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Designing Disk Brake Rotors: A Practical Approach

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Abstract:* Disc brake rotors play a critical role in the performance and safety of automotive braking systems. This paper presents a design and optimization methodology for disc brake rotors aimed at improving their durability, thermal performance, and weight reduction. The proposed approach combines analytical modelling, numerical simulations, and optimization techniques to achieve an optimal rotor design. The results demonstrate the effectiveness of the proposed methodology in enhancing the performance of disc brake rotors.

Keywords: Disc brake, rotor, optimization, retardation, velocity.

I. INTRODUCTION

Disc brakes are widely used in modern automotive braking systems due to their superior performance characteristics. The disc brake rotor, a key component of the disc brake assembly, plays a crucial role in dissipating heat generated during braking and providing effective braking force. Therefore, optimizing the design of disc brake rotors is essential to ensure optimal performance, durability, and safety.

This paper presents a comprehensive methodology for the design and optimization of disc brake rotors. The proposed methodology integrates analytical modelling, computational simulations, and optimization algorithms to obtain an optimal rotor design. The objectives of this study include improving rotor durability, enhancing thermal performance, and achieving weight reduction while maintaining or improving braking efficiency.

The design of disc brake rotors involves various considerations to ensure efficient braking performance and durability. Important factors to be considered include rotor material selection, geometry optimization, thermal management, and structural integrity. Additionally, rotor weight reduction is desirable to improve overall vehicle fuel efficiency and handling characteristics. Previous research studies have explored different approaches to rotor design and optimization. analytical models, finite element analysis (FEA), and numerical simulations have been employed to evaluate rotor performance under various loading conditions and thermal stresses. Optimization algorithms, such as genetic algorithms and simulated annealing, have been used to identify optimal designs considering multiple objectives and constraints.

II. LITERATURE REVIEW

Using the ANSYS computational code, Ali Belhocine et al. [1] studied the thermal behaviour of full and vented brake discs in automobiles. In order to predict the temperature distribution in the disc brake and determine the variables and characteristics influencing braking operations, such as braking type, disc geometry, and material properties, they used numerical simulations. A progressively thermal-structural coupled technique in ANSYS was utilised in the simulation to assess stress fields and disc deformations brought on by the force acting on the brake pads. The generated simulation results showed a satisfactory level of agreement when compared to those in the specialised literature.

In 1993, Lee & Barber [2,3] looked at the thermoelastic processes that take place in disc brakes. In order to study the thermoelastic response of the brake disc under repeated braking conditions, they solved heat conduction and elastic equations with contact issues and carried out numerical simulations. The thermoelastic instability (TIE), which develops from localised hot spots and can spread over time as a result of factors like rotor runout, road vibration, rotor size, and thickness, was also revealed by their computational results. These findings relate to heat flux distribution, temperature distribution on friction surfaces, and the occurrence of TIE. In order to assist the conceptual design of the disc braking system, the study also looked at how material qualities affected thermoelastic behaviour, specifically the maximum temperature on friction surfaces.

Through the use of computational calculations, Hartsock & Fash (1999) [4] investigated the thermoelastic phenomena of disc brake rotors and pads during braking. The study concentrated on torque fluctuations during initial rotor runout that can happen as a result of variations in rotor thickness or coefficient of friction.

Investigations were conducted on the formation of localised hot spots that are frequently asymmetric and the pulsing of brakes with sinusoidal components. The occurrence of thermoelastic instability below critical speed and its relationship to the rotor's thickness, coefficient of friction, and material parameters were also examined.

The analysis of load variations on disc rotors and the optimisation of rotor thickness were done by Dow & Burton in 1973 [5]. In their research, vehicle disc brake systems were experimentally examined with the goal of identifying the critical speed needed to cause thermoelastic instability.

L. Segal (1999) [6] emphasised the important role that temperature plays in braking performance. The brake rotor disc, brake shoe friction lining, and support system all experience significant heat generation while braking. The study's conclusions suggested that extended braking should be avoided during testing since it can cause brake elements to heat up to 80°C, which has an adverse effect on the qualities of the braking system and brake material.

