different types of materials. The total heat flux is calculated for structural steel and gray cast iron for the same geometry with the same mesh properties. The heat flow results show that the difference in heat flow from simulation or analysis is not much. It also shows that the simulated heat flux values are very close to the theoretical values calculated by formula [10].

The review shows that simulation using FEA produces results similar to analytical results. Thus, FEA is adopted in this work for static structural analysis and steady state thermal analysis. Structural analysis is necessary to ascertain the effect of mechanical loads on the piston material. A new tungsten material was chosen for the piston as the basis for the overhaul. It was decided to compare it with other piston materials, namely aluminum-4032 alloy and carbon graphite.

3 PISTON RINGS

Typically, a compression ring and oil ring are attached to an optional piston to form a piston ring assembly. The compression ring works to prevent a phenomenon called blow-by. The high-pressure flue gas flows into the crankcase of the combustion chamber. On the other hand, the oil ring mainly has the function of pressing the excess lubricant on the inner wall of the cylinder liner. The primary function of the piston rings is to seal the combustion chamber from the rest of the engine. Before designing the piston rings, some considerations must be made. The first piston ring should not be too far behind the piston head. This increases the volume of the space between the piston and the cylinder walls, which increases the exhaust gases of hydrocarbon compounds. At medium speed, the first touch takes over 75% of all pressure. The choice of the number of rings should be the result of a careful analysis, on the one hand it depends on whether the gas passing through the crankcase should be minimized, and on the other hand the number of rings determines the mass of the piston, the reduction in height. she does.

4 MATERIALS

Adverse working conditions make the requirements for materials used in pistons very wide and varied. The materials used in the manufacture of pistons can be divided into the following groups.

1. Cast Iron (Unalloyed Steel and Alloys)
2. Aluminum alloy
3. Special steel

The cast iron used in pistons is usually a pearlite structure with separate blades. Upon adhesion, a fine granular structure is obtained and will improve the mechanical properties of the material. The advantages of cast iron are: good sliding properties, high friction resistance, small loss of strength and hardness at high temperatures, small coefficient of thermal expansion. Disadvantages are: high density and small heat conduction coefficient. The hardness of cast iron should be in the range of 180 - 240 HB and should also match the hardness of rings and cylinder walls.

Also, for uniform pistons with higher speeds, lighter aluminum alloys are used. Advantages in aluminum alloys: low density (about three times less than cast iron), good thermal conductivity, easy casting and good machinability. Disadvantages are: average coefficient of linear expansion (2.5 times higher than cast iron), lower hardness, reduced strength at high temperatures and finally slightly higher cost. The small density of aluminum allows the construction of lightweight pistons, which positively affects fuel consumption and also reduces the stress and strain of torque forces.

5 ADVANTAGES OF THE PISTON

- Mechanical simplicity.
- Flexibility and reliability.
- Power to weight ratio.
- Multi-fuel capability.
- Low turbine operating temperature.
- Less vibration and noise.
- Less maintenance.
- Easy to start the piston.

6 PISTON PIN

The piston pin is used to transfer pressure from the piston to the connecting rod, it is also responsible for providing oscillating motion to the connecting rod. Working conditions are harsh and high temperatures, tight spaces and small sizes make calculations very difficult..

7 PISTON PIN MATERIALS

Working conditions determine the properties of the applied material. The great pressure demands a very hard and scratch-resistant surface, and due to the resistance of oscillations to fatigue. These requirements lead to the use of low carbon steel C=0.12 – 0.18%. After fabrication, the pins are externally hardened to give them a tough and scratch-resistant surface.

8 PISTON CROWN SURFACE

The piston crown surface is one of the most important parts of the piston. Where combustion takes place and where maximum pressure is maintained by the flue gases. As for pressure, no simplifications are made, this is a steady state analysis, so in the worst case, the maximum pressure is taken. The value is p = 3 MPa. When it comes to heat exchange between the gases and the surface of the piston crown, things get a little more complicated. The first method was to fix the temperature at the surface of the piston head, later it was observed that this resulted in incorrect results.

