Comparative study of aluminium alloy pistons manufactured by casting and powder forging

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ABSTRACT –

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. Damage mechanisms have different origins and are mainly wear, temperature, and fatigue. Mechanical fatigue, either at room or at high temperature, plays a prominent role. A static stress analysis is used to determine the stress distribution.

Keywords — ANSYS Workbench, Piston, Finite Element analysis, PRO/E

1 INTRODUCTION

Piston materials and designs have evolved over the years and will continue to do so until fuel cells, exotic batteries or something else makes the internal combustion engines obsolete. The piston is one of the most stressed components of an entire vehicle. Damages may have different origins: mechanical stresses; thermal stresses; wear mechanisms; temperature. In this work only mechanical damages will be assessed. Deformation occurs due to load on the piston. In this work, 1.4 litre diesel engine pistons from automotive engines will be presented. Only aluminium pistons are assessed in this work because most of the engine pistons are in aluminium.

2 Types of Pistons

The common types of pistons used in automotive industries are cast iron, aluminium alloy etc. Aluminum is the material commonly used for making pistons. It is the metal with features of excellent lightness, thermal conductivity, corrosion resistance, characteristics of casting, low temperature, machine processing and recycling, etc. Aluminium alloys will be made by casting, forging, powder metallurgy process like powder forging etc.

2.1 Material Properties

<table>
<thead>
<tr>
<th>Material property</th>
<th>Aluminium alloy - casting</th>
<th>Aluminium alloy - powder forging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poisson Ratio</td>
<td>0.3</td>
<td>0.33</td>
</tr>
<tr>
<td>Young’s Modulus</td>
<td>71 Gpa</td>
<td>81 Gpa</td>
</tr>
<tr>
<td>Tensile Yield Strength</td>
<td>435 Mpa</td>
<td>580 Mpa</td>
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<tr>
<td>Tensile Ultimate Strength</td>
<td>485 Mpa</td>
<td>630 Mpa</td>
</tr>
<tr>
<td>Hardness</td>
<td>71 HRB</td>
<td>77.5 HRB</td>
</tr>
</tbody>
</table>

2.2 Piston proE Model

The three dimensional models of piston is created in proE and file was exported in IGES (International Graphics Exchange Specification). The three dimensional models that were developed is shown in figure below.
The mesh was meshed with 10-node tetrahedral structural solid element. The wheel was meshed with an element of minimum edge length of $2.2576 \times 10^{-3}$m. Total number of nodes and elements are 21640 and 11607 respectively. The finite element realization of wheel obtained is shown in figure.

2.3 Meshing of piston

The meshing was performed by the mesh generate option in ANSYS workbench.

3 Loads and boundary conditions

To ensure the accuracy and reliability of the analysis result For 4 cylinder small car engine (say 1.4 litres) the power output might be 100 kW at 3600 RPM. There are 2 firing strokes per rev so there are 7200 strokes per minute or 120/second.

Length of piston stroke = say 0.1 meter

If the average force is F newton, work per stroke = 0.1F that gives an average force of 8300 newton or about 2000 pounds.

4 Results and Discussions

Following by von misses yielding principle; the results of finite elemental analysis were post-processed for visualization. Below fig shows the equivalent stress distribution of al wheel, mg wheel and the redesigned mg wheel respectively under the same working condition as illustrated in fig. the stress value is graded with colors from red to blue, reflecting the stress descending from high to low.

Deformation on casting

Deformation on powder forging
As the figures indicate the maximum stress acting on casting process is more when compared to powder forging.

5 Conclusion

Mechanical properties of the aluminium alloy piston is evaluated by the theoretical analysis, using simulation.

The deformation, von mises stresses, strain energy of the piston formed by powder forging technology were much excellent than casted pistons.

Tensile strength and hardness are more than casted pistons.

REFERENCES