Investigating the deformation of disc brakes during vehicle braking was Gracia-Pozuelo Ramos (2010) [7]. The lifespan of disc brake rotors is decreased by wear and tear caused by brake disc distortion. Using a roller brake tester to detect deformation, the researchers discovered that a brake disc runout of 125 microns caused a 50% distortion during testing.

The studies listed above shed vital light on a number of elements of the design and performance of disc brake rotors, including thermal behaviour, thermoelastic instability, load fluctuations, material characteristics, and deformation. These results advance our knowledge of disc brake rotor design and its optimisation for enhanced braking effectiveness, durability, and overall performance.

III. METHODOLOGY

A. Theory/Calculations

We should consider the maximum possible case for braking to withstand our brake in maximum speed and maximum loading capacity of the vehicle.

As taking reference from the user guide manual of Hero Xtreme 200S,

1) Maximum speed of vehicle:120 km/h or 33.33 m/s
2) Mass of vehicle: 149 kg.
3) Mass of passengers: 130 kg

If we consider the average weight of an Indian, it's 65 kg. So, the load capacity of the vehicle is 130 kg.

The other point to be considered is stopping distance when brake is applied. So, in our case its around 100m.

By using Newton's law,

We get retardation as;

$u = 120$ Km/h $= 33.33$ m/s

$v = 0$

$s = 100$

$v^2 - u^2 = 2as$

$0^2 - (33.33)^2 = 2a(100)$

$a = -1110.8889/ 200$

$a = -5.5544$

Maximum Speed of Vehicle	120 km/hr
Mass of Vehicle	149 kg
Total Mass	279 kg
Stopping distance	100 m
Retardation	5.5544

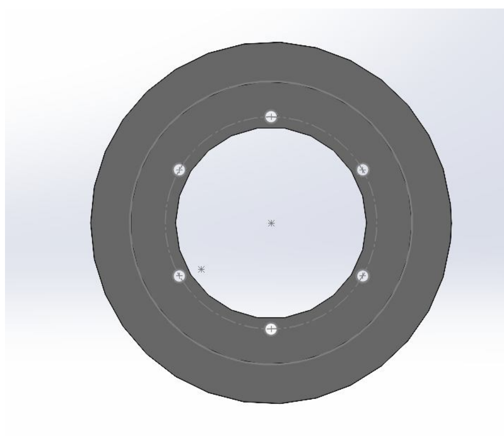
To calculate the braking force,
By using Newton's law'
F = (279)*(5.5544)
= 1549.6776 =1550 (approx.)
By using below formula we can calculate area to which force is to be applied,
Outer radius = 138 mm
Inner Radius = 73mm

$$A = \frac{1}{2}\theta(R_o^2 - R_i^2)$$

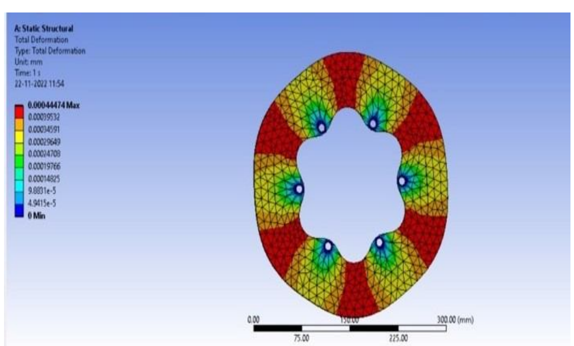
By using braking force we can calculate pressure on the rotor,
P = F/A
P = 0.20 MPa.
For above calculated pressure,
We have applied that pressure to various models and analyse deformations and pressure.
Given inputs in the program:
Fixed support in the 6 holes.
0.20 MPa pressure on both sides of the disk.
Rotational velocity of 120 rad/s.

