International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Innovative Approaches to Two-Wheeler Disc Brake Rotor Design and Performance Analysis

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ABSTRACT

Frictionally excited thermo elastic instability (TEI) represents a complex challenge inherent to sliding contact systems, most notably observed in disc brake rotors for two-wheeled vehicles. This intricate phenomenon arises due to the confluence of frictional heating, thermal deformation, and elastic contact during high-speed braking. The consequential development of localized high-temperature regions, known as "hot spots," underscores TEI's significance. Hot spots present critical concerns as they can induce material damage, thermal cracks, and undesirable frictional vibrations, thus compromising rider safety and braking performance. This thesis is dedicated to the paramount objective of addressing TEI in disc brake rotors through design optimization. The optimization strategy is multifaceted, aiming to minimize three pivotal aspects: weight, stress, deformation, and effectively manage thermal effects, all while ensuring the rotor's steadfastness under requisite loads. Specific objectives encompass: Weight Minimization: This facet involves the exploration of geometric optimizations and advanced materials to reduce the rotor's weight without compromising structural integrity. The design has prepared on Creo software and import the final design into Ansys software for analysis point of view.

Stress and Deformation Minimization: Leveraging finite element analysis (FEA), this research delves into detailed scrutiny of stress and deformation patterns in the rotor across a spectrum of operational conditions. Subsequently, design modifications will be enacted to alleviate stress concentration and deformation, thereby elevating rotor longevity. Thermal Management: Recognizing the critical role of thermal effects, this research will delve into innovative strategies for heat dissipation. This will include the exploration of heat sinks, advanced surface coatings, and material selections that effectively manage frictional heating and thermal deformation. The methodology underpinning this study employs advanced engineering tools and techniques, prominently featuring FEA for precise modeling and simulation, alongside structural optimization methodologies. This research contributes to the understanding and practical application of strategies for managing thermal effects in braking systems, thus enhancing the safety and performance of two-wheeled vehicles.

Keywords – Creo, FEM, Material, Disc Rotor and Ansys

1. Introduction

Disc brakes are a type of braking system that uses a disc rotor to slow down or stop a vehicle. The disc rotor is attached to the wheel, and when the brake pads are applied, they rub against the rotor to create friction. This friction converts the kinetic energy of the vehicle into heat, which slows the vehicle down. Disc brakes are more efficient than traditional drum brakes, and they also provide better stopping power. This is why they are becoming increasingly popular on two-wheelers

2. Problem Statement

Thermal instability is a phenomenon that can occur in sliding contact systems, such as brakes and clutches. It is caused by the coupling of frictional heating, thermal deformation, and elastic contact. When the sliding speed is too high, these coupled thermal and mechanical behaviors can become unstable, leading to the formation of localized high-temperature regions called "hot spots" on the sliding interface. Hot spots can cause material damage and thermal crack, and they can also induce undesirable frictional vibrations

3. Objective

The following objective of the thesis to be achieved

1. Minimize the weight of the disc. This can be done by optimizing the geometry of the disc, as well as the material properties.
2. Minimize the stress and deformation in the disc. This is important because stress and deformation can lead to premature failure of the disc.

3. Ensure that the disc can withstand the required load and deformation. This is the most important design objective, as the disc must be able to function as intended.

The optimization process can be computationally intensive, but it can be very effective in finding designs that meet the required criteria. By using structural optimization technology, engineers can design lightweight, strong, and stiff discs that meet the specific design requirements.

