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Design Modification & Optimisation Of Disc Brake Rotor

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Abstract- This work is presented with "Design modification & optimization in stress, deformation & weight of Disc brake rotor" which studies about on disc brake rotor by modeling & analysis of different shapes of slots of different vehicle's disc brake rotor with same outer diameter & inner mounting position of holes on wheel hub as like Bajaj Pulsar 150.Analysis done on real model of disc brake rotor of Bajaj pulsar 150 and disc brake Rotor of different shapes of slots of different vehicle's in one Disc brake rotor. Therefore, it gives optimise stress, deformation & weight of the modified disc brake rotor & also good heat dissipation. Hopefully this project will help everyone to understand experimental verification of disc brake rotor and how disc brake works more efficiently, which can help to reduce the accident that may happen in each day

Keywords- Disc brake, optimise, slots, heat dissipation, experimental verification.

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 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. [1]

Literature Survey

A Brake is a device by means of which artificial frictional resistance is applied to moving machine so it is being selected for investigating the effect of strength variations on the predicted stress distributions. Aluminium Metal Matrix Composite materials are selected and analysed. The results are compared with existing disc rotor. The model of Disc brake is developed by using Solid modelling 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, Von Mises 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, aluminium and carbon fibber 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]

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]

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 Von Misses 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 behaviours of disc brake rotor. In this study, finite element analysis approached has been conducted in order to identify the temperature distributions and behaviours of disc brake rotor in steady state and transient responses. ANSYS is 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]

Input Parameter for Disc brake standard of Bajaj Pulser 150

Rotor disc dimension = 240 mm. (240×10^{-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
Permissible temperature = 250 ºC
Maximum pressure = 1 MPa (10^6 Pa)
Tangential Force = 1000 N
Brake Torque = 120 N.m [3]

Original Model of Bajaj Pulser 150

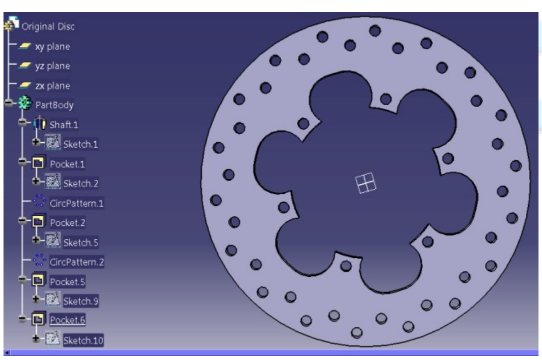


Fig. 1 Modeling of Original disc brake rotor

Fig.1 shows Modeling of Modified disc brake rotor 1 done in CATIA

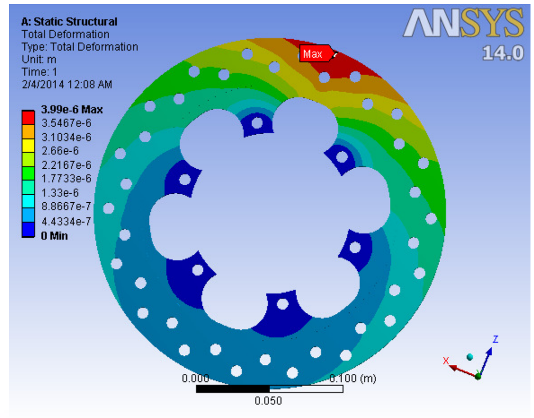


Fig. 2 Total Deformation in Disc Brake Rotor

Fig. 2 shows max. deformation occurs is 0.00399 mm & min. deformation is 0 mm.

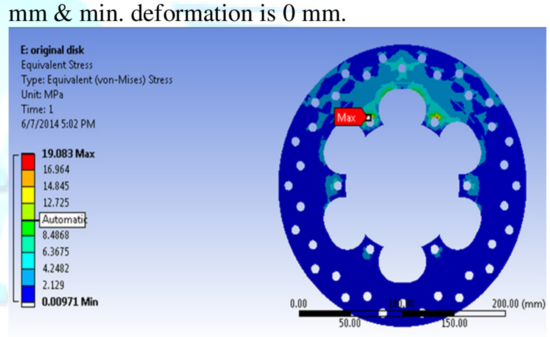


Fig. 3 Von-Misses stress in Disc Brake Rotor

Fig.3 shows Von-misses stress occurs in original disc brake rotor due temperature at 250 ºC &Max. stresses occurs near the hole.

