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REVIEW ON
MODELING AND ANALYSIS OF DISC BRAKE ROTOR

Yash Gupta[1], N Ajay [2]

[1]BTech(IV year), [2]Department of Mechanical & Engineering,
Guru Nanak Institute of Technology, Ibrahimaptnam ,Hyderabad, India.

Abstract - *This work is presented with "Force Analysis & Optimization of Disc Brake Rotor" which studied about the disc brake rotor by modeling & analysis of different profiles of disc brake rotor with the same outer & inner diameter of the rotor .This work also consist of analysis of selected disc profile no 3for different materials so as to give alternative for Gray cast Iron as it consumes much fuel due to its high specific gravity. & finally thickness analysis for selected disc rotor material is carried out.*

Hopefully this project will help everyone to understand how to optimize the disc brake rotor by changing the profiles, material & thickness of disc brake rotor, & how implemented disc brake rotor gives more heat flux rate as compare to existing one, which help in reducing thermal stress induced in the disc brake rotor, which improves the performance of disc brake that help to reduce the accident that may happen in each day.

***Key Words*: Disc brake, Heat Flux, stress, deformation, Disc profile, optimization.**

1. INTRODUCTION

While braking most of the kinetic energy is converted into thermal energy. When brake is applied, lots of friction takes place between the Disc brake rotor & brake Pad which produced lots of heat & thus increase the disc temperature & this increase in temperature induced thermal stresses in the disc brake rotor. In order to reduce this thermal stresses we need to optimize the disc brake rotor. Optimization of disc brake can be achieved by changing the profile, material & thickness of the Rotor & all these aspects are discussed in this paper. The findings of this research provide a useful design tool to improve the brake performance of disc brake system.

1.1 Why Needed?

A problem in Disc Brake occurs because of uneven stress & heat dissipation during braking.
The following problems are occurs in Disc Brake:
Rusting, Cracking, Poor stopping, Vibration, noise, Scarring, Pulling, Dragging, Pulsation etc.

2. LITERATURE REVIEW:

Ali Belhocine et. all [1] studied the thermal behavior of the full and ventilated brake discs of the vehicles using computing code ANSYS. The modeling of the temperature distribution in the disc brake is used to identify all the factors and the entering parameters concerned at the time of the braking operation such as the type of braking, the geometric design of the disc and the used material. The numerical simulation for the coupled transient thermal field and stress field is carried out by sequentially thermal- structural coupled method based on ANSYS to evaluate the stress fields and deformations which are established in the disc with the pressure on the pads. The results obtained by the simulation are satisfactory when compared with those of the specialized literature.

G. Babukanth et. al. [2] studied the thermo elastic phenomenon occurring in the disk brakes, the occupied heat conduction and elastic equations are solved with contact problems. The numerical simulation for the thermo elastic behaviour of disk brake is obtained in the repeated brake condition. The computational results are presented for the distribution of heat flux and temperature on each friction surface between the contacting bodies. Also, thermo elastic instability (TIE) phenomenon (the unstable growth of contact pressure and temperature) is investigated in the present study, and the influence of the material properties on the thermo elastic behaviors (the maximum temperature on the friction surfaces) is investigated to facilitate the conceptual design of the disk brake system. Based on these numerical results, the thermo elastic behaviors of the carbon-carbon composites with excellent mechanical properties are also discussed.

Oder, G. et. al. [3] present paper shows a thermal and stress analysis of a brake disc for railway vehicles using the finite element method (FEM). Performed analysis deals with two cases of braking; the first case considers braking to a standstill; the second case considers braking on a hill and maintaining a constant speed. In both cases the main boundary condition is the heat flux on the braking surfaces and the holding force of the brake calipers. In addition the centrifugal load1 is considered.