B. Design

1) Model 1

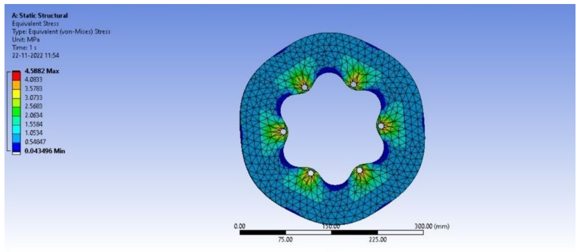


Deformation:



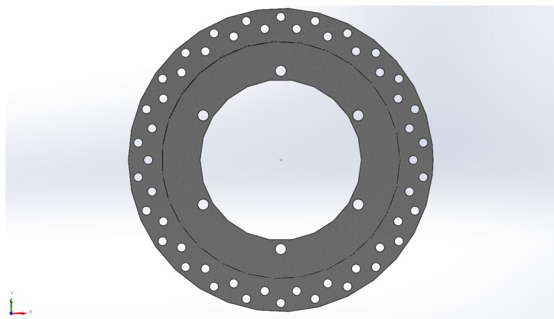
As you can see in the pictures the model performed up to the expectations. The deformation is more in this case. So, we decided to make some changes in the model.

Stress Analysis:

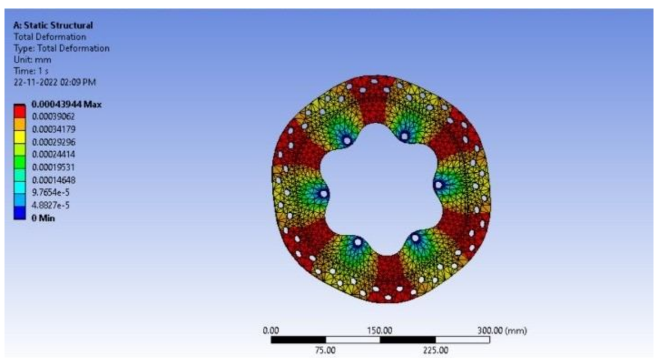


The disk performs up to the expectations in this stress analysis.

2) Model 2:

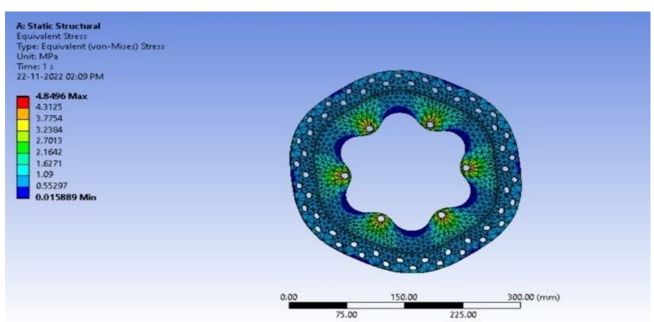


Deformation:



As you can see in the above model the total deformation is less as compared to the previous model.

Stress Analysis:



The model performed well in the stress analysis and marked up to the expectations.

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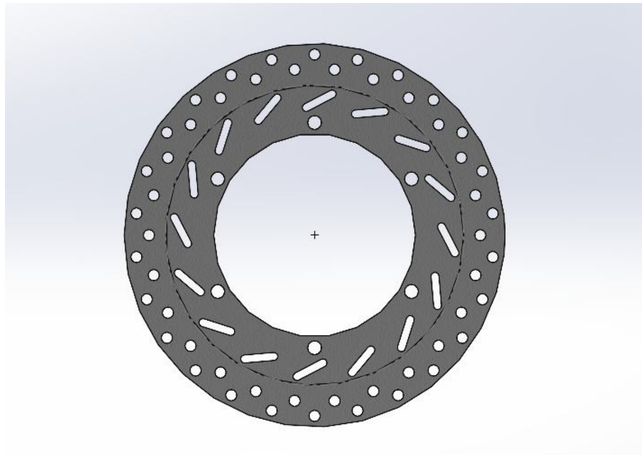
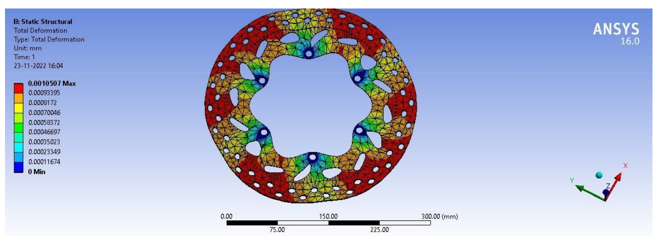
3) Model 3

