Finite Element Analysis and Optimization of Piston Head for Automotive Vehicle

Mr. S. Suresh 1 Arun Kumar. K 2 Prasath. A 3 Lokesh. V. R 4
1-Assistant Professor, 2,3&4-UG scholar
Department of Mechanical Engineering,
Hindusthan Institute of Technology, Coimbatore-641 032, Tamil Nadu, India.

Abstract:- In this paper we have performed design optimization of piston by using global sensitivity study along with finite element analysis through ANSYS. First a piston has been modeled and then finite element analysis has been performed to know about the structural and thermal loading effects. Then design optimization is performed to get the optimum mass by determining the optimum value of crown thickness and skirt length of the piston by limiting various conditions like maximum temperature, maximum principle stress, von misses stress and maximum strain energy.

INTRODUCTION

Piston is one of the most vital component of I.C engine. Piston is contained by the engine cylinder. Its function is to transfer the force from the expanding gases is the cylinder to the crankshaft through connecting rod. Its service requires great attention. The material of the piston is chosen according to its strength, wear properties, density and thermal expansion properties. Hotter engines require more stable alloys to maintain close tolerances without scuffing. Many pistons used to be made from hypoeutectic aluminum alloys. Now days we see hypereutectic alloys (Carleyet).

The modeling of piston is done using ANSYS software according to the environmental and structural conditions. Then the modeled was imported to ANSYS Mechanical module of ANSYS software to perform Finite Element Analysis (FEA) to know about the structural and thermal loading effects. Then the design optimization is carried out to have optimum mass of the piston by limiting various conditions like maximum temperature, maximum principle stress, von misses stress and maximum strain energy.

Graphs have been obtained for each parameter after global sensitivity study and equations are developed for each of the graph. Using these equations the optimum value of crown thickness has been obtained.

MATERIAL CHARACTERISTIC

The materials chosen for this analysis is alloy of Aluminum-AL-390 (Dmitri Kopeliovich, 2012; and Understanding Cold Finished Aluminum Alloys). Al-390 is a medium high strength heat treatable alloy. Good flow characteristics provided by high silicon content leads to both structural and automotive applications.
TYPES OF MODEL PISTON

1. Center Tapered
2. Center crown
3. Center ball crown

Are designed using CATIA V5 Software.

The model was imported to ANSYS software, where after defining the Boundary conditions and mesh models are given below.
NORMAL PISTON BALL CROWN:

TAPERED CENTER CROWN
Fig 7.2

Fig 7.3

Fig 7.4

**RESULTS**

<table>
<thead>
<tr>
<th>Types</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Center crown</td>
<td>58.54°C</td>
</tr>
<tr>
<td>Flat Head</td>
<td>57.60°C</td>
</tr>
<tr>
<td>Center ball crown</td>
<td>57.0°C</td>
</tr>
<tr>
<td>Center tapered</td>
<td>61.012°C</td>
</tr>
</tbody>
</table>

**TAB: 1**

<table>
<thead>
<tr>
<th>Types</th>
<th>Stress(MPA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>center crown</td>
<td>9.7429</td>
</tr>
<tr>
<td>flat head</td>
<td>17.918</td>
</tr>
<tr>
<td>center ball crown</td>
<td>12.239</td>
</tr>
<tr>
<td>center tapered</td>
<td>13.51</td>
</tr>
</tbody>
</table>

**TAB: 2**

**TEMPERATURE**

**TAB: 3**

**STRESS**
### ADVANTAGES
- It has maximum heat resistance.
- It has high efficiency.
- It produces less stress compared to other shapes.

### CONCLUSION
From the analysis of the piston optimization, it is done for:
- The various shape engine piston head models including flat piston head, full crown model, center crown ball model, and center tapered piston head models are modeled.
- In CATIA V5 software in Ansys – Workbench software, the maximum stress and temperature distribution of the piston in engine operating conditions are analyzed.

<table>
<thead>
<tr>
<th>Types</th>
<th>Total deformation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>center crown</td>
<td>0.012867</td>
</tr>
<tr>
<td>flat head</td>
<td>0.029194</td>
</tr>
<tr>
<td>center ball crown</td>
<td>0.010902</td>
</tr>
<tr>
<td>center tapered</td>
<td>0.0093707</td>
</tr>
</tbody>
</table>

- TAB: 6
- Crown models are produced with less stress compared to all other shapes and temperature also produces the maximum heat resistance in the surfaces.
- From this shape optimization, the center full crown model is the optimized piston design.

### REFERENCE