SPEED DEPENDENT DUAL CALIPER ACTION IN
DISC BRAKE

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ABSTRACT

In the existing automobile market which is growing, the competition for better automobile in climbing up enormously. The racing fans involved will surely know the importance of a good brake system not only for safety but also for staying competitive in every race though Brake is the key factor for safety. Braking is a process which converts the kinetic energy of the automobile into mechanical energy for arresting the rotation of the road wheels which must be dissipated in the form of heat. The disc brake is a device for decelerating or stopping the rotation of a wheel. A brake disc (or rotor) usually made of cast iron or ceramic composites, is connected to the wheel and/or the axle. Friction material in the form of brake pads (mounted on a device called a brake caliper) is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc to stop the wheel. The present research is basically deals with the modelling and analysis of disc brake using SolidWorks. Finite element (FE) models of the brake-disc are created using SolidWorks and simulated using SolidWorks which is based on the finite element method (FEM). In structural analysis displacement, ultimate stress limit for the design is found. Comparison can be done for displacement, stresses, nodal strains, etc. for the automobile having the disc brakes with single caliper and dual caliper going at the speed of within and above a specified speed.

Keywords: Analysis, Disc Brake, Dual Caliper, Finite Element Method, Modelling, SolidWorks.

I. INTRODUCTION

A brake is a device by means of which artificial frictional resistance is applied to moving machine member, in order to stop the motion of a machine. In the process of performing this function, the brakes absorb either kinetic energy of the moving member or the potential energy given
up by objects being lowered by hoists, elevators etc. The energy absorbed by brakes is dissipated in the form of heat. This heat is dissipated in to the surrounding atmosphere to stop the automobile, so the brake system should have the following requirements:

1. The brakes must be strong enough to stop the automobile with in a minimum Distance in an emergency.
2. The driver must have proper control over the automobile during braking and the automobile must not skid.
3. The brakes must have good ant fade characteristics i.e. their effectiveness should not decrease with constant prolonged application.
4. The brakes should have well anti wear properties.

Based on mode of operation brakes are classified as follows:

- Hydraulic brakes.
- Electric brakes.
- Mechanical brakes.

The mechanical brakes according to the direction of acting force may be subdivided into the following two groups:

1. Radial brakes.
2. Axial brakes.

1). Radial brakes:
   In these brakes the force acting on the brake drum is in radial direction. The radial brake may be subdivided into external brakes and internal brakes.

2). Axial brakes:
   In these brakes the force acting on the brake drum is only in the axial direction. e.g. Disc brakes, Cone brakes.

Disc brakes:
A disc brake consists of a cast iron disc bolted to the wheel hub and a stationary housing called caliper. The caliper is connected to some stationary part of the automobile, like the axle casing or the stub axle and is cast in two parts, each part containing a piston. In between each piston and the disc, there is a friction pad held in position by retaining pins, spring plates etc. passages are drilled in the caliper for the fluid to enter or leave each housing. These passages are also connected to another one for bleeding. Each cylinder contains rubber-sealing ring between the cylinder and piston. A schematic diagram is shown in the figure 1.
The disc brake is a wheel brake which slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of calipers. The brake disc (or rotor in American English) is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon–carbon or ceramic matrix composites. This is connected to the wheel and/or the axle. To stop the wheel, friction material in the form of brake pads, mounted on a device called a brake caliper, is forced mechanically, hydraulically, pneumatically or electromagnetically against both sides of the disc. Friction causes the disc and attached wheel to slow or stop. Brakes convert motion to heat, and if the brakes get too hot, they become less effective, a phenomenon known as brake fade.

But there is no increase in brake fluid pressure getting increased while riding the automobile faster. As the same brake fluid pressure is going to act on the Caliper whether the automobile goes faster or slower. So our idea comes in bringing the changes of brake fluid pressure depending on the automobile speed.

II. HISTORY OF DISC BRAKE AND DEVELOPMENT

Disc-style brakes development and use began in England in the 1890s. The first caliper-type automobile disc brake was patented by Frederick William Lanchester in his Birmingham, UK factory in 1902 and used successfully on Lanchester cars. Compared to drum brakes, disc brakes offer better stopping performance, because the disc is more readily cooled. As a consequence discs are less prone to the "brake fade"; and disc brakes recover more quickly from immersion (wet brakes are less effective). Most drum brake designs have at least one leading shoe, which gives a servo-effect. By contrast, a disc brake has no self-servo effect and its braking force is always proportional to the pressure placed on the brake pad by the braking system via any brake servo, braking pedal or lever, this tends to give the driver better "feel" to avoid impending lockup. Drums are also prone to "bell mouthing", and trap worn lining material within the assembly, both causes of various braking problems.

III. WORKING OF SPEED DEPENDENT DUAL CALIPER ACTION IN DISC BRAKE

Whenever we press the brake pedal in automobile, the brake fluid enter into the Caliper of the Disc Brake through the master cylinder. This is done by the ECU only if the automobile speed is below the pre-setted speed. Incase if the automobile speed exceeds the pre-set value then the ECU is said to come into the play. The ECU sends signal to the another Caliper such that indicating the automobile speed is high than the pre-set value, Therefore the another caliper also holds down the rotating disc along with the first caliper which is already in place. This increases the efficiency with which the brake stops the automobile forward motion. The figure 2 and 3 shows the modelled layout diagram of working which varies according to the automobile speed and 3D CAD model.
IV. MODELING AND ANALYSING USING SOLIDWORKS

SolidWorks is the standard in 3D product design, featuring industry-leading productivity tools that promote best practices in design while ensuring compliance with your industry and company standards. Integrated CAD/CAM/CAE solutions allow you to design faster than ever, while maximizing innovation and quality to ultimately create exceptional products.

