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Steady State Thermal Analysis of a Disc Brake Rotor with Composite Material

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Abstract: **In this work the study of Steady State thermal analysis on a disc brake rotor used in automobile by using composite material and comparing it with the Grey cast iron . In order to improve the breaking efficiency the heat dissipation is an important factor to be considered. Here steady state thermal analysis is done on the disc brake rotor by applying the temperature of 80^0C on the front face of the model and applying the convection load on the inner faces of the model for a time of one second from 22^0 C to 80^0 C .The model and analysis of the disk brake is done by using ANSYS Work bench 14.0 Software .The Temperature contour plot, Total Heat Flux and Directional Heat Flux is obtained and compared for the different materials .**

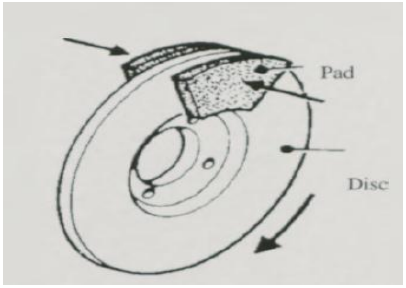
Keywords: Disk Brake Rotor, Steady State Thermal Analysis, Heat Transfer, ANSYS Workbench 14.5

1. INTRODUCTION:

The disk brake is a device for slowing or stopping the rotation of a wheel. Due to repetitive application of the brake the disk brake rotor is heated .The breaking system has to be cooled at a faster rate. The disk brake rotor is generally made by using the Cast iron due to its cost and ease of the manufacturing process. By using the reinforced Carbon- Carbon Composites the weight of the disk brake rotor can be reduced to considerable level. The disk brake offer better stopping compared to drum brake as disc is readily cooled.

2. ROTOR DISC OF DISK BRAKE:

A brake disc rotor is the rotating part of a disk brake assembly normally located in the front axle. It consists of a rubbing surface, a top-hat and a neck section. The rubbing surface is where a tangential friction force between the rotor and the stationary pad is generated that gives rise to the brake force in the tyre–ground plane which retards the vehicle.



2.1Cast Iron:

Cast iron is commonly used to create components of varying complexity for a long time. The cat iron normally consists of two main substances: Graphite (carbon) flakes and matrix ferrous metal.

2.2 Carbon-Carbon Composite:

Carbon –Carbon is an sole composite material with carbon fiber embedded in carbon matrix and is known for its thermo –structural properties .Carbon-Carbon composite is used in aircraft brake discs and various biomedical application

3. OBJECTIVE OF WORK:

1. To perform the steady state thermal analysis of the Disk Brake Rotor.
2. To predict the temperature distribution on the Disk Brake Rotor on the cylindrical surface of the disk Brake Rotor.
3. To predict the total Heat Flux.
4. To predict the directional heat Flux.
5. Comparative study of the disk Brake rotor by using Cast Iron and Carbon-Carbon Composite

4. LITERATURE SURVEY

[1]Manjunath T V, Dr Suresh P M Transient Thermal and Structural Analysis of the Rotor Disc of Disk Brake is aimed at evaluating the performance of disc brake rotor of a car under severe braking conditions and there by assist in disc rotor design and analysis.HMazidi, S.Jalalifar, J. Chakhoo[2]In this study, the heat conduction problems of the disc brake components (Pad and Rotor) are modeled Mathematically and is solved numerically using finite difference method. In the discretization of time Dependent equations. V.M.M.Thilak, R.Krishnaraj,Dr.M.Sakthivel, K.Kanthavel,DeepanMarudachalam M.G, R.Palani [3] In this work, an attempt has been made to investigate the suitable hybrid composite material which is lighter than cast iron and has good Young's modulus, Yield strength and density properties. The transient thermo elastic analysis of Disc brakes in repeated brake applications has been performed and the results were compared. **Aniket Bharambe [4]** Composite brake discs are lighter, economical, and have excellent high energy friction characteristics. These have twice thermal capability compared to steel, remain unaffected by thermal shocks and mechanical fatigue.

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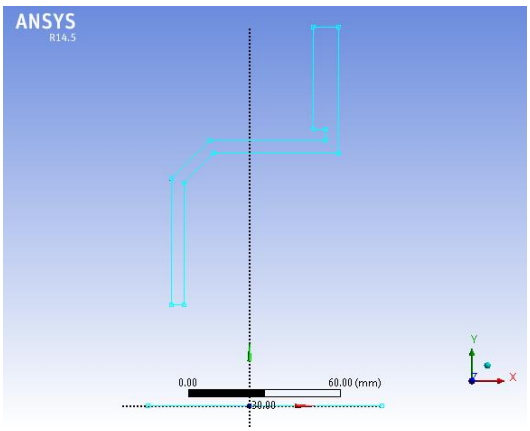
5. METHODOLOGY