The aim of this work was to investigate the temperature fields and also structural fields of the solid disc brake during short and emergency braking with four different materials. The distribution of the temperature depends on the various factors such as friction, surface roughness and speed. The effect of the angular velocity and the contact pressure induces the temperature rise of disc brake. The finite element simulation for two-dimensional model was preferred due to the heat flux ratio constantly distributed in circumferential direction. We will take down the value of temperature, friction contact power, nodal displacement and deformation for different pressure condition using analysis software with four materials namely cast iron, cast steel, aluminium and carbon fiber reinforced plastic. Presently the Disc brakes are made up of cast iron and cast steel. With the value at the hand we can determine the best suitable material for the brake drum with higher life span. The detailed drawings of all parts are to be furnished by Daniel Das. A et. al. [4]

M.A. Maleque et. al. [5] gives material section method for disc brake rotor. An automotive brake disc or rotor is a device for slowing or stopping the motion of a wheel while it runs at a certain speed. The widely used brake rotor material is cast iron which consumes much fuel due to its high specific gravity. The aim of this paper is to develop the 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 analyzed and alternative solutions were evaluated among cast iron, aluminum alloy, titanium alloy, ceramics and composites. 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 aluminum metal matrix composite as the most appropriate material for brake disc system.

3. VARIOUS PROFILES FOR TESTING:

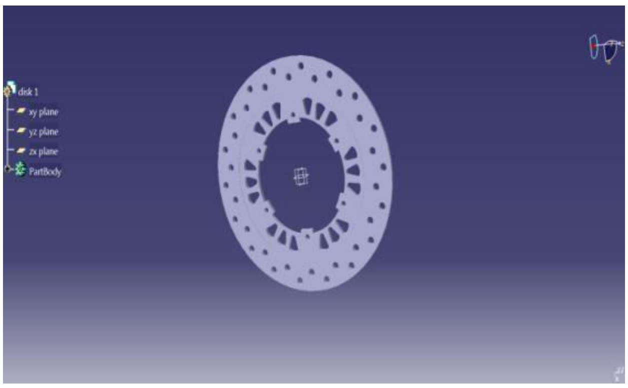

Figure 1: Profile 1

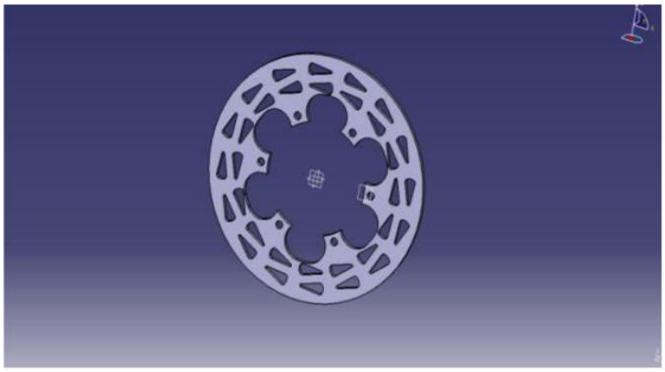

Figure 2: Profile 2

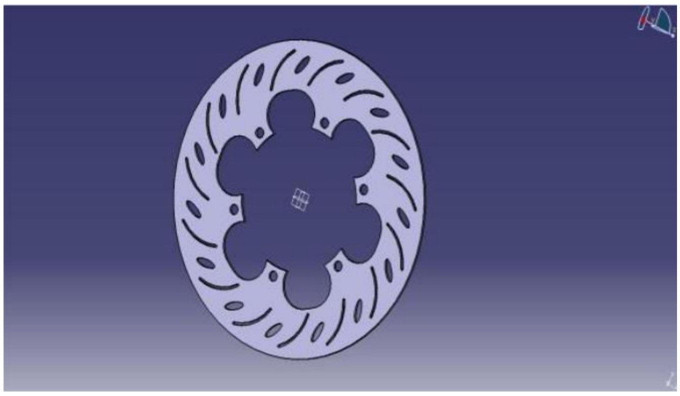

Figure 3: Profile 3

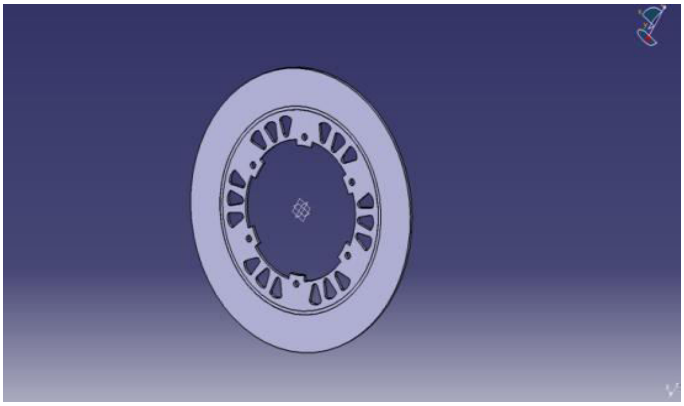

Figure 4: Profile 4

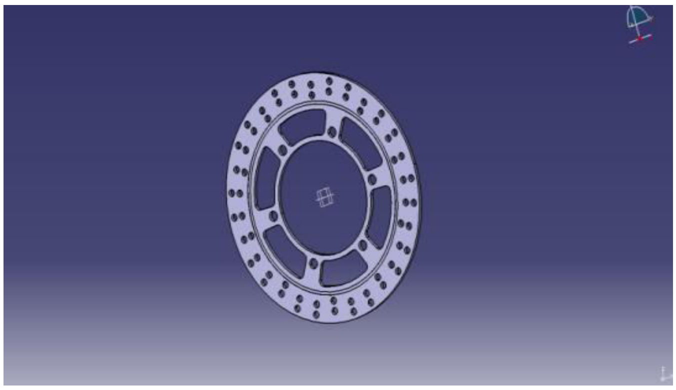

Figure 5: Profile 5

4. ANALYSIS FOR PROFILE SELECTION: Sample Analysis for Profile 3:

4.1 Static Analysis Results

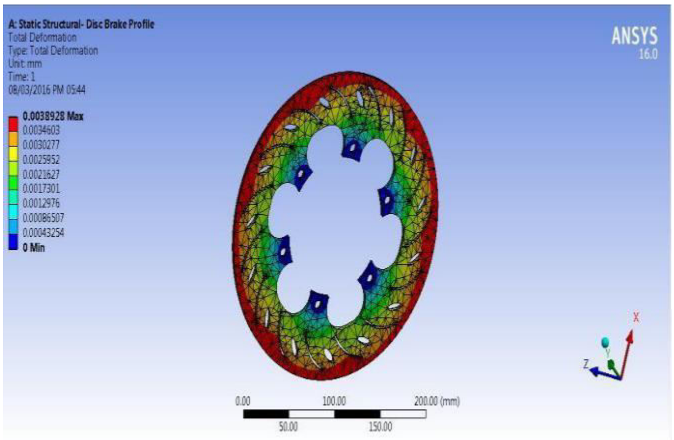

