

Failure of Piston & Piston pin in IC Engine: A Review

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Abstract: Piston & Connecting rod, important part for IC engine. Piston compressed the fluid and gave the required output. Connecting rod holds the piston and helps to move the cylinder during varying pressure condition. Piston & connecting rod connected by use of simple pin. This pin is also known as “Piston Pin” or “Wrist Pin” or “Gudgeon Pin”. Piston & Pin both undergoes stress, temperature, frequent pressure changes, & thermal and mechanical fatigue occurs. Hence failure of both components may possible. Here in this paper, review of causes of piston and pin failure observed during experiment and/or research.

Keywords: Connecting Rod, Failure, Piston, Wrist pin

1. Introduction

The current trend in the land transportation and power production is to develop IC engines of enhanced power-capacity and reduced emission. Main purpose of IC Engine is to transmit the motion and conversion of chemical energy of fuel into mechanical energy. Main components of Piston are Piston Head, Piston ring & Piston pin.

A piston is a component of reciprocating engines, reciprocating pumps, gas compressors and pneumatic cylinders, among other similar mechanisms. It is the moving component that is contained by a cylinder and is made gas-tight by piston rings. In an engine, its purpose is to transfer force from expanding gas in cylinder to Crankshaft via a piston rod and/or connecting rod. In a pump, the function is reversed and force is transferred from crankshaft to piston for purpose of compressing or ejecting the fluid in cylinder. In some engine, the piston also acts as a valve by covering and uncovering ports in the cylinder wall. The petrol enters inside the cylinder and the piston moves upward and spark plug produce spark and petrol set on fire and it produces an energy that pushes the piston upwards.

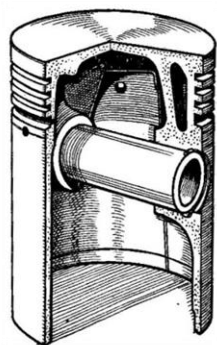


FIG-1 PISTON

In internal combustion engines, the Gudgeon pin connects the piston to the connecting rod and provides a bearing for the connecting rod to pivot upon as the piston moves. The gudgeon pin is typically a forged short hollow rod made of steel alloy of high strength and hardness that may be physically separated from both connecting rod and piston or crosshead. It uses two broad designs of configurations:

- A. Semi-floating
- B. Fully floating

2. Literature review

A. “RESEARCH ON OPTIMIZATION FOR THE PISTON PIN AND THE PISTON PIN BOSS” by Yanxia Wang in the Open Mechanical Engineering Journal on 2011. Page No-186-193.

“Due to the fatigue failure and the fracture injury occurs under the alternative mechanical loads, the optimal design of the piston pin and the piston pin boss is presented depending on the FEA static analysis. The optimization is carried out using the Genetic Algorithm (GA), and the piston noncircular pin hole is used to further reduce the stress concentration on the upper end of the piston pin seat.”

Points to be note from this:

- How to make mathematical model of piston for further work.

B. “STRESS ANALYSIS OF PISTON USING PRESSURE LOAD AND THERMAL LOAD” by Vaishali R. Nimbarte of Rajiv Gandhi College Of Engineering, Research and Technology, Chandrapur, in IPASJ International Journal of Mechanical Engineering (IJME), Volume-3, Issue-8, published on August-2015, ISSN 2321-6441.

“In this paper pressure analysis, thermal analysis and thermo-mechanical analysis is done. The parameter used for the analysis is operating gas pressure, temperature and material properties of piston. In I.C. Engine piston is most complex and important part therefore for smooth running of vehicle piston should be in proper working condition. Piston fails mainly due to mechanical stresses and thermal stresses. Analysis of piston is done with boundary conditions, which includes pressure on piston head during working condition and uneven temperature distribution from piston head to skirt. The analysis predicts that due to temperature whether the top surface of the piston may be damaged or broken during the operating conditions, because damaged or broken parts are so expensive to replace and generally are not easily available.”