To solve any problem in SolidWorks it mainly follows the following steps. These are common steps to all problems except material properties and type of analysis used.

1) Preliminary decisions
   a. Analysis type
   b. Model
   c. Element type

2) Pre processing
   a. Material
   b. Create or import the model geometry
   c. Mesh the geometry

3) Solution
   a. Apply loads
   b. Solve

4) Post processing
   a. Review results
   b. Check the validity of the solution.
Table 1: Material Properties in Brake Disc and Disc pad

<table>
<thead>
<tr>
<th>Material Properties</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Carbon Composites</td>
</tr>
<tr>
<td>Model type</td>
<td>Linear Elastic Isotropic</td>
</tr>
<tr>
<td>Default failure criterion</td>
<td>Max von Mises Stress</td>
</tr>
<tr>
<td>Yield strength</td>
<td>3.7e+008 N/m^2</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>3.44e+008 N/m^2</td>
</tr>
<tr>
<td>Elastic modulus</td>
<td>1.05e+011 N/m^2</td>
</tr>
<tr>
<td>Poisson's ratio</td>
<td>0.37</td>
</tr>
<tr>
<td>Mass density</td>
<td>4510 kg/m^3</td>
</tr>
<tr>
<td>Shear modulus</td>
<td>4.5e+010 N/m^2</td>
</tr>
<tr>
<td>Thermal expansion coefficient</td>
<td>9e-006 /Kelvin</td>
</tr>
</tbody>
</table>

For all the upcoming analysis we performed the steps as follows

- Create a study.
- From the Simulation drop-down menu, select Study.
- Select Static as the Type.
- Right-click the Parts folder and select Apply Material to All.
- Right-click Fixtures in the Simulation Study tree and select Fixed Geometry.
- Right-click External Loads in the Simulation Study tree and give the values you wanted.
- Right-click Mesh in the Simulation Study tree and select Create Mesh.
- Double click the Stress tab, Strain tab, Displacement tab to show to output.
- Export as a report for the Mathematical Values.

V. ANALYSED CALIPER

We performed the stress, strain, displacement, Factor of Safety (FOS) analysis for the design of the Caliper and then finally we came up with the good design to hold the required design analysis cases.

![Figure 4: 3D Designed Model of our Caliper](image1)

![Figure 5: Displacement Analysis](image2)
VI. ANALYSED DISC

We performed the stress, strain, displacement, Factor of Safety (FOS) analysis for the design of the Disc and then finally we came up with the good design to hold the required design analysis cases.
From the figure 15, the mesh that we did in the SolidWorks is a Curvature mesh with the 4 point Jacobian meshing formula, which gives the more precise output.

VII. STRESS AND STRAIN VALUES FROM ANALYSIS

From the analysed report of the speed dependent dual caliper action in disc brake, the following list of values for the disc and caliper are given in the form of tables. Such that these are the values formed during the analysis as a result using the SolidWorks Simulation.

<table>
<thead>
<tr>
<th>Table 2: Values of Stresses acting on Caliper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node</td>
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<tr>
<td>------</td>
</tr>
<tr>
<td>85688</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 3: Values of Strains acting on Caliper</th>
</tr>
</thead>
<tbody>
<tr>
<td>Element</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>65015</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 4: Values of Stresses acting in Disc</th>
</tr>
</thead>
<tbody>
<tr>
<td>Node</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>150309</td>
</tr>
</tbody>
</table>
Table 5: Values of Strains acting in Disc

<table>
<thead>
<tr>
<th>Element</th>
<th>X (mm)</th>
<th>Y (mm)</th>
<th>Z (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>201506</td>
<td>-144.007</td>
<td>-50.423</td>
<td>-5.82E-09</td>
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<tr>
<td>220300</td>
<td>152.552</td>
<td>2.78915</td>
<td>5.82E-09</td>
</tr>
<tr>
<td>222897</td>
<td>2.78915</td>
<td>-152.552</td>
<td>5.82E-09</td>
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<td>148246</td>
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<td>152.552</td>
<td>5.82E-09</td>
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<td>53198</td>
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<td>222525</td>
<td>126.191</td>
<td>-85.77</td>
<td>5.82E-09</td>
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<td>203233</td>
<td>-2.78915</td>
<td>-152.552</td>
<td>5.82E-09</td>
</tr>
</tbody>
</table>

VIII. CONCLUSION

The graph which gets generated by the SolidWorks Simulation tells that if two automobile are said to have, one with the normal disc brakes with single caliper and other with the dual caliper. The comparison shows that the stopping distance gets reduced by about 4.63%. Where if the normal automobile stops at a distance of 194m running at 130km/hr, then this speed dependent dual caliper action in disc brake makes the automobile to stop at a distance of 185m running at 130km/hr.

![Stopping Distance Characteristic Curve](image)

Figure 16: Stopping Distance Characteristic Curve

IX. REFERENCES