Fig 6: Deformation result of disc brake 3

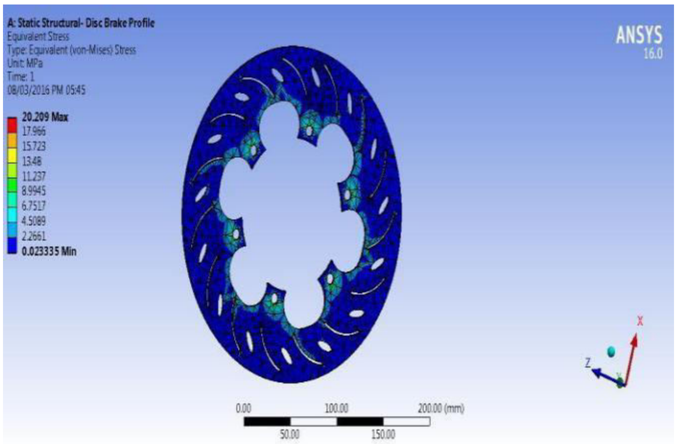

Fig 7: Stress result of disc brake 3

4.2 Thermal Analysis Results:

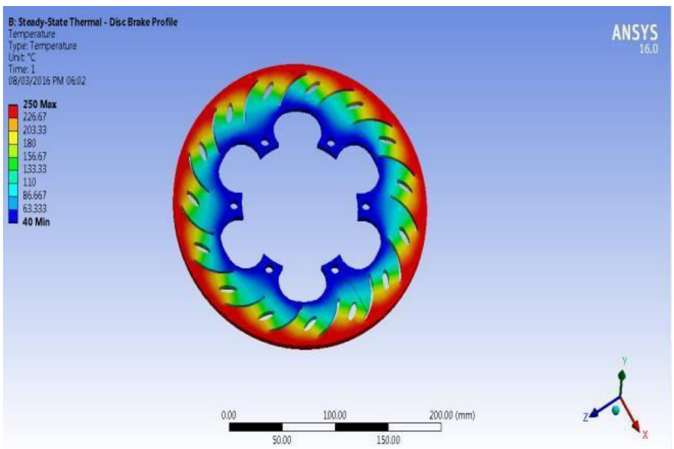

Fig 8: Temperature distribution on disc 3

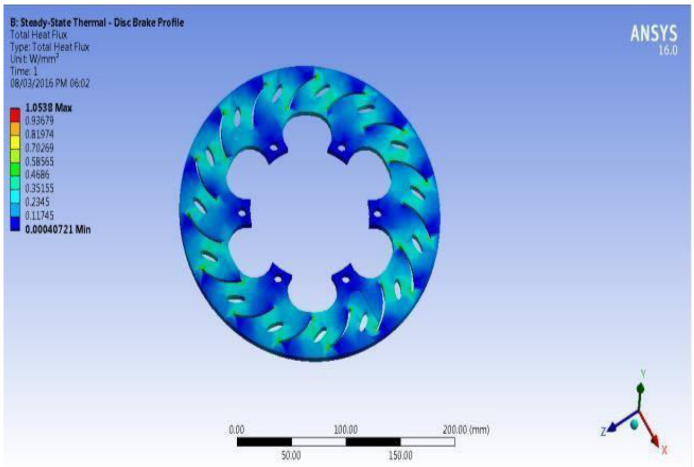

Fig 9: Heat Flux for Disc 3

Table -1: Results based on analysis carried out for profiles

Profile of Disc	Deformation, (mm)	Stress, (MPa)	Heat Flux, (W/mm2)
1	0.0029405	13.149	0.56531
2	0.0053579	14.399	0.93465
3	0.0038928	20.209	1.0538
4	0.0028292	12.742	0.49042
5	0.0047418	13.326	0.58095

From above results it's clear that profile 3 is giving higher heat flux among all profiles and hence can be used for further work. Stresses are on higher side but are within allowable limit -Gray Cast Iron material is used.

5. ANALYSIS OF SELECTED DISC PROFILE FOR DIFFERENT MATERIAL

Further Material analysis for selected disc profile has been done for 3 different materials as follows

1] Steel

2] Aluminum Alloy

3] Magnesium Alloy

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Sample Analysis for Aluminum Alloy:

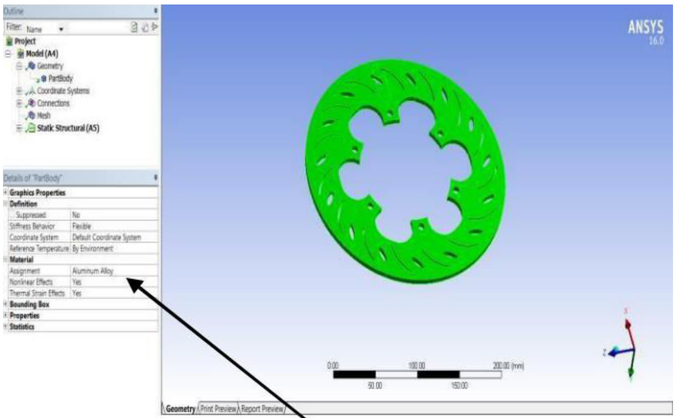

Fig 10: Aluminum Material Assignment

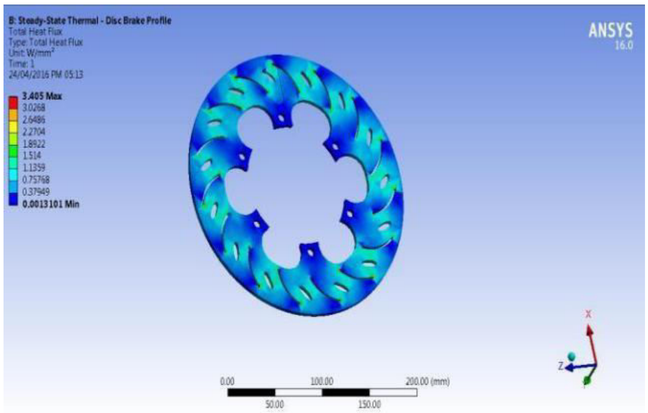

Fig13: Heat Flux for Aluminum Alloy

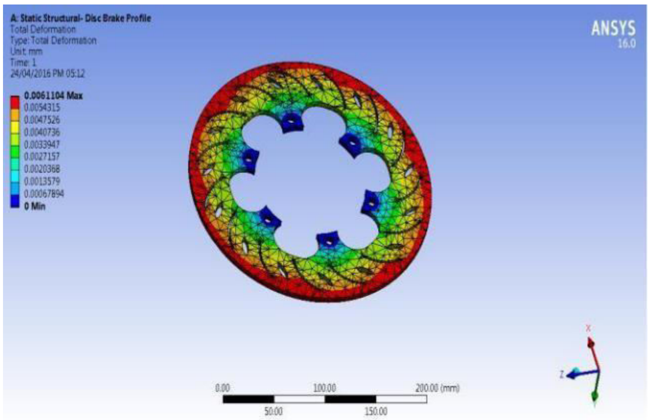

Fig11: Deformation result of disc brake for Aluminum Alloy

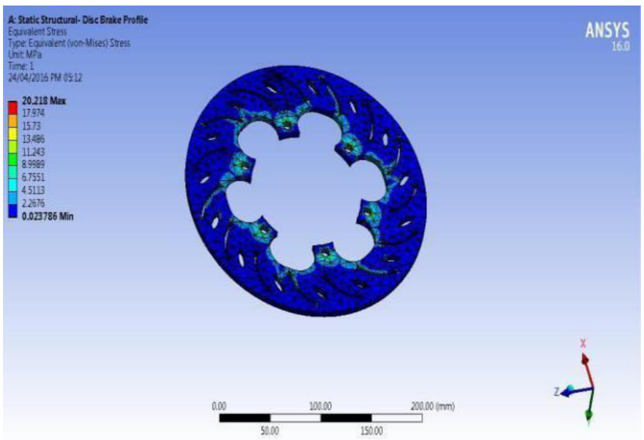

Fig12: Stress result of disc brake for Aluminum Alloy

Table no 2: Results of material Analysis

Material of Disc	Deformation, (mm)	Stress, (MPa)	Heat Flux. (W/mm2)
Gray Cast Iron	0.0038928	20.209	1.0538
Steel	0.0021528	20.216	1.2261
Aluminum Alloy	0.0061104	20.218	3.405
Magnesium Alloy	0.0096852	20.209	3.1615

From above results it's clear that Aluminum alloy shows higher Heat flux result and can be used for further work

6. THICKNESS ANALYSIS FOR DISC ROTOR:

Thickness analysis has been done for following 5 different thicknesses (mm).