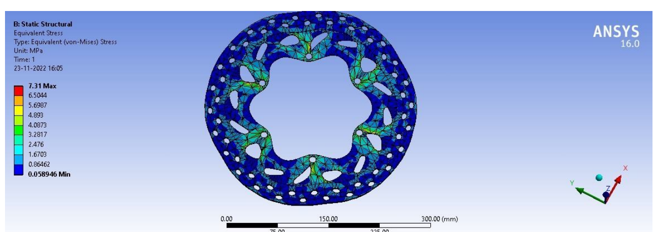


Deformation:



In this case, the deformation is low as compared to other models among the three models.

Stress analysis:



In this case, the stress acting is minimum among all the models.
Design and parameters:

Radius of the disc	138mm
Material	Grey cast iron
Thickness	3.5mm
No. of bolts	6

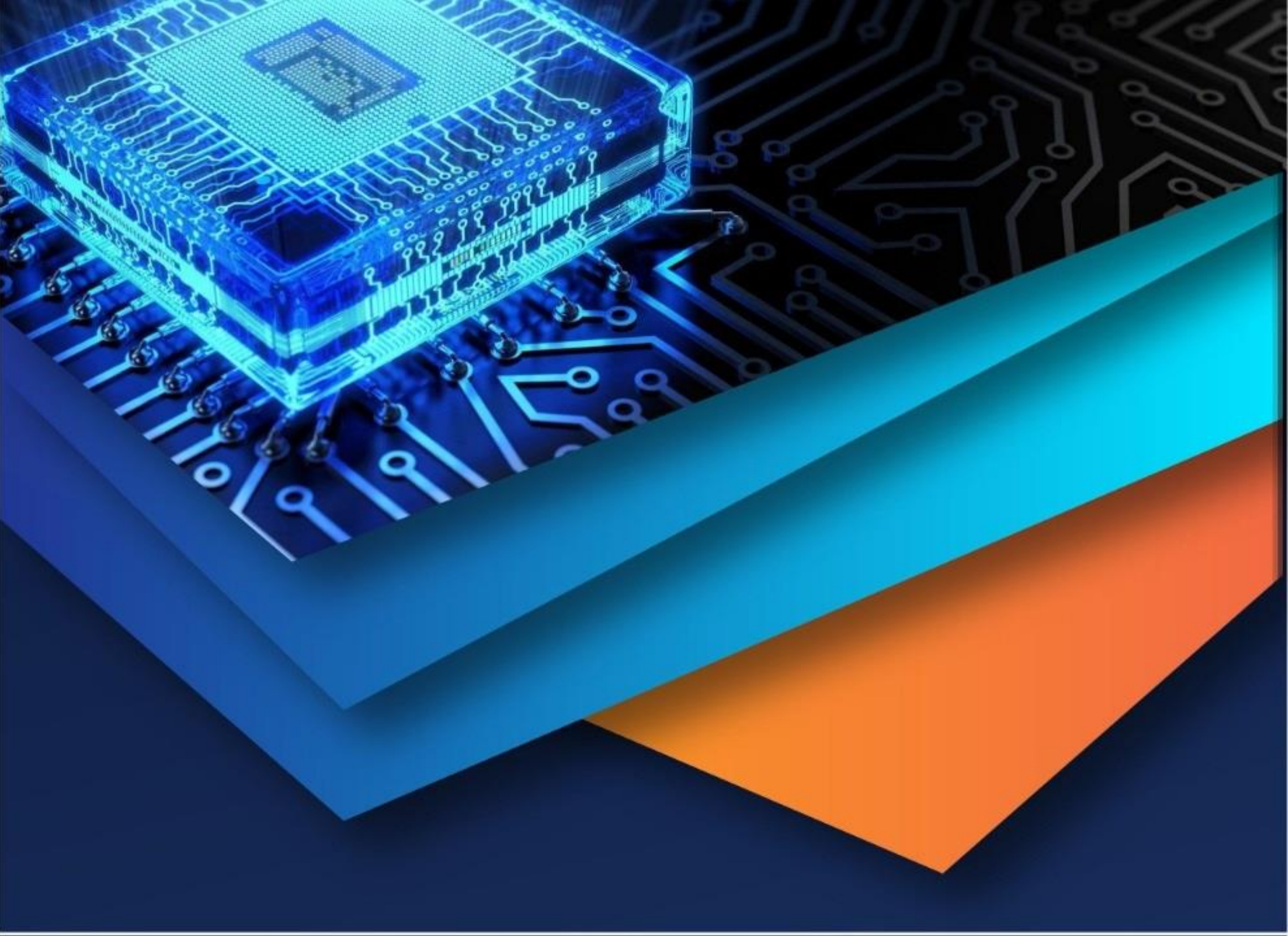
IV. CONCLUSION

The design of disc brake rotors plays a critical role in the overall performance and safety of the braking system. Through a systematic methodology involving literature review, data analysis, conceptualization, computer-aided design, finite element analysis, optimization, manufacturing considerations, an optimized disc brake rotor design can be achieved. Factors such as thermal behaviour, stress distribution, material properties, and geometrical design are crucial considerations in the design process.

The reviewed literature provided valuable insights into the load variations, material effects, and deformation of disc brake rotors. These findings contribute to the understanding and optimization of disc brake rotor design, leading to improved braking efficiency, durability, and overall performance. Further experimental validation, model analysis, and transient thermal analysis can be pursued to enhance the design and performance of disc brake rotors in future research. Overall, the design and optimization of disc brake rotors are essential for ensuring reliable and effective braking in various automotive applications.