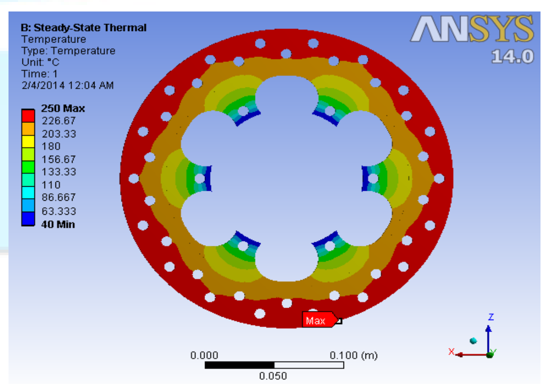


Fig. 4 Steady State Thermal anlysis of Disc Brake Rotor

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

Modified disc brake rotor 1

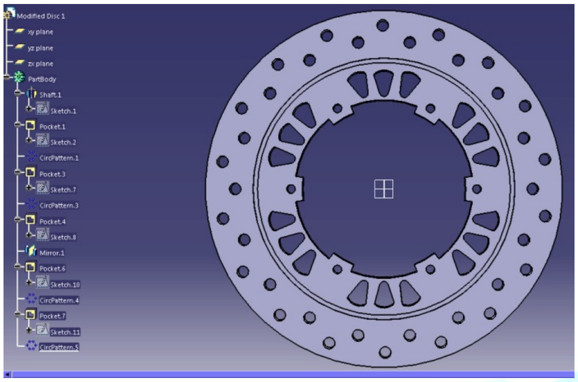


Fig. 5 Modeling of Modified shape 1 disc brake rotor

Fig. 5 shows Modeling of Modified shape 1 disc brake rotor done in CATIA

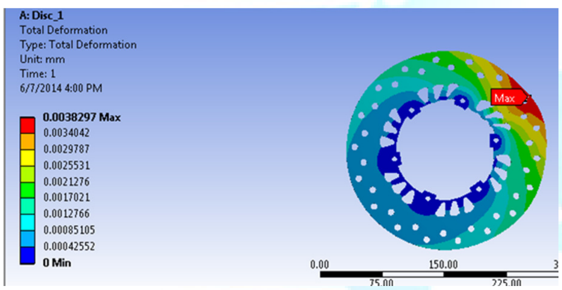


Fig. 6 Total Deformation in Modified shape 1 disc brake rotor

Fig. 6 shows max. deformation occurs is 0.00382 mm & min. deformation is 0 mm.

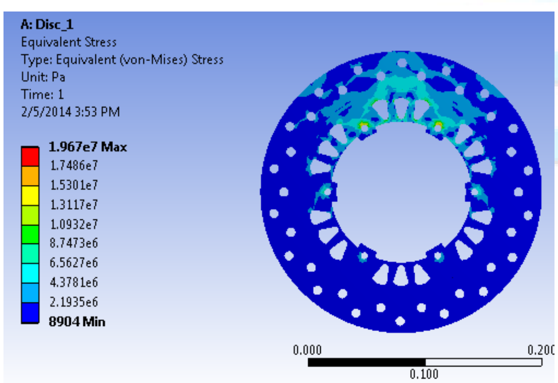


Fig. 7 Von-misses stress in Modified shape 1 disc brake rotor

Fig.7 shows shows max. von-misses stress occurs is 19.67 MPa & min. Deformation is 0.008904 MPa

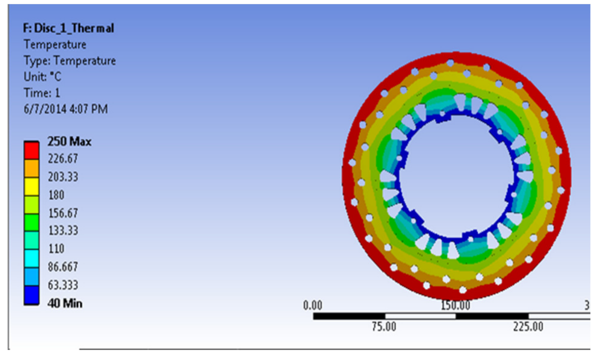


Fig. 8 Steady State Thermal anlysis of Modified shape 1 disc brake rotor

Fig. 8 shows Temperature distribution of Steady State Thermal analysis of Modified Modified shape 1 disc brake rotor in between 40 ºC& 250 ºC.

