International Journal of Engineering Technology, Management and Applied Sciences

IJETMAS

www.ijetmas.com January 2017, Volume 5, Issue 1, ISSN 2349-4476

# Analysis of Piston Pin Failure and Metallurgical Investigation

**Ankit Saxena**
M.Tech student
Dept. of Mechanical Engg.
NIT, Kurukshetra

**Dr. Surjit Angra**
Professor
Dept. of Mechanical Engg.
NIT, Kurukshetra

**V.K. Mittal**
Professor
Dept. of Mechanical Engg.
NIT, Kurukshetra

## ABSTRACT

*A piston pin is used to connect the piston to the connecting rod in internal combustion engine. It is used to transmit the motion of piston to connecting rod. A piston pin is typically forged short hollow rod which is made of steel alloy of high strength. A piston pin subjected to heavy shear and bending loads. Aim of current work is to analyze the piston pin failure. The study applied the metallographic observation using SEM (Scanning Electron Microscopy) of fractured section. Based on the images produced in SEM analysis it was found that there were some impurities and casting defects like gas porosity seen in the images.*

***Keywords***

***Piston pin, Metallurgical investigation, SEM, Porosity, Brittle fracture***

## I. INTRODUCTION

A piston pin is aalso known as gudgeon pin. A piston pin is used to connect the piston to the connecting rod in internal combustion engine. The piston pin has to operate under some of the highest temperatures experienced in the engine, with difficulties in lubrication due to its location. A piston pin subjected to heavy shear and bending loads. We use a small diameter rod which can fulfill the requirements for lightness and compactness demand. With the increased speed and loads of modern engines, it has become necessary to reduce the reciprocating masses of the piston and rod assemblies while providing stronger connecting pins between the piston and the rod. So to overcome these problems, the material used to make in piston pin and also the way from which it is manufactured are most highly engineered of any mechanical component found in internal combustion engine. The longitudinal and transverse cracking happened on the failed piston pin. These cracks are initiated from the internal hole surface and propagated towards the external surface [1]. Fatigue fracture is the dominant failure mechanism of piston pin failure. A hollow ceramic piston pin has a pair of ribs in the form of partition walls axially separating the inside thereof. The piston pin has the ribs in the axial positions where it mates diametrically opposed inner ends of piston pin bosses of a piston and opposite ends of a small end portion of a connecting rod when attached to the piston and the connecting rod[2]. to evaluate the effect of various surface engineering methods on the tribological performance of piston pins, we design a new test rig. The test rig was used to study scuffing resistance provided by CrN and diamond-like carbon (DLC) coatings and by laser surface texturing in comparison with a base line standard pin[3].

## II. ANALYSIS

The fracture analysis of the piston pin was done by visual inspection and SEM (Scanning Electron Microscope). The SEM observation has been taken using JEOL SEM Model JSM6100 Scanning Electron Microscope.

## III. VISUAL ANALYSIS

The failed piston pin of Hyundai is shown in Fig. It is found that the fracture had taken place on the inner surface and side surface of a piston pin.