5.1Profile of Disc Brake Rotor

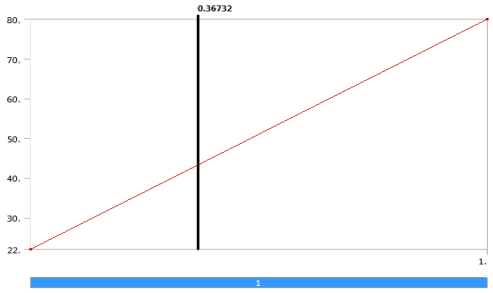


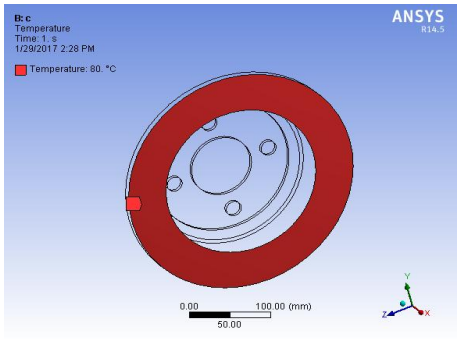
5.2Material Property

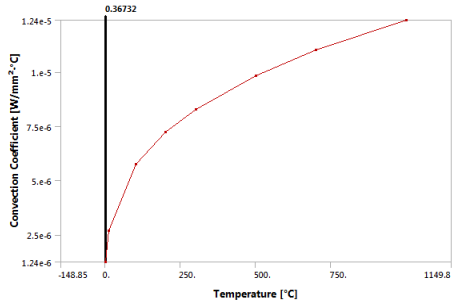
Table 1 Material Properties:

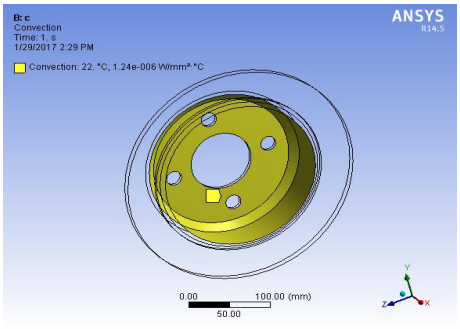
Property	Grey Cast Iron	Carbon-Carbon Composite
Density(Kg/m^3)	7200	7100
Young's Modulus (GPa)	110	125
Poisson Ratio	0.28	0.25
Thermal Conductivity (W/m-K)	52.0	54.5
Specific Heat(J/Kg-K)	447	586

5.3Boundary Condition









5.4 Meshed model

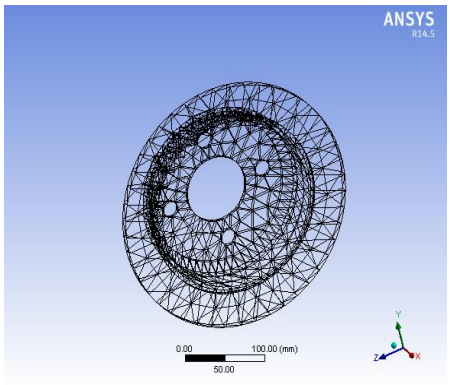


Table2:Element Table:

Number Of Node	Number Of Elements
5526	2818

6. MODELLING AND ANALYIS:

The finite element analysis was based on the following common assumptions:

a) Steady-state heat flow,

b) The materials are homogeneous and isotropic.

c) The temperature load of 22^0C to 80^0C on the front face in one seconds.

d)The conventional load on the inner faces of the model .The inner faces are exposed to air. The ambient temperature is 22 ^{0} C.

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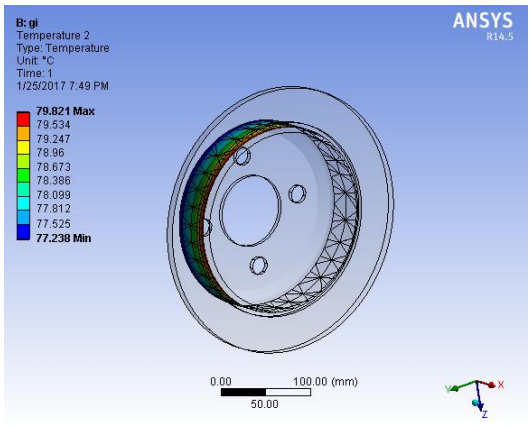
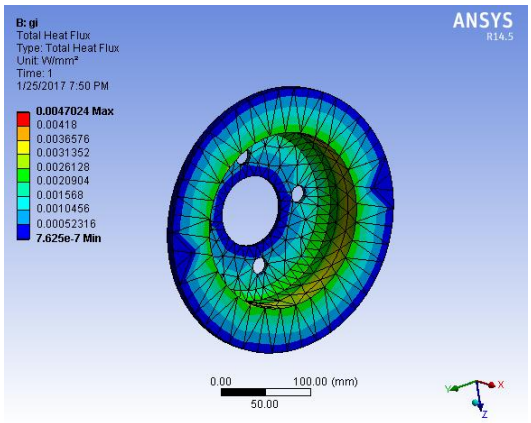
6.1Analysis Results Of Grey Cast iron

