Design and Thermal Analysis of Disc Brake Rotor with Weight Optimization

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Abstract— These day technologies go beyond us. For automotive field, the technology of engine develops very fast even the system of the car, luxury or comforts everything that develops by the innovation of engineer. Although the engineer gives priority for safety measure, but most consumers still have inadequate of knowledge in safety system. Thus safety is the first important thing we must focus. This paper is presented with "Thermal analysis of Disc Brake Rotor with slot shape optimization" which studies about on disc brake Rotor by analysis of different shapes of slots of different vehicle's Disc Brake Rotor. Therefore, we can optimize number of shapes of slots to estimate the good thermal conductivity of the disc brake Rotor. In this paper, Thermal analysis done on real model of Disc Brake Rotor of Bajaj Pulsar 220 and Thermal analysis of disc brake Rotor of different shapes of slots of different vehicle's in one Disc brake rotor. Different shapes of slots are because of to reduce the weight of disc rotor and for good thermal conductivity. Hopefully this paper will help everyone to understand Thermal analysis of disc brake rotor and how disc brake works more efficiently, which can help to reduce the accident that may happen in each day.

Key words: Disc Brakes, optimization, slots, Thermal Conductivity, Thermal analysis

I. INTRODUCTION

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 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 disc there is a friction pad held in position by retaining pins, spring plates. The passages are so connected to another one for bleeding. Each cylinder contains rubber-sealing ring between the cylinder and piston Due to the application of brakes on the car disc brake rotor, heat generation takes place due to friction and this temperature so generated has to be conducted and dispersed across the disc rotor cross section.

An Investigation into usage of new materials is required which improve braking efficiency and provide greater stability to vehicle.[1]

II. LITERATURE SURVEY

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. Disc brake is usually made of Cast iron, so it is being selected for investigating the effect of strength variations on the predicted stress distributions. Aluminum Metal Matrix Composite materials are selected and analyzed. The results are compared with existing disc rotor. The model of Disc brake is developed by using Solid modeling software Pro/E (Creo-Parametric 1.0).Further Static Analysis is done by using ANSYS Workbench. Structural Analysis is done to determine the Deflection, Normal Stress ,Vonmises stress.[1]

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, aluminum 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. [2]

III. DESIGN

This disc brake analysis "force and friction on disc brake analysis" which studies about action on disc brake by analysis the normal force, shear force, and piston force. Therefore, we can estimate the efficiency of the disc brake. [3]

This study is of disc brake used for cars. ANSYS package is a dedicated finite element package used for determining the temperature distribution, variation of stresses and deformation across the disc brake profile. In this present work, an attempt has been made to investigate the effect of stiffness, strength and variations in disc brake rotor design on the predicted stress and temperature distributions. By identifying the true design features, the extended service life and long term stability is assured. A transient thermal analysis has been carried out to investigate the temperature variation across the disc using axis symmetric elements. Further structural analysis is also carried out by coupling thermal analysis to study and evaluate the performance under severe braking conditions and there by assist in disc rotor design and analysis.. An attempt is also made to suggest a best combination of material and flange width used for disc brake rotor, which yields a low temperature variation across the rotor, less deformation, and minimum vonmises stress possible. [4]

Steady state and transient response has been conducted through the heat transfer analysis where to predict the worst case scenario and temperature behaviors of disc brake rotor. In this study, finite element analysis approached has been conducted in order to identify the temperature distributions and behaviors of disc brake rotor in steady state and transient responses. Ansysis has been used as finite elements software to perform the thermal analysis on both responses. Both results have been compared for better justification. Thus, both results provide better understanding on the thermal characteristic of disc brake rotor and assist the automotive industry in developing optimum and effective disc brake rotor. [5]

A. Input Parameter for Disc Brake Standard:

In this Paper study standard of bicycle name "Bajaj Pulsar 220"

- Rotor disc dimension = 250 mm. (250×10 -3 m)
- Rotor disc material = Gray cast iron
- Pad brake area = 2000 mm2 (2000×10 -6 m)
- Pad brake material = Asbestos
- Coefficient of friction (Wet) = 0.08-0.12
- Coefficient of friction (Dry) = 0.2-0.5
- Maximum temperature = 250 ºC
- Maximum pressure = 1 MPa (106 Pa) [3]