Modified disc brake rotor 2

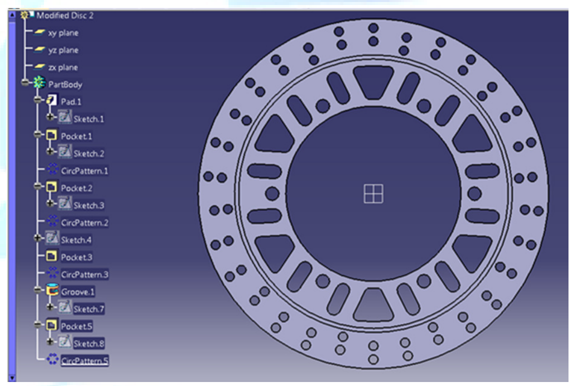


Fig. 9 Modeling of disc brake rotor 2

Fig. 9 shows Modeling of Modified shape 2 disc brake rotor done in CATIA

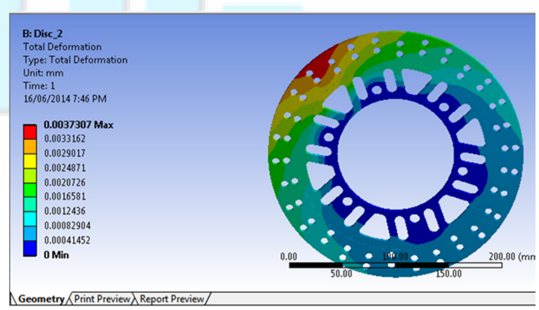


Fig. 10 Total Deformation in Modified shape 2 disc brake rotor

Fig.10 shows max. deformation occurs is 0.0037mm & min. deformation is 0 mm.

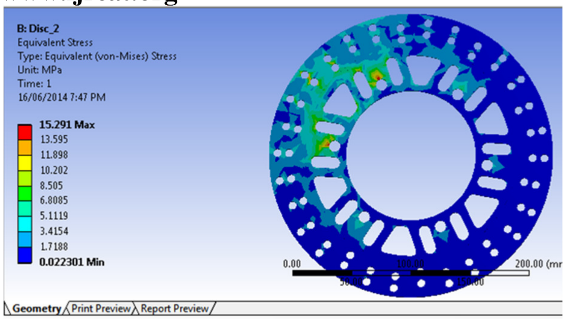


Fig. 11 Von-misses stress in Modified shape 2 disc brake rotor

Fig.11 shows shows max. von-misses stress occurs is 15.291 MPa & min. Deformation is 0.022301 MPa.

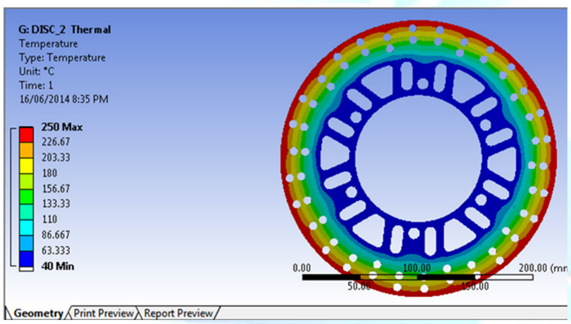


Fig. 12 Steady State Thermal anlysis of Modified shape 2 disc brake rotor

Fig. 12 shows Temperature distribution of Steady State Thermal analysis of Modified disc brake rotor 2 in between 40 ºC& 250 ºC

Modified disc brake rotor 3

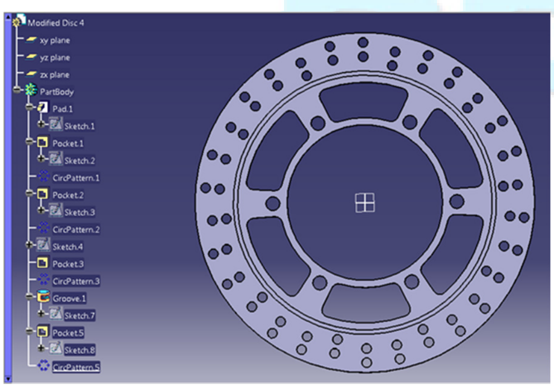


Fig.13 shows Modeling of Modified shape 3 disc brake rotor done in CATIA

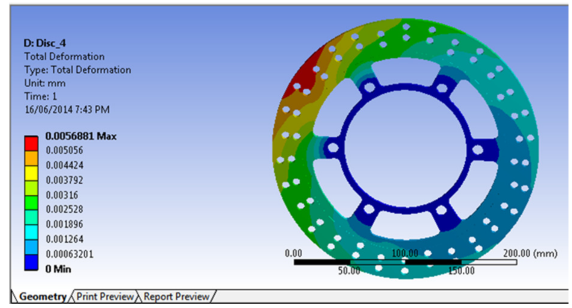


Fig. 11 Total Deformation in Modified shape 3 disc brake rotor

Fig.11 shows max. deformation occurs is 0.0056881 mm & min. deformation is 0 mm.

