FEA of Piston Ring by Using ABAQUS

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ABSTRACT:

The objective of undertaking this paper of "Structural Analysis of Piston Ring" is to study and evaluate the performance in real working conditions of the piston ring in internal combustion engine. In this paper, the wok is carried out to measure the stress and temperature distribution on the surface of the piston ring. The analysis predicts that due to stress the top surface of the piston ring may damage or break during the working conditions, because the damaged or broken parts are so expensive to replace and generally are not easily available. The part model of piston ring is most complex and important part therefore for smooth running of vehicle piston ring should be in proper working condition. FEA of piston ring is done with boundary conditions, which includes pressure on piston ring during working condition and created using Creo. 3 D model is imported to the Abaqus and FEA is performed. By identifying the true design features, the extended service life and long term stability is assured.

KEYWORDS: Creo, Abaqus, Structural analysis, piston ring.

1. Introduction

A piston ring is a split ring that fits into a groove on the outer diameter of a Piston in a reciprocating engine such as an internal combustion engine or steam engine. The piston ring is the one of the important component of the internal combustion engine.

The primary function of piston ring in reciprocating engine is to seal the combustion chamber so that there is no transfer of gases from the combustion chamber of the crank. The auxiliary function is heat transfer from the piston to the cylinder wall. The evenly distribution of oil along the cylinder liner in order to avoid engine seizure. Piston rings may account for a considerable proportion of the total friction in the engine, as much as 24%. The top two rings are the compression ring for the sealing and the lower ring is for the controlling the supply of oil to liner which lubricates the piston skirt.

When the engine is in running the all rings is affected by gas pressure and temperature resulting from compression and combustion. The cylinder pressure acts on the upper surface of the top ring and fraction of pressure acts below the top piston ring.

1.1.Compression Rings

The compression rings provide seal above the piston and prevents the gas escape from the combustion side. The compression rings are fitted in the top most grooves of the piston. Though, this may differ according the design of the engine. The major function of these rings is to seal the combustion gases and transmit heat from the piston to piston walls.

1.2.Oil ring

Oil ring distribute and control oil within the cylinder wall and assist scrape it back into the crankcase. This is essential to keep the cylinder wall lubricated with the cooler replacement oil, thereby aiding the heat transfer and lower the friction between the piston and the cylinder.

2. Objectives

The objectives of this report are:

1. To make a model of 3-dimensional of piston ring.
2. Stress distribution and deformation in liner assembly of piston ring is studied.
3. The mechanical impact loading on piston ring for deformation is studied.
4. The thermal and mechanical stresses distribution in piston ring is studied.

3. Methodology

The piston rings during the working conditions are exposed to the high gas pressure and high temperature gas due to combustion. So the methodology used for analyzing the piston ring is as considered as; the gas pressure 55 bar is applied uniformly on the top surface of piston ring. While on the side surface which is in contact with the cylinder liner is applied with a pressure of 10 bar.

4. Material Properties of Piston Ring:-

Material of piston ring- Grey cast iron

Young's modulus [E] - 157GPa

Poisson's ratio [μ] - 0.26

Tensile strength- 362MPa

Yield strength- 262MPa

Elongation- 1%

5. Geometry:

The given below image shows the geometry of piston ring imported into simulation software for analysis. Before importing a geometrical model of piston ring which can be processed by modeling software like creo or pro-e, the geometrical modeling can be done in ABAQUS. The below figure show the piston ring created by creo software for further analysis.

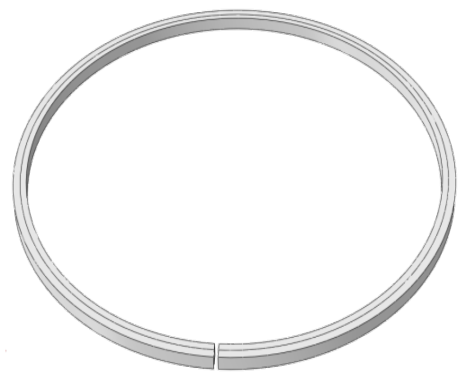

Figure1. Geometrical modeling of piston ring.