B. Original Model of Bajaj Pulsar 220:

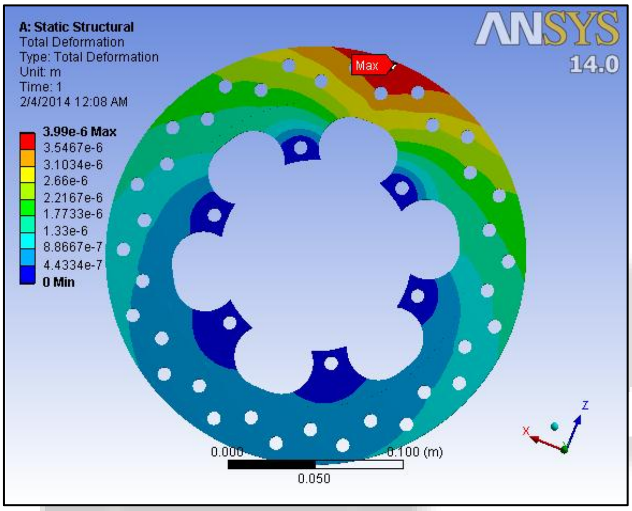

Fig. 1: Total Deformation in Disc Brake Rotor

Fig. 1 shows total deformation occurs in original disc brake rotor due temperature at 250 ºC

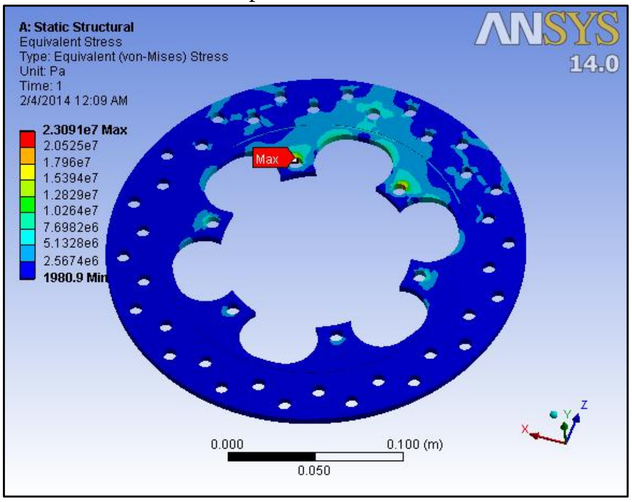

Fig. 2: Von-misses stress in Disc Brake Rotor

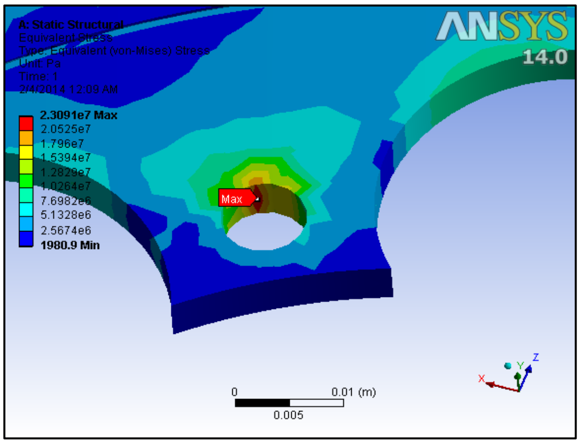

Fig. 3: Enlarged view of Von-misses stress in Disc Brake Rotor near the hole

Fig.2 & Fig. 3 shows Von-misses stress occurs in original disc brake rotor due temperature at 250 ºC.

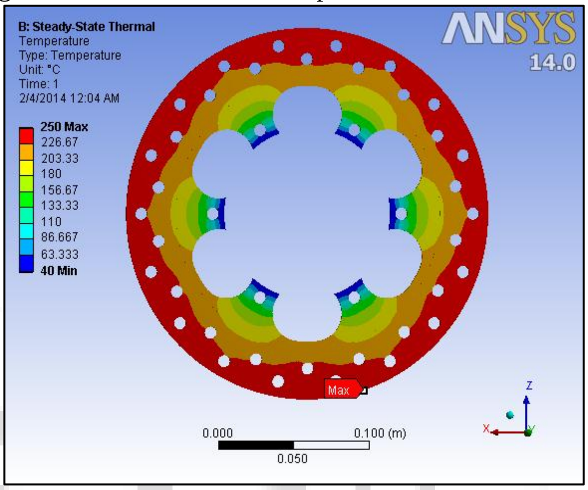

Fig. 4: Steady State Thermal Analysis of Disc Brake Rotor

Fig. 4 shows Steady State Thermal analysis of original disc brake rotor at 250 ºC temperature.

