ANALYSIS OF AUTOMOTIVE INTAKE MANIFOLD USING CAE SOFTWARE

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ABSTRACT: In automotive engineering, an intake manifold or inlet manifold is the part of an engine that supplies the fuel/air mixture to the cylinders. This project focused on simulation testing of automotive intake manifold design using computer aided engineering software. Finite element random vibration analysis is conducted on excavator intake manifolds designs for material cast iron and aluminium alloy. The purpose of this project is to study the computational maximum stress on the model due to the effect of engine vibrations and pressure pulsation loads. The softwares used are PRO-E 4.0, HYPERMESH-10 and ANSYS-11. Based on the simulation results obtained, the maximum stress of both materials is compared to distinguish which is better in resisting the vibration loads applied.

Keywords: Automotive Intake Manifold, Modal analysis, Intake Manifold Analysis

1. INTRODUCTION

The primary function of the intake manifold is to evenly distribute the combustion mixture (or just air in a direct injection engine) to each intake port in the cylinder head(s). Even distribution is important to optimize the efficiency and performance of the engine. It may also serve as a mount for the carburetor, throttle body, fuel injectors and other components of the engine [1-4]. Due to the downward movement of the pistons and the restriction caused by the throttle valve, in a reciprocating spark ignition piston engine, a partial vacuum (lower than atmospheric pressure) exists in the intake manifold [5-6]. This manifold vacuum can be substantial, and can be used as a source of automobile ancillary power to drive auxiliary systems: power assisted brakes, emission control devices, cruise control, ignition advance, windshield wipers, power windows, ventilation system valves, etc[7-8].

2. DESCRIPTION

In this work static and modal analysis of the intake manifold made of cast iron and aluminium was carried out and is compared.

- Length of the intake manifold = 357 mm
- Maximum load capacity = 30Mpa

Material Properties:

(i) Cast Iron: Young’s modulus = 1.8 x 10⁵ MPa
    Poisson’s Ratio = 0.40
    Density = 7.4 x 10⁻⁶ Kg/mm³

(ii) Aluminium: Young’s modulus = 0.7x10⁵ MPa
    Poisson’s Ratio = 0.34
    Density = 2.7 x 10⁻⁶ Kg/mm³
3. MODELLING AND MESHING

The chosen problem is considered as 3-D solid model. With the dimensional parameters the structure is modeled in Pro-E wildfire3.0 modeling software as shown in Fig.1. The model is meshed for further analysis using a meshing package Hypermesh10 with tetra mesh. The model consists of 22289 elements and 41238 number of nodes. Fig.3 shows the solid 92 element considered for meshing. FE model of the intake manifold is shown in Fig.2. Appropriate boundary conditions are incorporated in the analysis. The solid 92 is defined by ten nodes having three degrees of freedom (UX, UY and UZ) at each node translations in the nodal X, Y and Z directions. The element has plasticity, creep, swelling, elasticity, stress stiffening, large deflection, large strain, adaptive descent, and initial stress import capabilities.

Fig.1: Geometric model of Intake Manifold

Fig.2: The Finite Element Model by using Pro-E 3.0 by using Hyper mesh10.

Fig.3: Solid 92 Elements

Table 1: QUALITY PARAMETERS

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspect Ratio</td>
<td>6</td>
</tr>
<tr>
<td>Tet collapse</td>
<td>0.7</td>
</tr>
<tr>
<td>Length</td>
<td>10</td>
</tr>
<tr>
<td>Min angle of trias</td>
<td>20</td>
</tr>
<tr>
<td>Max angle of trias</td>
<td>135</td>
</tr>
</tbody>
</table>
4. INTAKE MANIFOLD

4.1 Static Analysis

(i) Cast Iron

Static Analysis of intake manifold made up with cast iron is performed. Displacements in X, Y and Z-directions are shown in Fig.4; Fig.5 and Fig.6 respectively. Fig.7 shows stress in X direction. Stress in Y direction is shown in Fig.8. Fig.9 shows stress in Z direction.
(ii) Aluminium

Static Analysis of intake manifold made up with aluminium is performed. Displacements in X, Y and Z-directions are shown in Fig.11, Fig.12 and Fig.13 respectively. Fig.14 shows stress in X-direction. Stress in Y-direction is shown in Fig.15. Fig.16 shows stress in Z-direction. The vonmises stress of the intake manifold shown in Fig.17.