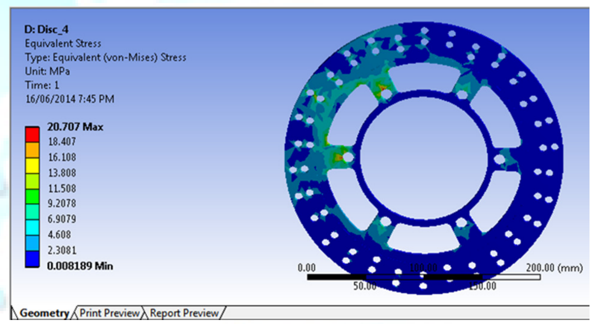


Fig. 14 Von-misses stress in Modified disc brake rotor 3

Fig.14 shows shows max. von-misses stress occurs is 20.707 MPa & min. Deformation is 0.008189 MPa

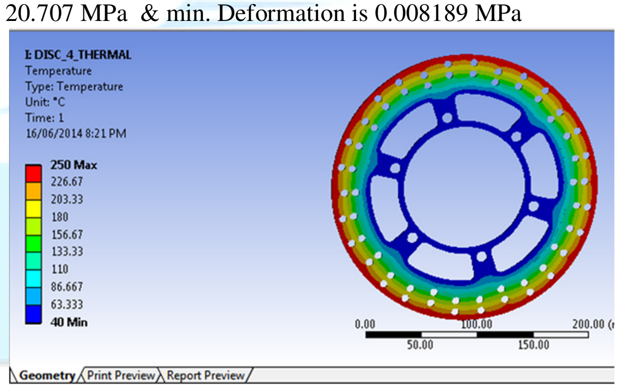


Fig. 15 Steady State Thermal anlysis of Modified shape 3 disc brake rotor

Fig. 15 shows Temperature distribution of Steady State Thermal analysis of Modified disc brake rotor 3 in between 40 ºC& 250 ºC

Software Result Table

Table No.-1 Result of Original disc brake rotor & Modified disc brake rotors.

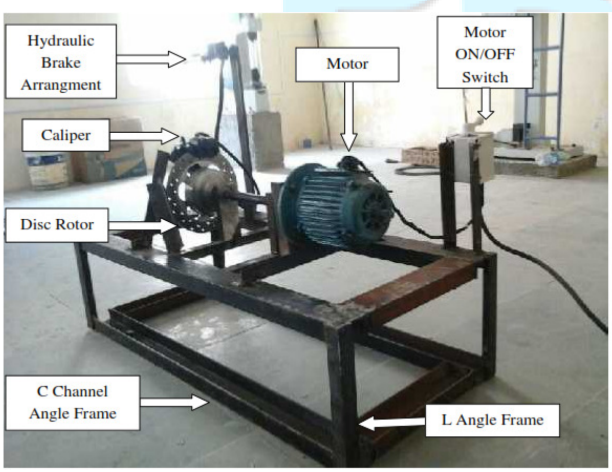
Disc brake rotor	Weight (Kg)	Deformation (mm) Max.	Von-misses stress (MPa) Max.
Original	1.052	$3.695*10^{-3}$	19.08
Modified shape 1	1.15	$3.829*10^{-3}$	19.67
Modified shape 2	1.207	$3.730*10^{-3}$	15.29
Modified shape 3	0.954	$5.342*10^{-3}$	20.70

From the software results von mises stresses are induced in modified disc brake rotor 2 is less than the original disc brake rotor so brake disc design is safe based on the strength and rigidity criteria. Therefore maximum heat dissipation occurs from modified shape 2 disc brake rotor so it is taken for experimental testing.

Experimental Setup

The experimental Setup consists of different parts

- Motor-Three Phase, 2 HP, 1440 Rpm.
- Shaft & Bearings
- Caliper and hydraulic brake arrangement.
- Non Contact Temperature Measurement Sensor
- Base Frame
- Original Disc Brake Rotor
- Optimum Disc Brake Rotor



Working

Disc is rotating at constant rpm due the motor arrangement. Brake is applied periodically to reduce or to stop the disc. While applying the break the friction is takes place between the disc and friction pad. These friction forces resist to the motion of disc, due to the friction between the disc and friction pad heat is generated in the disc and it distribute over the disc..Heat generated in the disc is dissipated by the conduction as well as convection mode of heat transfer. Temperature measuring set up mount the disc on the frame and gives it rotation by the motor with 1440 rpm with constant speed. Experiment test takes on both disc brake rotor i.e original & modified shape 2 disc brake for an hour applying brake periodically & temperature measurement is taken after 1 hour and notice that temperature of both disc brake rotor Region-wise diameter. During experiment maximum temperature of original & modified shape 2 disc brake rotor could not go beyond 153 ºC & 139 ºC respectively, because frictional heat escapes in the air ambient by convection and radiation.