www.ijetmas.com January 2017, Volume 5, Issue 1, ISSN 2349-4476

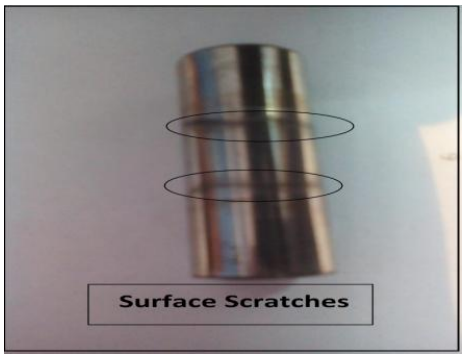


**Figure- Surface scratches**


**Figure- Part of piston pin to undergo SEM**

## IV. SCANNING ELECTRON MICROSCOPE

SEM produces images of sample by scanning it with the help of beam of focused electrons. After that electron interacts with atom in sample which produces various signals that can be detected and which contains information about sample`s surface topography and composition. And SEM can achieve better resolution than 1 nanometer. The highly common SEM mode is detection of the secondary electrons which are emitted by atoms excited by the electron beam. The number of secondary electrons which are to be detected depends upon the angle at which beam meets surface of specimen, i.e. on specimen topography. By scanning the sample and collecting the secondary electrons with a special detector with an image displaying the topography of the surface is created. The Scanning Electron Microscope (SEM) consists of an energetically well-defined and highly focused beam of electrons scanned across a sample. The microscope also uses a LaB6 source and is pumped using turbo and ion pumps to maintain the highest possible vacuum. Images at various resolution are taken to study the defects properly.

**Figure- JEOL SEM Model JSM6100**

www.ijetmas.com January 2017, Volume 5, Issue 1, ISSN 2349-4476

## V. EXPERIMENTAL PROCEDURE

A failed piece of piston pin has been from the workshop and a piece has been taken out from the failed area of piston pin. After that this piece has been converted into specimen for undergoing SEM in the dimension of 14mm x 7mm. The operating environment of a standard scanning electron microscope dictates that specialist preparation techniques are used. Basically a specimen is chemically fixed, dehydrated through an acetone or ethanol series and after that dried at the critical point - a method used to minimize specimen distortion due to drying tensions.

## VI. RESULT AND DISCUSSION

The images found through SEM in the present observation are shown next.

### A. CASTING DEFECTS

Gas porosity is the formation of bubbles within the casting after it has cooled. This occurs because most liquid materials can hold a large amount of dissolved gas, but the solid form of the same material cannot, so the gas forms bubbles within the material as it cools. Gas porosity may present itself on the surface of the casting as porosity or the pore may be trapped inside the metal, which reduces strength in that vicinity. Nitrogen, oxygen and hydrogen are the most encountered gases in cases of gas porosity. Dendrite shrinkage is a distribution of very fine lines or small elongated cavities that may vary in density and are usually unconnected.

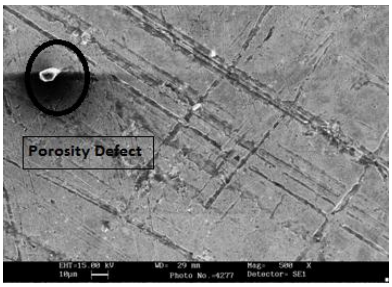


**Figure- Image was taken at an manufacturing range of 500X**

It is showing casting defects i.e. gas porosity, dendrite shrinkage and accumulated inclusion, together with initiated crack. The characteristics of this shows that fracture is a brittle fracture-granular fracture (also cleavage fracture).

### B. PURE AND IMPURE SURFACE

During casting some unwanted material had been also present Due to these impurities the piston pin could not be able to withstand fatigue stresses and failure has taken place.

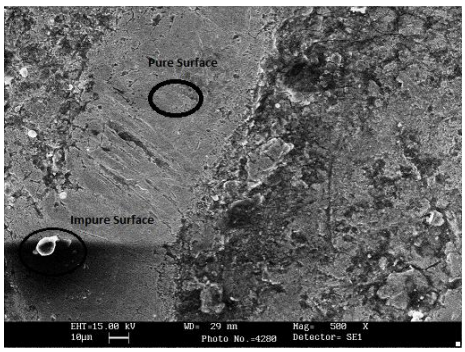


**Figure- This image was take at a magnification of 500X from two different surfaces were seen.**

www.ijetmas.com January 2017, Volume 5, Issue 1, ISSN 2349-4476

## C. BRITTLE FRACTURE

From various literature review it was seen that the fracture which usually occurs in piston pin is the brittle fracture and in this case we also get an image at a magnification factor of 1000X. We get that fracture was a brittle fracture. As the loads come on the piston pin are varying in nature these are heavy shear and bending forces .So the failure occurs in piston pin is the fatigue failure or sudden failure.