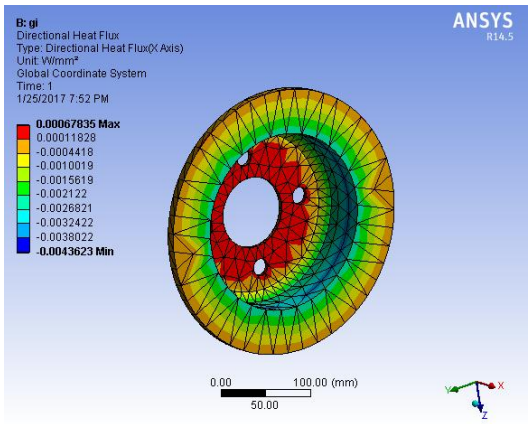
Temperature Contour Plot



Total Heat Flux

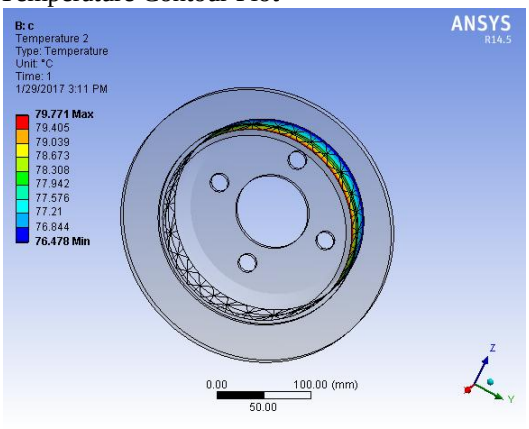


Directional Heat Flux Plot

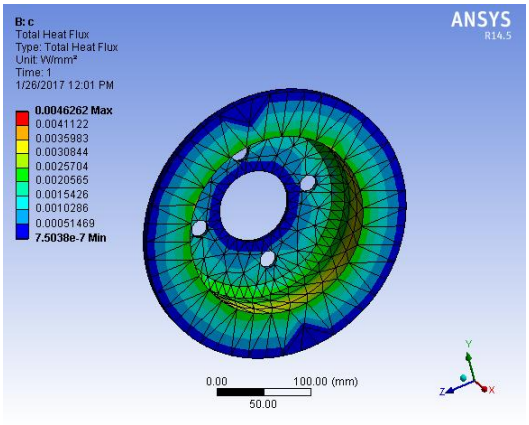


6.2Analysis Results Of Carbon-Carbon Composite

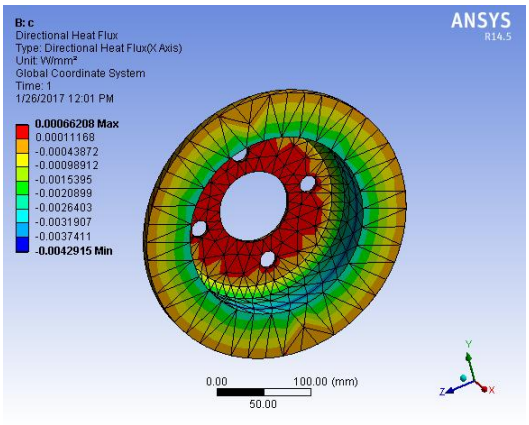
Temperature Contour Plot



Total Heat Flux



Directional Heat Flux Plot



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7. RESULT AND DISCUSSION

Table3:Results

Material	Temperature ^{0}C		Total Heat Flux(W/mm^2)		Directional Heat Flux	
	Max	Min	Max	Min	Max	Min
Grey Cast Iron	79.8	77.2	4.7e-3	7.6e-7	6.7e-4	-4.3e-3
Carbon-Carbon Composite	79.7	76.4	4.6e-7	7.5e-7	6.6e-4	-4.2e-3

7.1 Temperature Distribution:

The thermal analysis of the disk brake rotor is conducted using Ansys Work bench and the results obtained are given in the table3.The temperature distribution on the cylindrical surface of the disk brake is shown in the table3.It is found that the temperature is less in case of using the Carbon-Carbon Composite compared to Grey Cast Iron. By replacing by Carbon-Carbon Composite the value of the temperature is less as compared to Grey Cast Iron.

CONCLUSION

The heat produced in the cylindrical surface of the disk brake is found out by using the Grey Cast iron and Carbon-Carbon Composite materials. It has observed that the temperature produced is less by using Carbon-Carbon Composite material. The cost of the disk brake rotor can be reduced by using the Carbon-Carbon Composite material. The Total Heat flux and the Directional Heat Flux produced are also less in Carbon-Carbon Composite. The analysis can be done by also providing angular velocity to the disk Break Rotor.

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