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Couple Field Analysis on Disk Brake with Different Conventional Materials by Using FEA

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ABSTRACT:

Disc rotor brakes are exposed to large thermal stresses during routine braking and extraordinary thermal stresses during hard braking. The aim of the project is to design, model a disc. Modelling is done using catia. Structural and Thermal analysis is to be done on the disc brakes using three materials Stainless Steel and Cast iron & carbon carbon composite. Structural analysis is done on the disc brake to validate the strength of the disc brake and thermal analysis is done to analyze the thermal properties. Comparison can be done for deformation, stresses, temperature etc. form the three materials to check which material is best. Catia is a 3d modelling software widely used in the design process. ANSYS is general-purpose finite element analysis (FEA) software package. Finite Element Analysis is a numerical method of deconstructing a complex system into very small pieces (of user- designated size) called elements

1. INTRODUCTION:

A disk brake consists of a cast iron disk bolted to the wheel hub and a stationary housing called caliper. The caliper is connected to some stationary part of the vehicle like the axle casing or the stub axle as is cast in two parts each part containing a piston. In between each piston and the disk 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. The passages are also connected to another one for bleeding. Each cylinder contains rubber-sealing ring between the cylinder and piston. Brake is an integral part of a vehicle which is used to retard or stop the vehicle from moving.

From the safety aspect, the brake is an important and crucial component. So the brake rotor should be strong enough to withstand the thermal effect and dissipate the generated heat quickly. The material for brake should be suitably selected. Commonly used material for disc brakes is cast iron. Density of cast iron is high and leads to more fuel consumption and emissions. Composite materials are light weight and have good mechanical properties.

Keywords:
Disk brake, Failure analysis, Creo Elements, FEM, Ansys.

2. CALCULATION

BRAKE LINE PRESSURE:

Master cylinder is the compartment for the hydraulic oil storage. Human effort is required for pumping the oil. According to Pascal the required pressure in the brake tube is obtained.

Master cylinder diameter (d) = 0.019 m

Area of the master cylinder

$$A = \frac{\pi \times (d)^2}{4}$$

$$A = \frac{\pi \times (.019)^2}{4} = 0.000283385 \text{ m}^2$$

Line pressure

$$\left(\frac{F}{A} \times L.R \times P\right) = \eta p. \quad P = \frac{445}{0.0002833} \times 3.5 \times 0.8 = 4.39 \text{ MPa}$$

Hence the line pressure created from the master cylinder is 4.39 MPa.

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BRAKE FORCE ON PAD:

Brake pad is a friction material which offers a dissipation of heat when the pad comes in contact with the rotating disc.

Slave cylinder efficiency (ηc) = 0.98

Brake force on pad F = P × A.

Brake force on pad F= $4.4\times10^{6}\times0.0006387\times0.98$ =2754.07N

Brake force on wheel $= 2 \times F \times (\frac{r}{R})$.

$= 2 \times 2754.07 \times (\frac{0.08}{0.02921})$.

=1508.56N

BRAKING PRESSURE:

Brake swept area = 0.1m

$$P = \frac{2\times 1508.56}{0.01} = 301712 = 0.3\text{MPa}$$

3. DESIGN CRITERIA OF DISK BRAKE:

Geometry of the disc brake is developed using CATIA V5.

Figure 1: Geometry of disk brake

MESHING:

One of the most relevant steps in the Finite Element Analysis is the meshing. The speed and the accuracy of the results have a direct connection in how this part is done. The higher the numbers of nodes are the higher the accuracy of the results, however the speed of the simulation decreases. Figure 2 shows how the mesh looks in ANSYS Mechanical. Tetrahedral second order meshed is used in the present analysis.