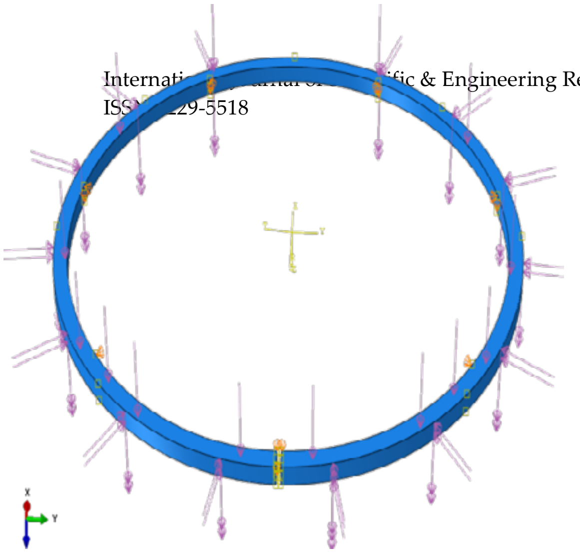

Figure 2. Loading applied at the piston ring

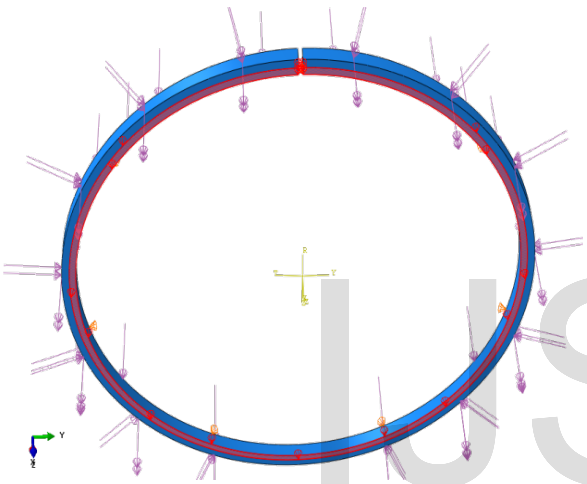

Figure 3 Boundary conditions applied at the lower surface of the piston ring

5.1. Finite Element Modeling

Finite element method is a numerical analysis technique for obtaining approximate solution to avoid variety of engineering problems. Although originally developed and applied to the broad field of continuum mechanics. Because of its diversity and flexibility as analysis tool, it is receiving much attention in engineering colleges and industry.

5.2. Details of the compression ring

Outside diameter of the ring: 59mm
Inside diameter of the ring: 56mm
Width of the ring: 3mm
Load on the ring: 55bar

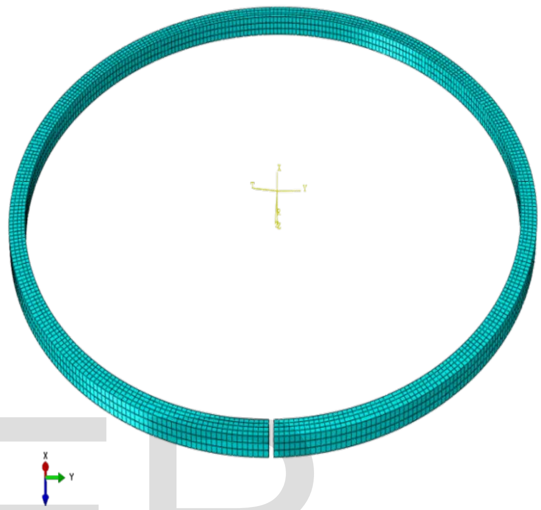

Figure 4. Finite element mesh of the piston ring of the piston ring

6. Results and Discussions

6.1. Von-misses stress distribution in the piston ring-

Below figure shows the distribution of Von misses stresses induced within the piston ring. The maximum von misses stress acting on piston ring in real working condition was found to be 3.694×10^{1} N/mm^2 and 1.286 N/mm^2 as minimum.

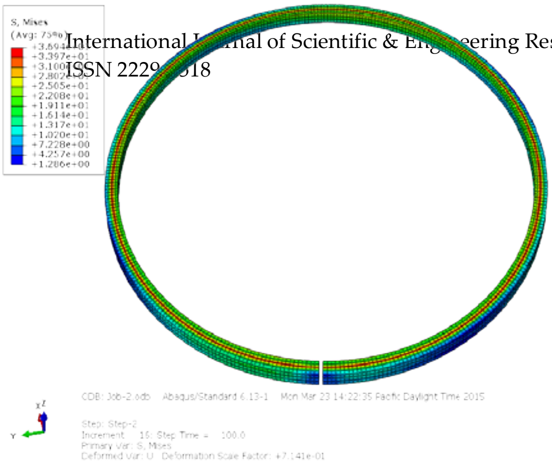

Figure 5 Von-misses stress distribution in the piston ring.

