Structural Analysis of Disc Brake Rotor for Different Materials

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2. LITERATURE SURVEY

M.A. Maleque1,2 have been study about the brake rotor material selection method and select the optimum material for the application of brake disc system emphasizing on the substitution of this cast iron by any other lightweight material. Two methods are introduced for the selection of materials, such as cost per unit property and digital logic methods. Material performance requirements were analysed and alternative solutions were evaluated among cast iron, aluminium alloy, titanium alloy, ceramics and composites. He has been considered Mechanical properties including compressive strength, friction coefficient, wear resistance, thermal conductivity and specific gravity as well as cost, were used as the key parameters in the material selection stages. The analysis led to AMC 2 material and identified as an optimum material among the candidate materials for brake disc. This could be justifiable in this case as higher friction coefficient and lower density are advantageous from the technical and economical point of view for this type of application.

Faramarz Talati1,3 have been study the governing heat equations for the disk and the pad are extracted in the form of transient heat equations with heat generation that is dependant to time and space. In the derivation of the heat equations, parameters such as the duration of braking, vehicle velocity, geometries and the dimensions of the brake components, materials of the disk brake rotor and the pad and contact pressure distribution have been taken into account. The problem is solved analytically using Green's function approach. It is concluded that the heat generated due to friction between the disk and the pad should be ideally dissipated to the environment to avoid decreasing the friction coefficient between the disk and the pad and to avoid the temperature rise of various brake components and brake fluid vaporization due to excessive heating.

Susmitha Sankatala1 have been study about Friction causes between disc and attached wheel to slow or stop. Brakes convert friction to heat, but if the brakes get too hot, they will cease to work because they cannot dissipate enough heat. This condition of failure is known as brake fade. Disc brakes are exposed to large thermal stresses during routine braking and extraordinary thermal stresses during hard braking. The aim of the paper is to model a disc brake used in Honda Civic. Structural and Thermal is done on the disc brake. The materials used are Stainless Steel, Cast Iron and Aluminium Alloy. Analysis is also done by changing the design of disc brake. Actual disc
brake has no holes, design is changed by giving holes in the disc brake for more heat dissipation.

3. PROBLEM DEFINATION

1. Compare the weight, Strength & stresses induced in Disc brake rotor for all material according to criteria minimum weight, high compressive strength & minimum induced stresses.

2. Find the best alternative possible material for disc brake rotor by comparing all experimental investigated parameters & analysed parameters.

4. EXPERIMENTATION

1. Grey Cast Iron (GCI)
2. Aluminium Alloy (Al)
3. Titanium Alloy (Ti-2)
4. Titanium Alloy (Ti-5)
5. Aluminium-Copper alloy (Al-Cu)

<table>
<thead>
<tr>
<th>Material</th>
<th>GCI</th>
<th>Al</th>
<th>Ti-2</th>
<th>Ti-5</th>
<th>Al-Cu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal Conductivity (W/mK)</td>
<td>58</td>
<td>237</td>
<td>16.3</td>
<td>7.3</td>
<td>399</td>
</tr>
<tr>
<td>Mass Density (Kg/m³)</td>
<td>7800</td>
<td>3020</td>
<td>4510</td>
<td>4420</td>
<td>2840</td>
</tr>
<tr>
<td>Specific Heat (KJ/KgK)</td>
<td>460</td>
<td>910</td>
<td>540</td>
<td>570</td>
<td>390</td>
</tr>
<tr>
<td>Coefficient of Friction (μ)</td>
<td>0.4</td>
<td>1.10</td>
<td>0.32</td>
<td>0.28</td>
<td>0.29</td>
</tr>
<tr>
<td>Compressive Strength (Mpa)</td>
<td>1293</td>
<td>406</td>
<td>1070</td>
<td>1300</td>
<td>761</td>
</tr>
<tr>
<td>Specific Gravity (Kg/m³)</td>
<td>7200</td>
<td>2660</td>
<td>4420</td>
<td>4680</td>
<td>2800</td>
</tr>
<tr>
<td>Ultimate Strength (Mpa)</td>
<td>320</td>
<td>240</td>
<td>870</td>
<td>1020</td>
<td>515</td>
</tr>
<tr>
<td>Yield Strength (Mpa)</td>
<td>210</td>
<td>200</td>
<td>752</td>
<td>950</td>
<td>276</td>
</tr>
<tr>
<td>Wear Rate (x10⁻⁶mm⁢²/N/m)</td>
<td>2.36</td>
<td>3.25</td>
<td>8.19</td>
<td>24.6</td>
<td>2.91</td>
</tr>
</tbody>
</table>

The weight of disc rotor for all materials were recorded by actually weighing the disc materials and which were given below in table no.-2.