4. Design Modeling

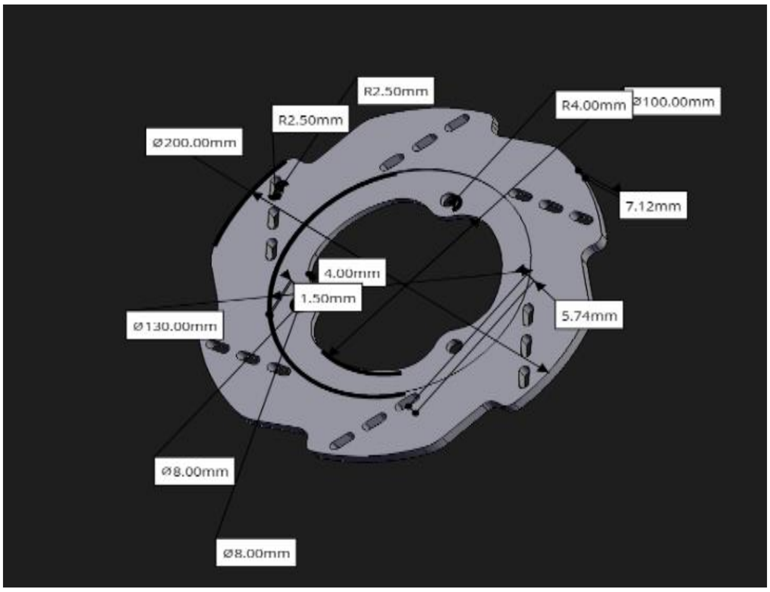

Fig.1 Original Disc rotor

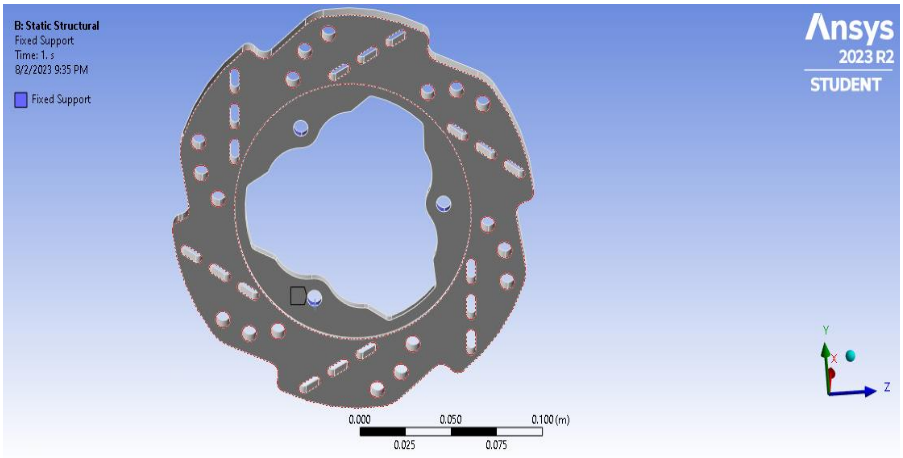

Fig.2 New Design Modification in Original Disc rotor

The image you sent me shows a 3D model of a brake disc. The disc is made of metal and has holes in it. The holes are arranged in a way that makes it look like it is floating in the air. The disc is sitting on top of a white surface. The holes in the brake disc are there to improve the cooling performance of the disc. When the brakes are applied, the disc heats up due to friction. The holes allow the hot air to escape from the disc, which helps to prevent the

The holes in the brake disc also help to reduce the weight of the disc. This is important because lighter discs are easier to stop, which can improve the braking performance of the vehicle. The brake disc in the image is made of structural steel. Structural steel is a type of steel that is designed to be strong and durable. It is often used in the construction of buildings and bridges. The yield stress of structural steel is around 240 Mpa, which means that it can withstand a load of 240 MPa before it begins to deform plastically.

5. Analysis of Disc Brake

TABLE 1 Model Geometry

Bounding Box	
Length X	7.e-003 m
Length Y	0.2 m
Length Z	0.19983 m
Properties	
Volume	1.3274e-004 m³
Mass	1.042 kg
Scale Factor Value	1.
Statistics	
Nodes	6189
Elements	2852
Mesh Metric	None
Update Options	
Assign Default Material	Structural steel