Points to be note from this:

- Piston & piston pin design consideration
- Base for static design calculation

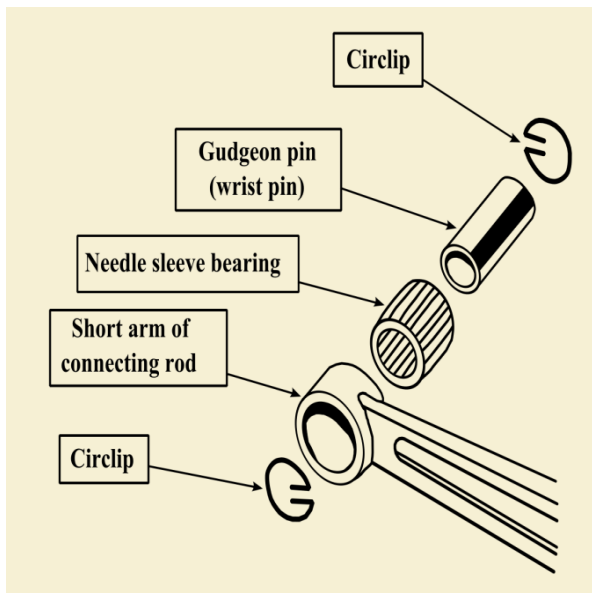


FIG-2 GUDGEON PIN

C. "THEORETICAL ANALYSIS OF STRESS AND DESIGN OF PISTON HEAD USING CATIA & ANSYS" by Dilip Kumar Sonar, asst. Prof of Dept. of College of Engineering & Management Kolaghat, in International Journal of Engineering Science Invention, Volume-4, Issue-6, published on June-2015, ISSN 2319 – 6734, Page No-52-61.

"Engine pistons are one of the most complex components among all automotive or other industry field components. The engine can be called the heart of a car and the piston may be considered the most important part of an engine. Notwithstanding all these studies, there are a huge number of damaged pistons. Damage mechanisms have different origins and are mainly wear, temperature, and fatigue related. Among the fatigue damages, thermal fatigue and mechanical fatigue, either at room or at high temperature, play a prominent role. Aluminum alloy have been selected for structural and thermal analysis of piston. An analysis of thermal stress and damages due to application of pressure is presented and analyzed in this work. Results are shown and a comparison is made to find the most suited design."

Points to be note from this:

- Alternative method for solution
- Analysis consideration and thermal boundary

D. "FAILURE OF PISTON IN IC ENGINES: A REVIEW", by R. C. Singh, Asst. Prof of Delhi Technological University, Delhi, in International OPEN ACCESS Journal Of Modern Engineering Research (IJMER), Volume-4, Issue-9, published on Sept-2014, ISSN: 2249-6645.

"Piston in the internal combustion (IC) engine is robust, dynamically loaded tribo pair that reciprocates continuously at varying temperature. Study has been made by various researchers on piston design, dynamics, fatigue and wear at the interface with other element in contact along with their effects on IC engines. It was found that the friction coefficient increases with increasing surface

roughness of liner surface and thermal performance of the piston increases with increased coating thickness. The free material liberated due to deep scoring between the piston and liner snowballs, leads to seizure failure."

Points to be note from this:

- Various causes of failure of piston & pin
- Location of failure

E. "THERMAL ANALYSIS OF A PISTON OF RECIPROCATING AIR COMPRESSOR", by Bhaumik Patel, Asst. Prof. Mechanical Engineering, L.D.R.P Institute of Technology and Research, Gandhinagar, in International Journal of Advanced Engineering Research and Studies, Volume-1, Issue-3, ISSN 2249-8974, Page No- 73-75.

"In this study, the wok is carried out to measure the distribution of the temperature on the top surface of the piston. Which predicts that due to temperature weather the top surface of the piston may be going to damaged or broken during the operating conditions because damaged or broken parts are so expensive to replace and generally are not easily available. So it is possible to recover the damage or broken parts due to thermal analysis before taking into operations. It can be seen from that the prescribed operating temperature inside the cylinder penetrates the piston crown through nearly 75 % of its thickness before piston ring dissipates some of heat."

Points to be note from this:

- Boundary condition for thermal analysis
- Temperature distribution in piston

F. "THERMAL ANALYSIS AND OPTIMIZATION OF I.C. ENGINE PISTON USING FINITE ELEMENT METHOD", by S. Srikanth Reddy, Department of Mechanical Engineering, JNTU College of Engineering Hyderabad, Andhra Pradesh, in International Journal of Innovative Research in Science, Engineering and Technology, Volume-2, Issue-12, ISSN: 2319-8753, Page No-7834-7843.



"In this work, the main emphasis is placed on the study of thermal behavior of functionally graded coatings obtained by means of using a commercial code, ANSYS on

aluminum and zirconium coated aluminum piston surfaces. The analysis is carried out to reduce the stress concentration on the upper end of the piston i.e. (piston head/crown and piston skirt and sleeve). With using computer aided design NX/Catia software the structural model of a piston will be developed. Furthermore, the finite element analysis is done using Computer Aided Simulation software ANSYS.”