Table-1: Standard Properties of Material [03]

Table-2: Actual weight of disc brake rotor for different materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (Kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GCI</td>
<td>4.510</td>
</tr>
<tr>
<td>Al</td>
<td>2.762</td>
</tr>
<tr>
<td>Ti-2</td>
<td>3.200</td>
</tr>
</tbody>
</table>

From table no.-2, we get that the density of Grey Cast Iron is very high compared to other material from which we were observed that the GCI having the more weight other than all tested materials as observed in actual weight measurement.

5. TRANSIENT STRUCTURAL ANALYSIS

In transient structural analysis we have analyzed all the material for Von-Mises Stress, Max Principal Stress, Shear Stress & total Deformation of rotor in transient state. The boundary condition were considered as a fixed bolt support on all wheel hub and the pressure applied on a friction area. After analyzing the disc rotor for every material, the obtain results were shown in below.

The figure 1 to 6 shows the transient structural analysis of Grey Cast Iron material were the max principal stress induced at contraption area and value is 1.762 Mpa. The von-Mises Stress Induced at the bolting points of Disc Rotor and max value of it is 1.8585 Mpa. The total deformation of rotor is 0.001688 mm and is were observed at the outer periphery of rotor and minimum at centre of rotor.
Figure-3: Shear Stress (XY Plane) in GCI

Figure-4: Equivalent (Von-Mises) Stress in GCI

Figure-5: Total Deformation in GCI (Side View)

Figure-6: Total Deformation in GCI

Figure-7: Maximum Principal Stress in Al (Side View)

Figure-8: Maximum Principal Stress in Al

Figure-9: Shear Stress (XY Plane) in Al

Figure-10: Equivalent (Von-Mises) Stress in Al
The figure 7 to 12 shows the transient structural analysis of Aluminium material were the max principal stress induced at contraption area and value is 1.5 Mpa. The von-Mises Stress Induced at the bolting points of Disc Rotor and max value of it is 1.054 Mpa. The total deformation of rotor is 0.0009888 mm and is were observed at the outer periphery of rotor and minimum at center of rotor.

The figure 13 to 18 shows the transient structural analysis of Al-Cu Alloy material were the max principal stress induced at contraption area and value is 1.421 Mpa. The von-Mises Stress Induced at the bolting points of Disc Rotor and max value of it is 1.0015 Mpa. The total deformation of rotor is 0.00001688 mm and is were observed at the outer periphery of rotor and minimum at center of rotor.

The figure 19 to 24 shows the transient structural analysis of Titanium-2 material were the max principal stress induced at contraption area and value is 1.8542 Mpa. The von-Mises Stress Induced at the bolting points of Disc Rotor and max value of it is 1.745 Mpa. The total deformation of rotor is 0.0000988 mm and is were observed at the outer periphery of rotor and minimum at center of rotor.

The figure 25 to 30 shows the transient structural analysis of Titanium-5 material were the max principal stress induced at contraption area and value is 1.8012 Mpa. The von-Mises Stress Induced at the bolting points of Disc Rotor and max value of it is 1.6873 Mpa. The total deformation of rotor is 0.00000158 mm and is were observed at the outer periphery of rotor and minimum at center of rotor.
Figure-17: Total Deformation in Al-Cu Alloy (Side View)

Figure-18: Total Deformation in Al-Cu Alloy

Figure-19: Maximum Principal Stress in Ti-2 (Side View)

Figure-20: Maximum Principal Stress in Ti-2

Figure-21: Shear Stress (XY Plane) in Ti-2

Figure-22: Equivalent (Von-Mises) Stress in Ti-2

Figure-23: Total Deformation in Ti-2 (Side View)

Figure-24: Total Deformation in Ti-2
6. RESULT & DISCUSSION

From all the values recorded in transient analysis, it is observed that the Maximum Principal Stresses induced in Titanium-2 which is 1.8542 Mpa. The maximum von-Mises Stress induced in Titanium-2 which is 1.745 Mpa. It is observed that the lowest deformation is present in Al-Cu Alloy which is 0.00001688 mm. Also the Von-Mises stress are also less compared to other material. So from comparing all analysis it is found that the Al-Cu material is best option for Grey Cast Iron Material.

7. CONCLUSIONS

From transient analysis, it were observed that the Maximum Principal Stresses, Von-Mises Stresses, Shear Stress induced in Al-Cu alloy is less among all materials. Also the deformation were very small compared to Al-Cu alloy Material.

From theoretical study, it was justify that higher friction coefficient and lower density are advantageous from the technical and economical point of view for this type of application.

So from all above experimentation and analysis, it is observed that Al-Cu alloy is best suitable alternative option for grey cast iron disc brake rotor.
REFERENCES