6.2. Temperature distribution on piston ring-

Below figure shows the distribution of temperature induced within the piston ring at the nodes. The maximum temperature acting on piston ring in real working condition was found to be 200 ^{0}C and 195 ^{0}C as minimum.

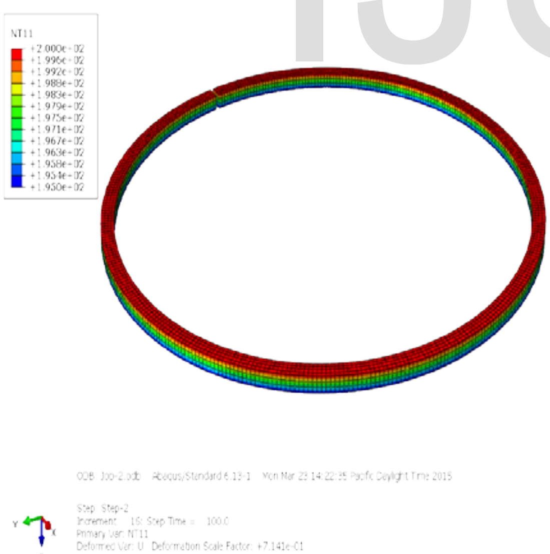

Figure 6. Temperature distribution in the piston ring.

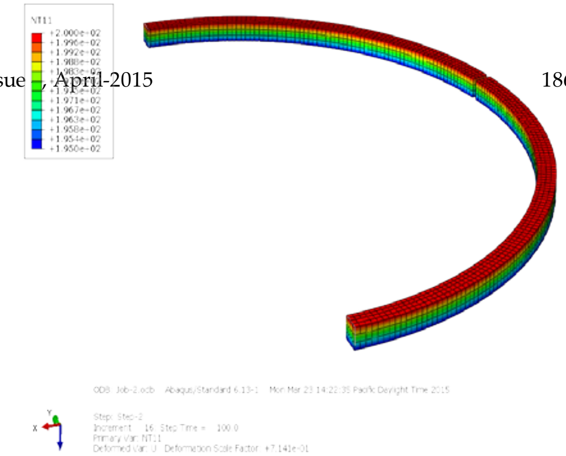

Figure 7. Temperature distribution in the cut section of the piston ring.

6.3. Displacement in piston ring-

Below figure shows the displacement of stresses induced within the piston ring. The maximum thermal stress acting on Piston ring in real working condition was found to be 1.260×10^{-3} mm and 3.3003×10^{-4} mm as minimum.

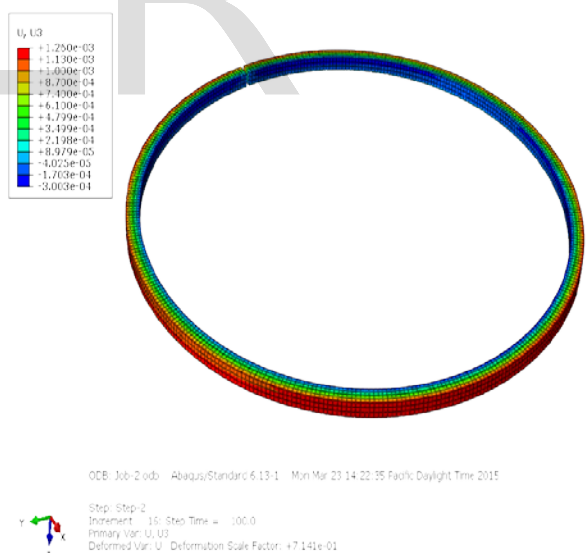

Figure 7. Displacement in the piston ring.

Conclusion:

It is observed that although fatigue is not the responsible for biggest portion of damaged piston rings, but the stresses induced are the major factor for piston ring failure. Also from analysis various Results are obtained. The maximum displacement occurred about **1.260×10^{-3}** mm due to the application of 55 bar gas pressure on piston ring. **3.694×10^{1}** N/mm^2 of maximum von misses stress is observed and **1.286** N/mm^2 of minimum von misses stress. Also maximum temperature of **200 ^{0}C** is observed. Thus we conclude that piston ring of grey cast iron is suitable to use.

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