C. Result of Disc Brake Rotor:

SSr. No	Max. Temp.	Max. Deformation	Max.Von-misses stress
1	250 ºC	3.99 X 10^{-6} m	2.30 X 10^{7} Pa

Table 1: Result of Disc Brake Rotor

D. Modified Shape Model-1:

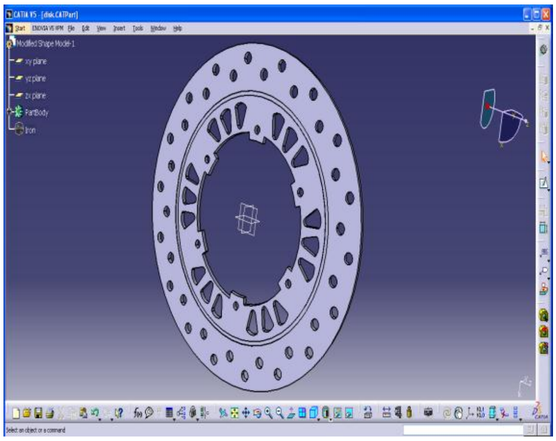

Fig. 5: Modeling of Modified Shape Model-1 of Disc Brake Rotor

Fig. 5 shows Modeling of Modified Shape of Disc Brake Rotor with slots done in CATIA

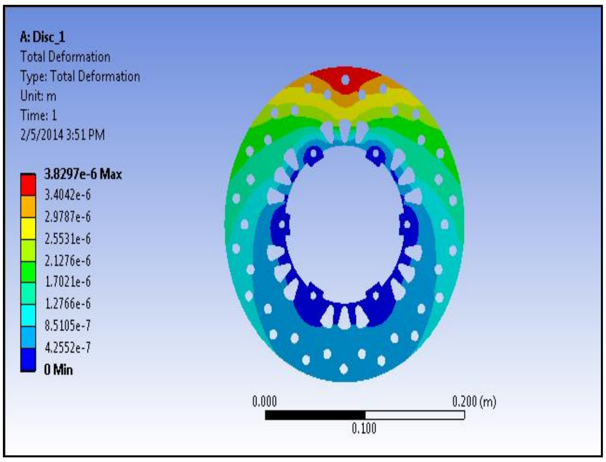

Fig. 6: Total Deformation in Modified Shape Model-1

Fig. 6 shows total deformation occurs in Modified Shape Model-1 of disc brake rotor due temperature at 250 ºC.

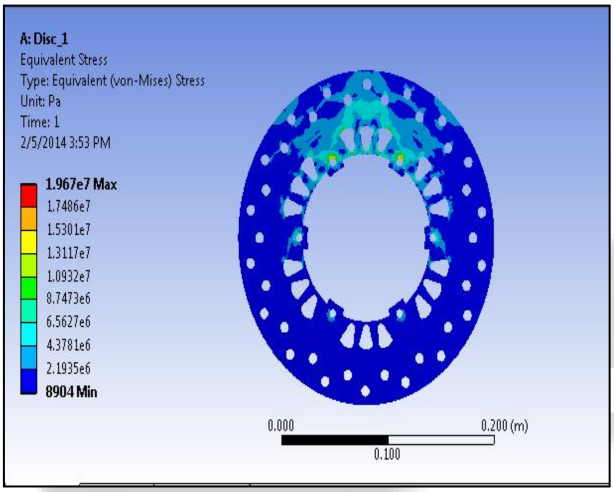

Fig. 7: Von-misses stress in Modified Shape Model-1

Fig. 7 shows Von-misses stress occurs in Modified Shape Model-1 disc brake rotor due temperature at 250 ºC.

