Design & Structural Analysis of Poppet Valves for TVS Luna Bike

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Abstract - Intake and exhaust valves in I.C. engines are called as poppet valves. These valves are operated by valve mechanism. When these valves are exposed to load stress and strains are developed so that Stress and strain analysis is very important to predicting and preventing failures in structures. This paper aims to model and simulate the stresses and strain analysis of poppet valves applications of 99.3cc. Modeling was done in the solidworks and structural was carried out in the ANSYS.

Keywords: Inlet valve, Exhaust valve, Composite materials, Ceramics, Solidworks, FEA.

I. INTRODUCTION

The valves used in internal combustion engines are of the three types
1. Poppet or mushroom valve
2. Rotary valve
3. Sleeve valve

Out of these three valves, poppet valve is very frequently used. It possesses certain advantages over the other valve types because of which it is extensively used in the automotive engines. The advantages are;
1. Simplicity of construction
2. Self-centering.
3. Free to rotate about the stem to the new position.
4. Maintenance of sealing efficiency is relatively easier.

Sagar.S Deshpande, et.al.(2014) Analyzed the effect of varied materials and Geometric parameters on mechanical properties of poppet engine valve to improve its performance over life and fatigue life using Ansys software [1].

Sanoj.T, et.al.(2012) Analyzed the stress induced in a valve due to high thermal gradient and high pressure inside the combustion chamber. In the first stage of analysis the temperature distribution across the valve was determined. In the second stage found displacement [2].

II. DESIGN CONSIDERATIONS

II.I Specifications

<table>
<thead>
<tr>
<th>Engine specification:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Displacement</td>
</tr>
<tr>
<td>2 Bore &amp;stroke</td>
</tr>
<tr>
<td>3 Compression ratio</td>
</tr>
</tbody>
</table>

Exhaust valve dimensions

- Diameter of the valve= 10.4mm
- Distance between the groove= 9.8mm
- Base diameter= 23.2mm
- Diameter above the base=9.8mm
- Total length of the valve=66.4mm
- Length of the stem=47.2mm
- Thickness of valve disc=2.4mm

Inlet valve dimensions

- Diameter of the valve= 10.2mm
- Distance between the groove= 9.8mm
- Base diameter= 20mm
- Diameter above the base=9.6mm
- Total length of the valve=67mm
- Length of the stem=42mm
- Thickness of valve disc=2mm

Karan Soni et.al. (2015) They conclude valve design can be optimized to reduce its weight, without affecting permissible stress and deformation values. Due to reduction in strength improves the valve strength [4].
II.2. 2D Model

Fig. 1. Inlet valve
Fig. 2. Exhaust valve

II.3. 3D Model

Fig. 3. Inlet valve
Fig. 4. Exhaust valve

II.4. Methodology

II.5. Modeling

The 3-D modeling was done by using Solidworks software.

II.6. Meshing

The all the components was meshed by using ANSYS software.

II.7. FEM analysis

The deformation, equivalent elastic strain, equivalent stress, strain energy and shear stress are very important for poppet valve. To meet these requirements to perform structural analysis on stainless steel and ceramic composite materials of poppet valves. The finite element analysis was carried out by using Ansys software. This analysis was performed based on the following assumptions.

The maximum load for stainless steel and ceramic composite poppet valve during applications 7312.84N and minimum load is 314.37N, this data is related in structural analysis for both the valves.

III. MATERIAL

III.1. Inlet valve

Steel

<table>
<thead>
<tr>
<th></th>
<th>Density in (kg/cm³)</th>
<th>7.6</th>
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<tbody>
<tr>
<td>2</td>
<td>Young’s modulus in (GPa)</td>
<td>190</td>
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<tr>
<td>3</td>
<td>Poissons ratio</td>
<td>0.25</td>
</tr>
<tr>
<td>4</td>
<td>Thermal conductivity in (W/m·K)</td>
<td>12-45</td>
</tr>
<tr>
<td>5</td>
<td>Coefficient of linear expansion in (µm/m·°C)</td>
<td>11-12.5</td>
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</table>

Alumina
### III.2. Exhaust valve

#### Stainless steel

<table>
<thead>
<tr>
<th></th>
<th>Property</th>
<th>Value</th>
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</thead>
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<tr>
<td>1</td>
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<td>Thermal conductivity (W/m·K)</td>
<td>12-45</td>
</tr>
<tr>
<td>5</td>
<td>Coefficient of linear expansion (µm/m·°C)</td>
<td>11-12.5</td>
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#### Silicon Nitride

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<tr>
<td>2</td>
<td>Young’s modulus (GPa)</td>
<td>317</td>
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<td>3</td>
<td>Poissons ratio</td>
<td>0.23</td>
</tr>
<tr>
<td>4</td>
<td>Thermal conductivity (W/m·K)</td>
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<td>5</td>
<td>Coefficient of linear expansion (µm/m·°C)</td>
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</table>