Points to be note from this:

- Base for dimension & stress calculation
- Standard material data for design.

3. Observation obtain from Review Paper

With idea keep in mind that past research was genuine source for research work, we study various research papers and observation made out is listed below:

- A. Types of failure for Piston & Pin
- B. Design Consideration for piston & Pin
- C. Design Parameter

3.1 Types of Failure:

I. For piston,

Due to,

- too low spark plug heat factor,
- Too lean air-fuel mixture
- Valve damage or leak or clearance problem
- Fuel with an inadequate, too low octane number
- Large amount of oil in combustion chamber
- High engine temperature
- Piston head fusion
- Piston skirt seizure etc.

II. For Piston Pin,

The principal causes of failure were inadequate heat treatment of the case and design that incorporated a raised central section of inner diameter, which acted as a stress raiser.

3.2 Design consideration for Piston & Pin:

In designing a piston for an engine, the following points should be taken into consideration:

- It should have enormous strength to withstand the high pressure.
- It should have minimum weight to withstand the inertia forces.
- It should form effective oil sealing in the cylinder.
- It should provide sufficient bearing area to prevent undue wear.
- It should have high speed reciprocation without noise.
- It should be of sufficient rigid construction to withstand thermal and mechanical distortions.
- It should have sufficient support for the piston pin.

3.3 Design Parameter

- Thickness of piston head (tH)
- Heat flows through the piston head (H)
- Radial thickness of the ring (t1)
- Axial thickness of the ring (t2)
- Width of the top land (b1)
- Width of other ring lands (b2)

4. Summary:

In this paper, Review carried out on causes of failure of Piston, Piston Pin & other IC Engine component. Various locations from where piston may fail under application. Also design considerations are given to maintain safe design of piston and Wrist Pin.

5. References

[1] “RESEARCH ON OPTIMIZATION FOR THE PISTON PIN AND THE PISTON PIN BOSS” by Yanxia Wang in The Open Mechanical Engineering Journal on 2011. Page No-186-193.

[2] “STRESS ANALYSIS OF PISTON USING PRESSURE LOAD AND THERMAL LOAD” by Vaishali R. Nimbarte of Rajiv Gandhi College Of Engineering, Research and Technology, Chandrapur, in IPASJ International Journal of Mechanical Engineering (IJME), Volume-3, Issue-8, published on August-2015, ISSN 2321-6441.

[3] “THEORETICAL ANALYSIS OF STRESS AND DESIGN OF PISTON HEAD USING CATIA & ANSYS” by Dilip Kumar Sonar, asst. Prof of dept. of College of Engineering & Management Kolaghat, in International Journal of Engineering Science Invention, Volume-4, Issue-6, published on June-2015, ISSN 2319 – 6734, Page No-52-61.

[4] “FAILURE OF PISTON IN IC ENGINES: A REVIEW”, by R. C. Singh, Asst. Prof of Delhi Technological University, Delhi, in International OPEN ACCESS Journal Of Modern Engineering Research (IJMER), Volume-4, Issue-9, published on Sept-2014, ISSN: 2249–6645.

[5] “THERMAL ANALYSIS OF A PISTON OF RECIPROCATING AIR COMPRESSOR”, by Bhaumik Patel, Asst. Prof. Mechanical Engineering, L.D.R.P Institute of Technology and Research, Gandhinagar, in International Journal of Advanced Engineering Research and Studies, Volume-1, Issue-3, ISSN 2249–8974, Page No- 73-75.

[6] “THERMAL ANALYSIS AND OPTIMIZATION OF I.C. ENGINE PISTON USING FINITE ELEMENT METHOD”, by S. Srikanth Reddy, Department of Mechanical Engineering, JNTU College of Engineering Hyderabad, Andhra Pradesh, in International Journal of Innovative Research in Science, Engineering and Technology, Volume-2, Issue-12, ISSN: 2319-8753, Page No-7834-7843.

Books:

[1] “A Course in Internal Combustion Engines” by V.M.Domkundwar, Dhanpat Rai & Co.

Websites:

- [1] www.Mcbperformance.com/p-25418-piston-failures-causes.html
- [2] www.madsens1.com/saw_piston_fail.htm
- [3] www.researchgate.net