E. Modified Shape Model-2:

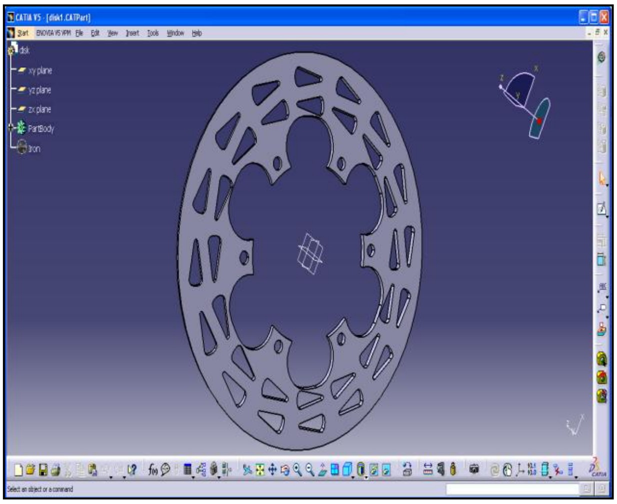

Fig. 8: Modeling of Modified Shape Model-2 of Disc Brake Rotor

Fig. 8 shows Modeling of Modified Shape of Disc Brake Rotor with slots done in CATIA

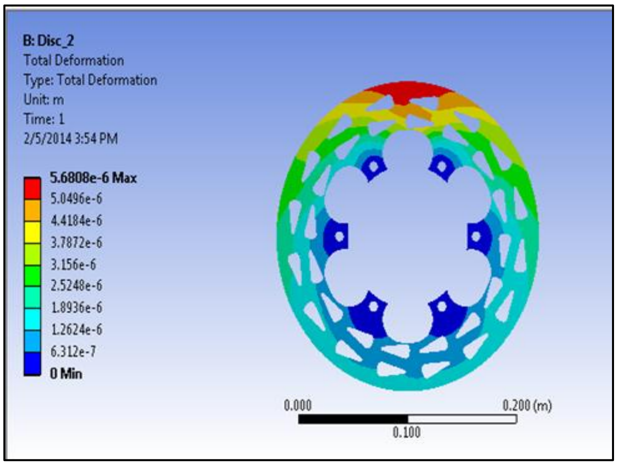

Fig. 9: Total Deformation in Modified Shape Model-1

Fig. 9 shows total deformation occurs in Modified Shape Model-2 of disc brake rotor due temperature at 250 ºC.

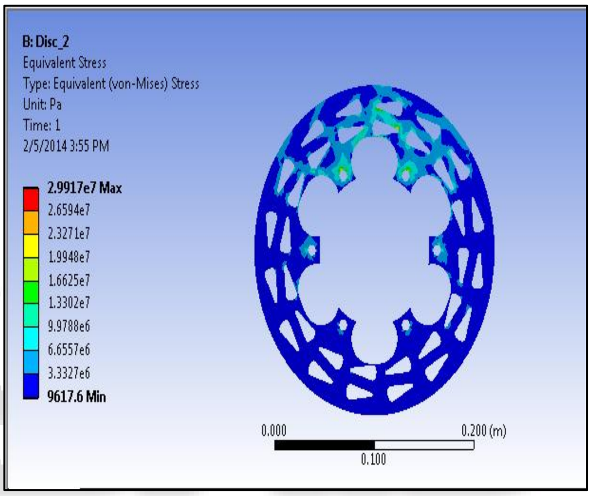

Fig. 10: Von-misses stress in Modified Shape Model-2

Fig. 10 shows Von-misses stress occurs in Modified Shape Model-2 disc brake rotor due temperature at 250 ºC.

IV. Result Table

	Deformation (Meter)	**Von-misses stress (Pascal)**
Original Model	3.99 X 10^{-6}	2.30 X 10^{7}
Modified Shape Model-1	3.8297X10^{-6}	1.967 X 10^{7}
Modified Shape Model-2	5.6808X10^{-6}	2.9917X 10^{7}

Table 2: Result of original Disc Brake Rotor & Modified Shape Models

V. Conclusion

From this two result we have to be concluded that modified shape 1 is best for use as a rotor disc in disc brake.

VI. Future Scope

1) We have 2 more modified shapes for analysis
2) All shape must be analyzed for Thermal analysis.

3) Optimized shape validated on practical model for Thermal analysis

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