9 PISTON REDESIGN IMPROVEMENTS

1. Reduction in piston crown thickness.
2. Optimize piston ring temperature for more accurate results.
3. Increasing the height of the cube to reduce stress.
4. Introduction of the shape of the barrel above the piston.
5. Increase scrap ring height to actually fit.

10 COOLING SYSTEM

Piston engines, and especially internal combustion engines, are usually cooled by lubricating oil. Traditionally, this is achieved by spraying the piston with lubricating oil to cool the underside of the piston head surface. In large engines this system becomes inefficient due to excessive heat transfer. A large amount of oil spray is required to correct this problem. This requires additional components such as oil storage tanks that are larger than necessary, reducing the engine's power-to-weight ratio and increasing the operating costs of engine manufacturing. Consequently, the heat transfer between the piston and the lubricating oil is not uniform throughout the engine. This causes thermal gradients and stresses within the motor, potentially leading to cracking.

11 METHODOLOGIES

In this research work, the principle of reverse engineering has been applied to piston design. Piston design data was collected from various sources. Material selection plays an important role in determining both static structural analysis and steady state thermal analysis. An air cooled 4 stroke single cylinder engine was considered for our study. Piston dimensions are measured using tools like calipers, screw gauges, scales etc. A 3D model of the piston is created using CATIA which is scaled. Boundary conditions of maximum gas pressure and temperature of 480°C at the top surface of the piston are set. Three types of materials are selected from the software library for piston design. FEA is performed using ANSYS to determine the mechanical deformation and stress. Steady-state thermal analysis estimates the extent of the surface temperature distribution and the total heat flux.

12 CONCLUSIONS

In this work the piston is designed in two stages: design and analysis. First, use Catia modeling software to create a piston model according to the design specifications. After loading the piston model into the engineering simulation and 3D design software ANSYS, boundary conditions are applied to the piston. Then several properties (stress and deformation) are analyzed, and the results are obtained instantly. In this study the piston is optimized for the piston material. A thermal analysis is performed to determine the overall heat flow in the current piston under specified temperature parameters. The operating temperature is applied to the surface of the piston. The results were also used to calculate the total heat flux of a given material.

REFERENCES

1. A. K., Abdullah, S. and Muhamad. N. “Proceedings of the 2nd IMT-GT Regional Conference Of Mathematics, Statistics And Applications University Sains Malaysia”,June 13-15,2006.
2. Dhoble, R. P. Sharma**,** “R& D Centre, Mahindra & Mahindra Ltd.,Nashik”**,** SAE Paper 930797 (1993).
3. E. Abu-Nada, I. Al-Hinti, A. Al-Sarkhi, B. Akash “Department of Mechanical Engineering, Hashemite University, Zarqa 13115, Jordan”, Institution of Mechanical Engineers, London, pp. 133–145.
4. Gunter Knoll, Adrian Rienäcker, Jochen Lang, “Lehrstuhl für Maschinenelemente und Tribologie Universität Gh Kassel Germany”, McGraw-Hill Book Company, p. 700 f.

5. Jibhakate Y M 2012 Thermal Analysis and Optimization of IC Engine Piston using finite element method, International Journal of Modern Engineering Research (IJMER) 2(4) 2919-2921
6. Nazri Kamsah, Member, IAENG, " Proceedings of the World Congress on Engineering 2011 Vol III WCE 2011, July 6 - 8, 2011, London, U.K.
7. Sanjay Shrivastva,Kamal Shrivastava, Rahul S. Sharma and K Hans Raj, **"**Journal of scientific &Industrial Research", vol .63, December 2004,pp 997-1005.
8. Shi H Y 2010 Finite Element Static and Dynamic Analysis for a Piston, Advanced Materials Research 97-101 3323-3326
9. Singh P and Pramanik D 2015 Structural and thermal analysis of a C. I. engine piston of different materials using FEM technique, MR International Journal of Engineering and Technology 7(1) 41-48
10. Srinadh M and RajasekharaBabu K 2015 Static and Thermal Analysis of Piston and Piston Rings, International Journal of Engineering Technology, Management and Applied Sciences 3(8) 51-58