Number of nodes = 84607

Number of elements = 53639

Element type = Solid 187

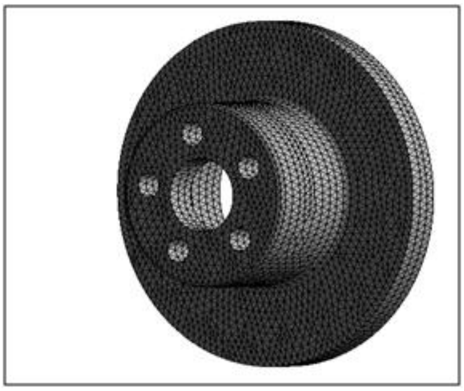

Figure 2: Finite element meshed model of the disc brake

4.RESULTS AND DISCUSSIONS

4.1 STRUCTURAL STEEL RESULTS

4.1.1 TOTAL DEFORMATION (mm)

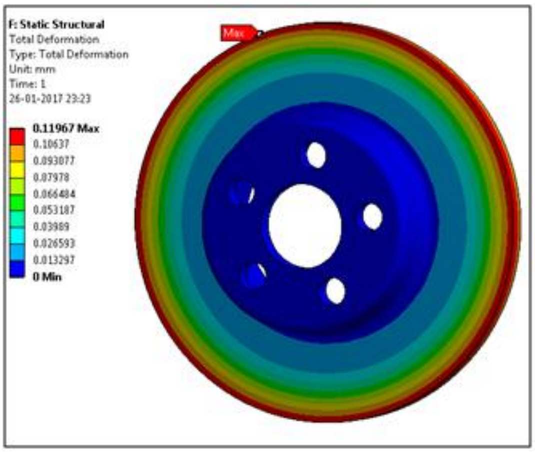

Figure 3: Total deformation

4.1.2 VON MISES STRESS (MPa)

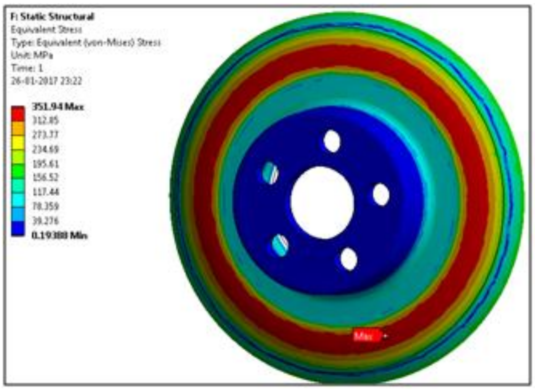

Figure 4: von Mises stress in the structure

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4.1.3 MAXIMUM TEMPERATURE (DEG C)