Thus temperature of disc measured by infrared sensor, which is non contact type of sensor, projecting laser beam on region-wise diameter of disc brake rotor of original & modified shape 2 disc brake rotor which are decided by according CAD & steady state temperature distribution.

Experimental Result Table

Table No.-2 Result of original disc brake rotor

Region-wise diameter (mm)		Software Result (Average Temp. in ºC)	Experimental Result (Average Temp. in ºC)
Region	Diameter		
I	240-220	238.33	153
II	220-200	191.67	128.21
III	200-180	145	92.1
IV	180-170	98.33	65.12
V	170-110	51.67	33.16

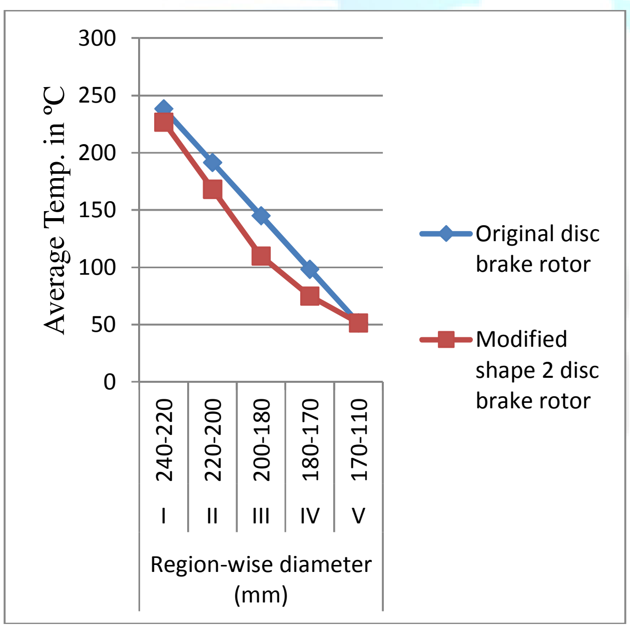
Table No.-3 Result of modified disc brake rotor 2

Region-wise diameter (mm)		Software Result (Average Temp. in ºC)	Experimental Result (Average Temp. in ºC)
Region	Diameter		
I	240-220	226.66	139
II	220-200	168.33	103.29
III	200-180	110	67.49
IV	180-170	75	46.02
V	170-110	51.66	31.7

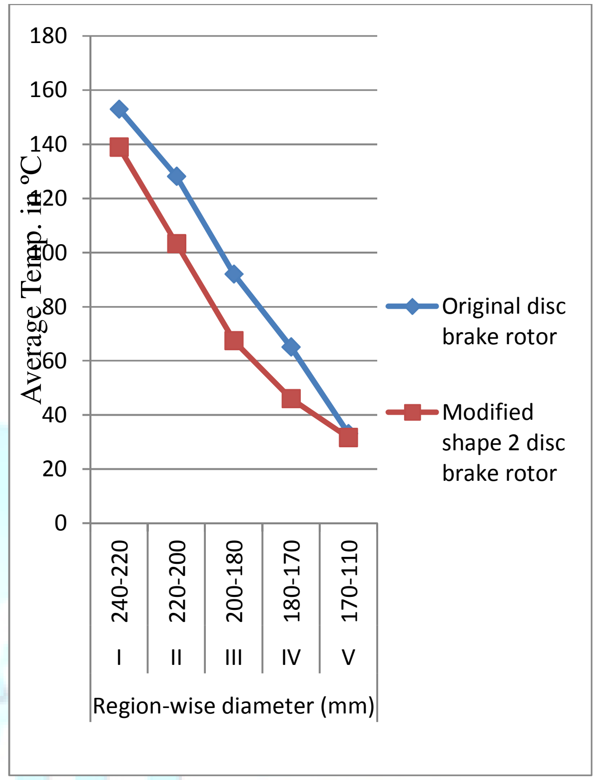
Table No.2 & Table No.-3 shows the variation in temperature distribution by region-wise diameter according to software & experimental results in original & modified shape 2 disc brake rotor.

Comparisons between original & modified disc brake rotor 2

Graph 1: Software result of original & modified shape 2 disc brake rotor



Graph 2: Experimental result of original & modified shape 2 disc brake rotor



Conclusion

From comparing the different results obtained from graph of experimental & software results, it is concluded that deformation & Von Mises stress obtained Modified Shape 2 disc brake rotor is minimum as compare to Original disc brake rotor .

so Modified Shape 2 disc brake rotor is best possible shape modification for the present application.

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