REFERENCES

[1] "Thermomechanical modeling of dry contacts in automotive disc brake" at International Journal of Thermal science 60 (2012) 161 el 70, 2012 Published by Elsevier Masson SAS by Ali Belhocine Mostefa Bouchetara.
[2] Frictionally excited thermoelastic instability in automotive disc brakes‖, Journal of Tribology, Transaction of ASME,vol.115,October, pp.607- 614 by Lee. K. & Barber J.R. (1993).
[3] "Effect of intermittent contact on the thermoelastc instability of automotive disc brake system" ,AMD, Vol 198, Thermoelastc problem & the Thermodynamics of Continum, ASME by Lee. K. & Barber J.R.(1995).
[4] Effect of pad / caliper stiffness, rotor thickness on thermo-elastic instability in disc brakes‖, Journal of Tribology, Vol. 129, No 1, 513–517 by Hartsock, D.L. &Fash, J.W. (1999).
[5] Thermoelastic instability of sliding contact in the absence of wear‖, Journal of Wear, Vol.19, pp.315-328 by Dow, T.A.& Buttoner. (1972).
[6] Diagnostic method for vehicle brakes‖, Journal of NDT&E, International 32, Isreal Institute of Technology, pp.369-373 by L. Segal(1999),.
[7] New procedure to estimate the brake warping in roller test‖, International Journal of Automotive Technology,, Vol No.1,pp. 691-69, Madrid, Spain by Garcia-Pozuclo Ramos, D. (2010).
[8] "Design of Machine Elements" by V B Bhandari, V B Bhandari retired as Professor and Head, Department of Mechanical Engineering at Vishwakarma Institute of Technology, Pune.



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