6. Result

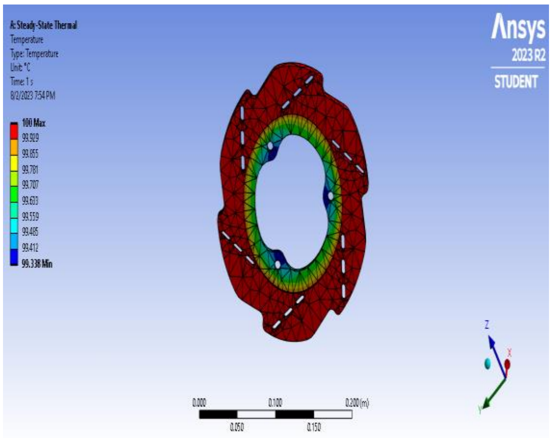

Fig.1 Temperature in original disc

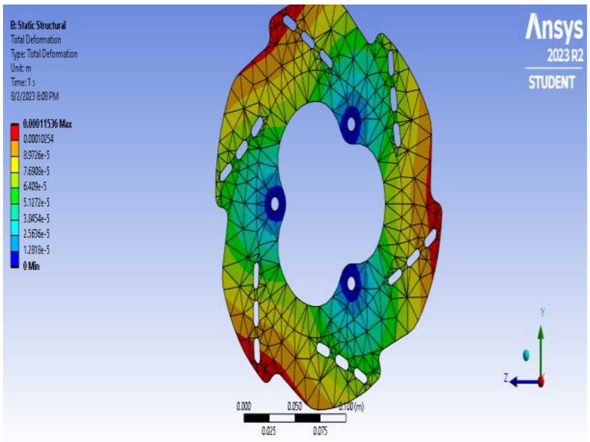

Fig.2 Deformation in original disc

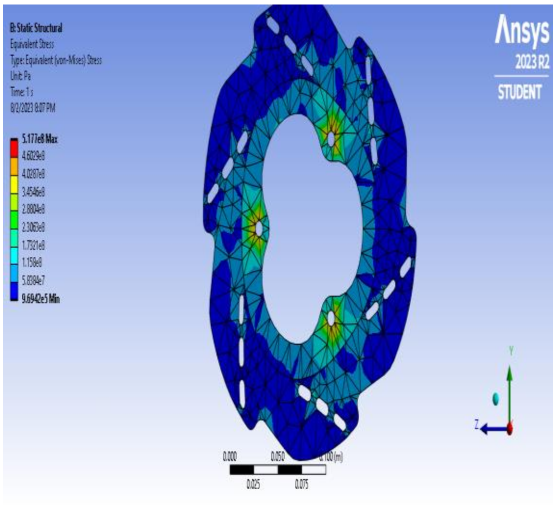

Fig.3 Stress in original disc

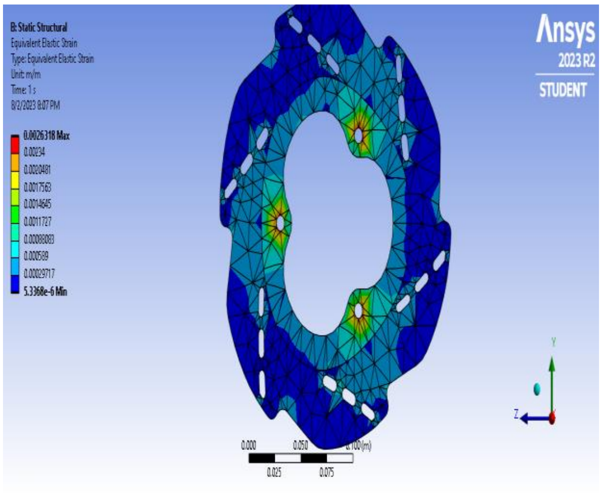

Fig.4 Strain in original disc

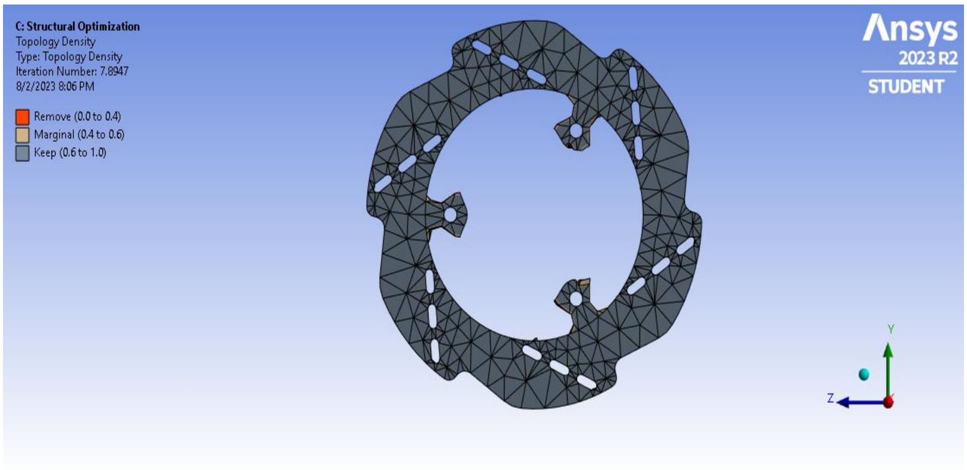

Fig.5 Structural Optimization of original disc

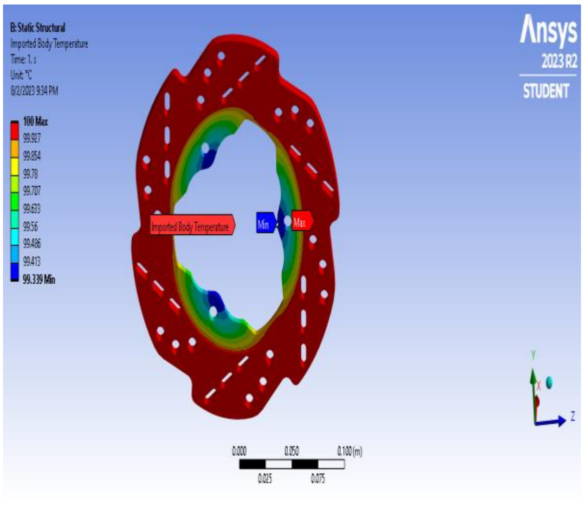

Fig.6 Temperature in New disc

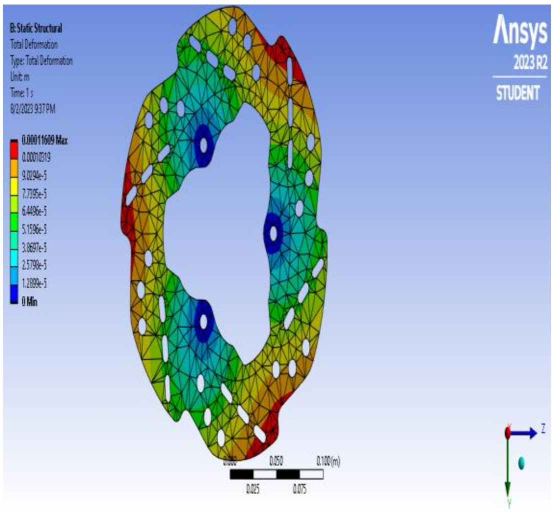

Fig.7 Deformation in New disc

7. Conclusion

Table 2 Deformation of discs

Deformation	NEW	ORIGNAL
Minimum	0. mm	0. mm
Maximum	1.1609e-004 mm	1.1536e-004 mm
Average	6.6611e-005 mm	6.7121e-005 mm

Table 3 Strain of disc’s

Strain	NEW	ORIGNAL
Minimum	1.72E-05	5.34E-06
Maximum	2.51E-03	2.63E-03
Average	3.48E-04	3.96E-04

Table 4 Stress of disc’s

Stress	NEW Disc	ORIGNAL Disc
Minimum	9.6942e+005 Pa	9.6942e+005 Pa
Maximum	4.5852e+008 Pa	5.177e+008 Pa
Average	6.0896e+007 Pa	6.9187e+007 Pa

The deformation of new disc higher than the original disc as we can observed into the table 41 but the value of stress and strain lower than the original disc as well during the structural optimization technique material excessive material remove from the disc with not take part into the stress distribution during the loading condition so over all weight of the new disc is lower than the original disc without any load carrying capacity distortion

As we also observed that the deformation of both disc not much more difference and new disc also having same working ability so on the basis of the design modification can be concluded that new design disc would be take place from original disc after the application testing in the lab.

Following Benefited are achieved

I. Reduce the weight of original disc

II. Stress Concentration not occurring at the end of the corner

III. Over all frication level minimize so brake pad life increase

IV. Contact area decrease with the help of hole provided into circumference on disc profile so heat generation will be less than the original disc

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