Sr. No.	Thickness of Disc (mm)
1	4
2	4.5
3	5
4	5.5
5	6.0

Analysis Result for 4.0 mm thickness:

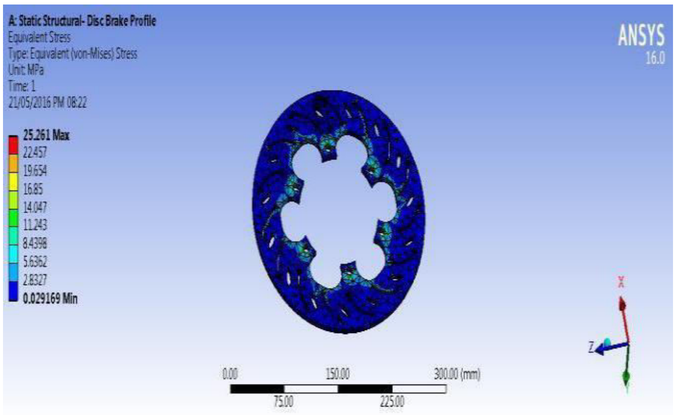

Fig 14: Stresses result for 4.0 mm thickness

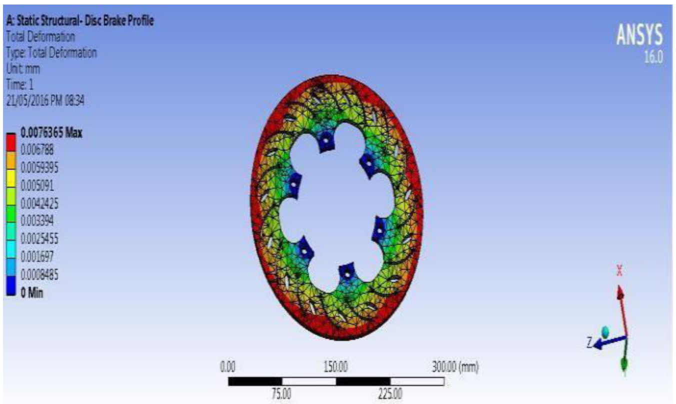

Fig15: Deformation result for 4.0 mm thickness

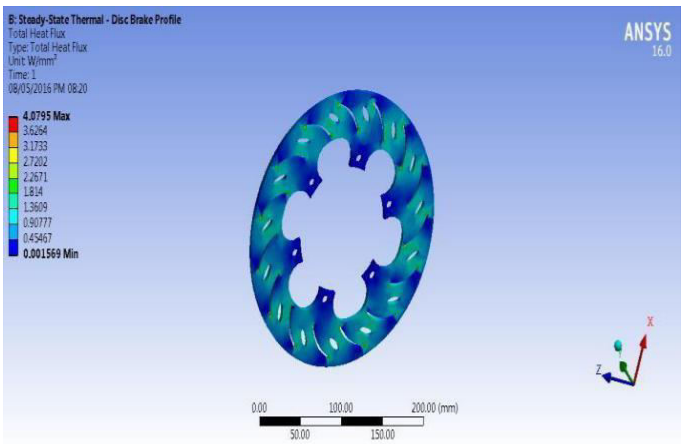

Fig 16: Heat Flux result for 4.0 mm thickness

Table 3: Result table for various thicknesses

Sr. No.	Thickness of Disc (mm)	Stress (MPa)	Deformation (mm)	Heat Flux (W/mm2)
1	4.0	25.261	0.0076365	4.0795
2	4.5	23.577	0.0071278	3.7402
3	5.0	20.218	0.0061104	3.4050
4	5.5	18.524	0.0056017	3.0654
5	6.0	16.84	0.0050931	2.7278

From the above result it is clear that when thickness of disc decreases from 5.0 mm to 4.0mm Heat Flux increases from 3.4050 to 4.0795. It is also observed that stress is also increases from 20.218 to 25.261 but that are within allowable limit hence can be finalized.

7. CONCLUSION:

- Disc profile plays important role in thermal distribution and should be carefully selected.

-The results we got for selected profile no. 3 are showing good improvement compare to other profiles.

- Further in material case :Material Aluminum Alloy shows very high 5.02times heat flux over gray cast iron C-70 and hence finally suggested for profile improvement.

- Finally in thickness case : Disc having 4.0mm thickness give 19.80 % more heat flux compare to disc having 5.0 mm thickness. In this case stress is increases by 5.043 MPa But that is within allowable limit.

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