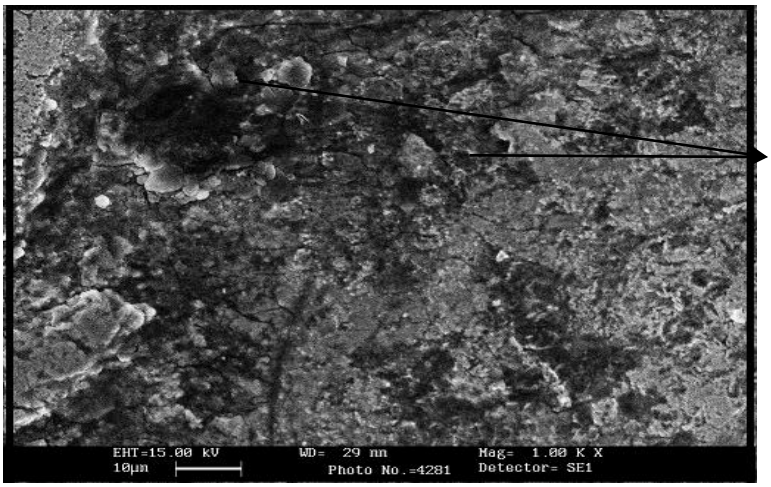


**Figure A perfect brittle fracture surface could be seen at 1.00 KX**

## D. IMPURE SURFACES AT HIGHER MAGNIFICATION

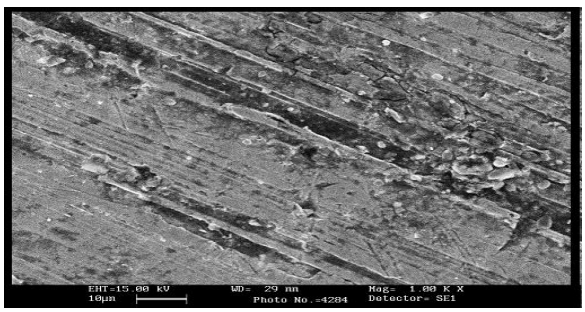

**Figure The image was taken at a magnification of 1000X. to see the impure surface. White like crystals like material is impurity**

## VII. CONCLUSION

The main reason for the failure is casting defect, inclusion and crack propagation which decreased the lifecycle of piston pin. Provision should be done for the removal of inclusion and shrinkage, avoidance of hard particle to enter. Some unwanted impurities have been also detected which allow cracks to pass straight through. Failure of piston pin may lead to failure of other components and can cause harm while in use. Finally piston pin should be designed with high reliability. It must be capable for sustaining heavy shear and bending stresses caused by thrust and pull of the piston. So the homogeneous and continuous structure is a desired factor for piston pin.

## REFERENCES

[1] Zhiwiyu, Xiaolei \Xu, Hongxin Ding, " Failure analysis of a diesel engine piston pin", Engineering failure analysis volumn 14, issue, January 2017.
[2] T kojima – US patent 5, 114262, 1992. " Hollow ceramic piston pin."


www.ijetmas.com January 2017, Volume 5, Issue 1, ISSN 2349-4476

[3] Etsion, G. Haperin, E. Becker, "The effect of various surface treatment on piston pin scuffing resistance", Wear volume 261 Issues 7-8, 2006.
[4] P.C. Sharma and D.K. Aggarwal "A Textbook of Machine Design" S.K Kataria & Sons vol. 12, 2012.
[5] P. Kannaiah "Machine Design" Scitech Publications (India) Pvt. Ltd. Vol. 2, 2014.
[6] Robert C. Juvinall and Kurt M. Marshek "Fundamental of machine component design" John wiley & sons Inc. 1999.
[7] M. fonte, Bin Li, L. Reis, M. Frietas: Journal on "Piston pin failure analysis of a motor vehicle".
[8] V B BHANDARI : Design of machine element (Third edition)
[9] W.Y. Chien, J. pan, D. close. Fatigue analysis of piston pin sections under bending with consideration of residual stresses. International Journal of Fatigue 27 (2005) 1–19.