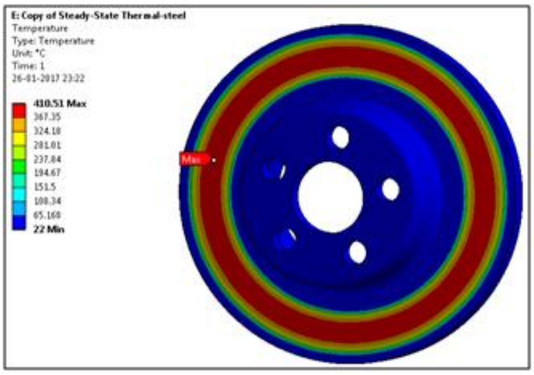

Figure 5: Maximum Temperature

4.2CAST IRON RESULTS

4.2.1 TOTAL DEFORMATION (MM)

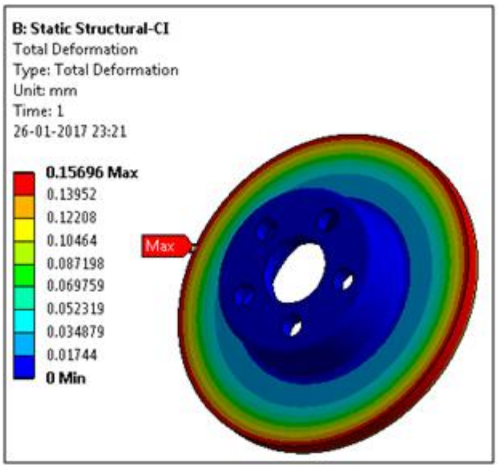

Figure 6: Total deformation

4.2.2 VON MISES STRESS (MPA):

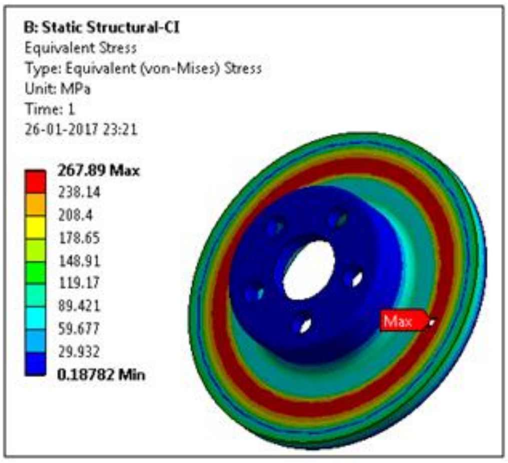

Figure 7: von Mises stress in the structure

4.2.3 MAXIMUM TEMPERATURE (DEG C):

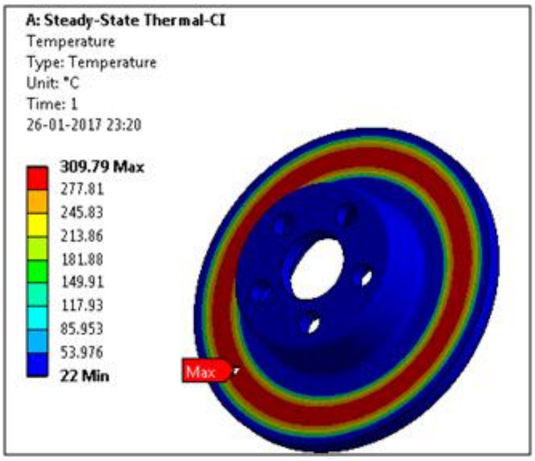

Figure 8: Maximum Temperature

4.3 ALUMINUM RESULTS

4.3.1 TOTAL DEFORMATION (MM)

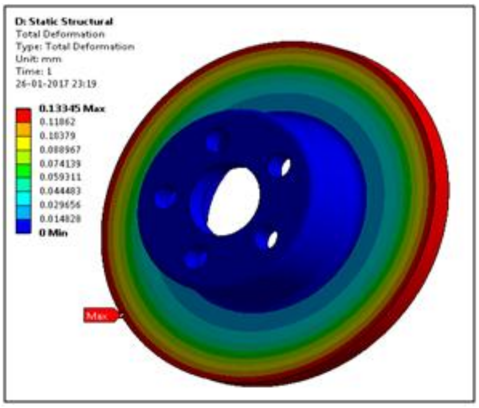

Figure 9: Total deformation

4.3.2 VON MISES STRESS (MPA):

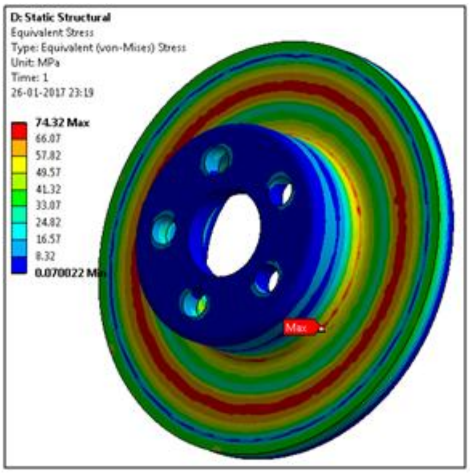

Figure 10: von Mises stress in the structure

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4.3.3 MAXIMUM TEMPERATURE (DEG C)

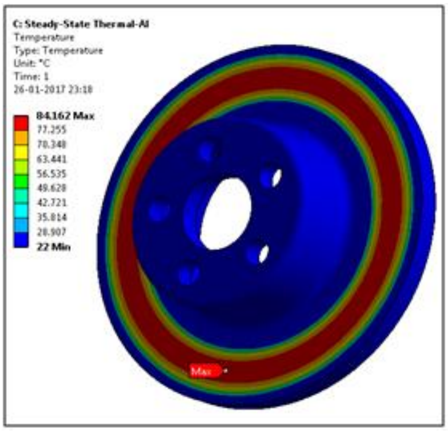

Figure 11 Maximum Temperature

CONCLUSION:

In this project we have designed a disk brake rotor. We have modeled the disk brake rotor by using 3D parametric software CATIA.To validate the strength of our design, we have done structural analysis together with thermal analysis on the disk brake rotor. The summary of the analysis results are given below

	Structural steel	Cast Iron	Aluminium
Max temperature (deg C)	410	310	84
Total deformation(mm)	0.119	0.157	0.133
Max Von Mises Stress(MPa)	352	268	74

Table 1: Results Comparison of Structural Steel, Cast Iron and Aluminum

Comparing the results of temperature rise and stress field obtained from analysis it is observed that the values are less in case of ALMMC than the other materials. It can be concluded that aluminum metal matrix composite is the most appropriate material for brake disc. ALMMC is also of less weight giving better fuel economy and reduction in greenhouse gas emissions.

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