Fig.11: Displacement in X- direction
Fig.12: Displacement in Y- direction
Fig.13: Displacement in Z- direction
Fig.14: Stress in X direction
Fig.15: Stress in Y direction
Fig.16: Stress in Z direction
Fig.17: Vonmises Stress
4.2. Modal Analysis

i) Cast Iron

Natural frequencies and mode shapes of intake manifold made up of cast iron is performed. Fig.18 shows mode shape 1 of the intake manifold. Mode shape 2 of intake manifold is shown in Fig.19. Mode shape 3, 4, 5 & 6 of intake manifold made up with cast iron is shown in figures 20, 21, 22, 23 respectively.

(ii) Aluminium

Natural frequencies and mode shapes of intake manifold made up of Aluminium is performed. Fig.24 shows mode shape 1 of the intake manifold. Mode shape 2 of intake manifold is shown in Fig.25. Mode shape 3, 4, 5 & 6 of intake manifold made up with cast iron is shown in figures 26, 27, 28, 29 respectively.
5. RESULTS & DISCUSSION

Table 2 shows displacement and stresses of the intake manifold made up with cast iron by static analysis, which shows displacement in X-direction and Z-direction are 0.424 mm, 0.130 mm, and 0.73 mm respectively. Stresses in X, Y and Z-directions are found as 239.736MPa, 367.462MPa, 454.133MPa respectively. The vonmises stress found as 541.578 MPa. Table 3 shows displacement and stresses of the intake manifold made up with Aluminium by static analysis, which shows displacement in X-direction, Y-direction and Z-direction are 0.1227 mm, 0.3347 mm, 0.1920 mm respectively. Stresses in X, Y and Z-directions are 218.038MPa, 327.086MPa, 425.668MPa respectively. Vonmises stress is found as 531.68MPa. Table 4 shows the natural frequencies of the intake manifold made up with cast iron by modal analysis, Table 5 shows the natural frequencies of the intake manifold made up with Aluminium by modal analysis.
Table-2 Static Analysis of intake manifold for cast iron and Aluminium

<table>
<thead>
<tr>
<th>Static Analysis of Cast Iron</th>
<th>Static Analysis of Aluminium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Displacement in X-direction ,mm</td>
<td>0.424</td>
</tr>
<tr>
<td>Displacement in Y-direction ,mm</td>
<td>0.130</td>
</tr>
<tr>
<td>Displacement in Z-direction ,mm</td>
<td>0.073</td>
</tr>
<tr>
<td>Stress in X-direction, MPa</td>
<td>239.736</td>
</tr>
<tr>
<td>Stress in Y-direction , MPa</td>
<td>367.462</td>
</tr>
<tr>
<td>Stress in Z-direction , MPa</td>
<td>454.133</td>
</tr>
<tr>
<td>Vonmises Stress , MPa</td>
<td>541.578</td>
</tr>
</tbody>
</table>

Table-3 Modal Analysis of intake manifold for cast iron and Aluminium

<table>
<thead>
<tr>
<th>Modal Analysis of Cast Iron</th>
<th>Modal Analysis of Aluminium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mode shape 1</td>
<td>58.405</td>
</tr>
<tr>
<td>Mode shape 2</td>
<td>81.971</td>
</tr>
<tr>
<td>Mode shape 3</td>
<td>88.68</td>
</tr>
<tr>
<td>Mode shape 4</td>
<td>101.236</td>
</tr>
<tr>
<td>Mode shape 5</td>
<td>116.499</td>
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<tr>
<td>Mode shape 6</td>
<td>137.289</td>
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</table>

6. CONCLUSION

The following conclusions are drawn from the present work.

- The maximum deflection induced is 0.424mm in case of cast iron, which is higher than 0.3347mm obtained for aluminium.
- The maximum stress induced is 541.578 MPa in case of cast iron, which is higher than the maximum stress induced as 531.68 MPa obtained for aluminium.
- The natural frequencies obtained for cast iron is lesser than the aluminium.
- Hence comparing all these conditions it may be considered that design of aluminium is better for manufacturing of intake manifold.

REFERENCES

[6] LOU Yi-qiang,ZHAO Wen-li,MENG Qing-hua(College of Mechanical Engineering, Hangzhou Dianzi University, Hangzhou 310018,China);Finite element analysis for drive intake manifold based on dynamic load[J];Mechanical & Electrical Engineering Magazine;2009-03
[7] Zhu Zhengtao−1, Ding Chenghui−2(1 Nanchang University, Nanchang 330029, CHN; 2Nanchang University of Mechanical Research Institute, Nanchang 330029, CHN); [J]; Modern Manufacturing Engineering; 2006.