#### Alumnum Nitride

<table>
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<th></th>
<th>Property</th>
<th>Value</th>
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</thead>
<tbody>
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<td>1</td>
<td>Density (kg/cm³)</td>
<td>3.25</td>
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<tr>
<td>2</td>
<td>Young’s modulus (GPa)</td>
<td>308</td>
</tr>
<tr>
<td>3</td>
<td>Poissons ratio</td>
<td>0.25</td>
</tr>
<tr>
<td>4</td>
<td>Thermal conductivity (W/m·K)</td>
<td>82.3-170</td>
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<tr>
<td>5</td>
<td>Coefficient of linear expansion (µm/m·°C)</td>
<td>4.6-5.7</td>
</tr>
</tbody>
</table>

### IV. Results and Discussion

#### Structural analysis of exhaust valve

- **Fig. 6. Boundary conditions**
- **Fig. 7. Equivalent elastic strain**
- **Fig. 8. Shear Stress (XY Plane)**
- **Fig. 9. Strain energy**

#### Boundary Conditions

The boundary conditions were considered under the head, just above the head and at the neck portion of both the valves in structural. The boundary conditions are shown in the respective figures.
Fig. 10. Equivalent (von-Misses) stress

Fig. 11. Total Deformation

Fig. 12. Boundary Conditions

Fig. 13. Strain Energy

Fig. 14. Equivalent (von-misses) Stress

Fig. 15. Equivalent Elastic

Fig. 16. Total Deformation

Fig. 17. Shear Stress (XY Plane)

Fig. 18. Boundary Conditions
Fig. 19. Strain Energy

Fig. 20. Strain Energy

Fig. 21. Equivalent (von-Mises) Stress

Fig. 22. Equivalent Elastic Strain

Fig. 23. Total Deformation

Fig. 24. Shear Stress (XY Plane)

Structural analysis of inlet valve

Fig. 25. Strain energy

Fig. 26. Equivalent (von-mises) Stress

Fig. 27. Equivalent Elastic Strain

Fig. 28. Total Deformation
Fig. 29. Shear Stress (XY Plane)

Fig. 30. Equivalent (von-Mises) Stress

Fig. 31. Equivalent Elastic Strain

Fig. 32. Total Deformation

Fig. 33. Shear Stress (XY Plane)

Fig. 34. Strain Energy

Fig. 35. Equivalent (von-Mises) Stress

Fig. 36. Equivalent Elastic Strain

Fig. 37. Total Deformation

Fig. Shear Stress (XY Plane)
Table.1. Structural Analysis of Inlet valve

<table>
<thead>
<tr>
<th>S. No</th>
<th>Material</th>
<th>Total Deformation in (mm)</th>
<th>Equivalent Elastic Strain in (mm/min)</th>
<th>Equivalent Stress in (MPa)</th>
<th>Strain Energy in (mJ)</th>
<th>Shear Stress in (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mini</td>
<td>Max</td>
<td>Mini</td>
<td>Max</td>
<td>Mini</td>
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<tr>
<td>1.</td>
<td>Alumina</td>
<td>0</td>
<td>5.7677e-006</td>
<td>3.3317e-018</td>
<td>2.1114e-006</td>
<td>2.6029e-013</td>
</tr>
<tr>
<td>2.</td>
<td>Silicon</td>
<td>0</td>
<td>1.5602e-005</td>
<td>4.3802e-18</td>
<td>6.6011e-018</td>
<td>2.1435e-013</td>
</tr>
<tr>
<td>3.</td>
<td>Stainless Steel</td>
<td>0</td>
<td>1.0934e-005</td>
<td>1.5665e-17</td>
<td>3.7385e-06</td>
<td>8.9906e-013</td>
</tr>
</tbody>
</table>

Table.2. Structural Analysis of Exhaust valve

<table>
<thead>
<tr>
<th>S. No</th>
<th>Material</th>
<th>Total Deformation in (mm)</th>
<th>Equivalent Elastic Strain in (mm/min)</th>
<th>Equivalent Stress in (MPa)</th>
<th>Strain Energy in (mJ)</th>
<th>Shear Stress in (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Mini</td>
<td>Max</td>
<td>Mini</td>
<td>Max</td>
<td>Mini</td>
</tr>
<tr>
<td>1.</td>
<td>Aluminium Nitride</td>
<td>0</td>
<td>7.0857e-006</td>
<td>9.9943e-019</td>
<td>2.8842e-006</td>
<td>1.4511e-013</td>
</tr>
<tr>
<td>2.</td>
<td>Silicon Nitride</td>
<td>0</td>
<td>7.0327e-006</td>
<td>1.7321e-18</td>
<td>2.949e-006</td>
<td>2.0535e-013</td>
</tr>
<tr>
<td>3.</td>
<td>Stainless Steel</td>
<td>0</td>
<td>1.0302e-005</td>
<td>2.5775e-18</td>
<td>3.7965e-006</td>
<td>2.0316e-013</td>
</tr>
</tbody>
</table>

VI. CONCLUSION

- The structural analysis was successfully carried out to determine stresses on the valves. Both the valves were analyzed with different materials.
- Compared and suggested best material for both the valves.
- In this study found out, in structural analysis maximum von-Mises stress was observed high in silicon (1.0516MPa) for inlet valve whereas silicon...
nitride (0.92341MPa) for exhaust valve. From the above results it was observed that the silicon is the best material for inlet valve and for exhaust valve aluminum nitride.

REFERENCES


