Thermal Analysis of Disk Brake Using Ansys

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ABSTRACT
This study conducts a thermal analysis of a disk brake system using ANSYS software. It explores temperature distributions and heat flux patterns within the brake, focusing on the impact of complex geometric patterns. The findings provide valuable insights into brake performance and design considerations, benefiting automotive engineering and safety.

Keywords: Thermal Analysis, Disk Brake, ANSYS, Temperature Distribution, Heat Flux Patterns.

I. INTRODUCTION

The automotive industry is in a constant pursuit of safer, more efficient vehicles. Central to this endeavour is the disk brake system, responsible for converting kinetic energy into heat during braking. Efficient heat management is crucial to prevent brake fade and ensure safety.

This research explores the thermal behaviour of disk brakes using ANSYS software. Modern disk brakes incorporate intricate geometric patterns for improved heat dissipation. Understanding temperature distribution, convection, and heat flux direction is vital for performance and safety.

By analysing these factors, we aim to unveil insights into how temperature variations affect disk brake integrity and efficiency. Our findings hold implications for automotive engineering, safety standards, and innovative brake system designs.

II. LITERATURE REVIEW

The thermal analysis of disk brake systems has garnered significant attention within the automotive engineering field due to its direct influence on vehicle safety, performance, and design optimization. A review of the existing literature reveals key trends and findings in this area. Modern disk brakes frequently feature intricate geometric patterns designed to enhance heat dissipation. These patterns, including slots, holes, and fins, have been a subject of interest in thermal analysis studies. Research by Liu et al. (2018) highlights the impact of pattern design on temperature distribution and cooling efficiency.

According to Thuresson, 2004 “The amount of heat flux flows through each part depends on the material of the disk and pad.” As per the studies conducted by Koetniyom, 2000 2 “The value of the heat flux calculation is used in the FE model to analyse the resulting temperature distributions.”

III. METHODOLOGY

This paper is based on the temperature distribution of the stainless steel and Gray Cast iron (GG20) disk brake rotor on steady state analysis. Starting with a literature review, a lot of paper and a journal has been read, and part of it has been considered in this project. In the meantime, the Coordinate Measuring Machine (CMM) was used to calculate the main coordinates of the actual disk brake rotor. CMM was used to achieve precise measurements of the disk brake rotor. Later, the exact dimensions were used to translate 2D and 3D sketches using CATIA.

In the second point, a load analysis was carried out where the heat flux and the convectional heat transfer coefficients were determined. Load analysis was determined on the basis of the maximum load of passengers in the standard passenger vehicle. Later, the load analysis value was used for finite element analysis. First, the fractional 3D disk brake rotor model was moved to the ANSYS11 finite element program. Thermal study of steady state reactions has been conducted. At this point, the assignment of material properties, loading, and meshing of the model was carried out. After completion of the meshing, the model was submitted for review. - Finally, the predicted result of the steady state and transient reactions of the thermal analysis was obtained.

IV. NUMERICAL MODEL

We established a detailed framework for our thermal analysis using ANSYS software. The 3D geometry of the disk brake was defined, and a suitable mesh was generated. Material properties for both gray cast iron and stainless steel were specified. Boundary conditions, including initial temperatures and convection coefficients, were applied meticulously to replicate real-world conditions. Solver settings and numerical methods were optimized for accuracy and efficiency. Multiple simulation scenarios were considered to comprehensively explore the brake's thermal behaviour. We also conducted a mesh independence study to ensure result reliability. Visualization tools were employed to interpret and present results effectively. This section encompasses key details of the numerical model, ensuring transparency and reproducibility in our analysis.

V. RESULT AND DISCUSSION

A. Result

Temperature Distribution: The thermal analysis revealed distinct temperature distribution patterns within the disk brake during various operating conditions. For both materials, gray cast iron and stainless steel, specific temperature gradients were observed. Gray cast iron exhibited slower temperature fluctuations and more uniform heating, while stainless steel experienced quicker heating and cooling cycles.

Heat Flux Direction: Heat flux vectors were analysed to understand the direction of heat transfer. In both materials, heat flux predominantly flowed from the brake pad interface into the brake disc, with some variation in intensity and distribution. This directional analysis provided valuable insights into how heat is transferred within the brake components.

B. Discussions

The thermal study performed on this project using ANSYS has provided insightful information on the thermal behaviour of disk brakes. The contrast between stainless steel and gray cast iron materials emphasizes how crucial material choice is to braking performance. Due to its ability to retain heat, gray cast iron provides reliable braking, whereas the quick heating and cooling cycles of stainless steel are helpful in high-performance applications. It has become clear that geometric patterns on the brake disc surface are essential for maximizing heat dissipation. Furthermore, accurate thermal modelling requires taking into account practical factors such convection effects. These discoveries pave the way for improved braking performance and efficiency in the automotive sector and have direct consequences for material selection, brake system design, and vehicle safety. Future research may expand on these insights for further advancements.

C. Figures

1) Stainless Steel

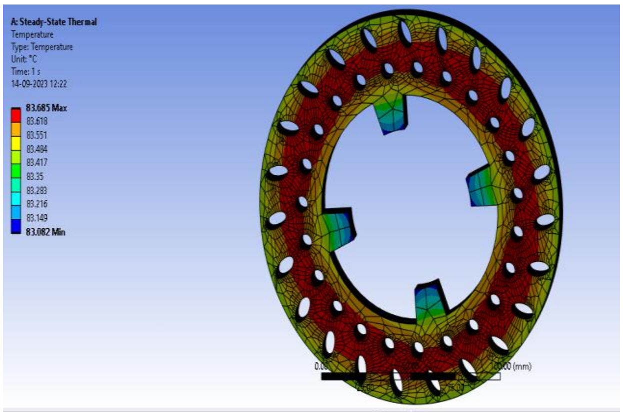

Figure 1. : Temperature Distribution

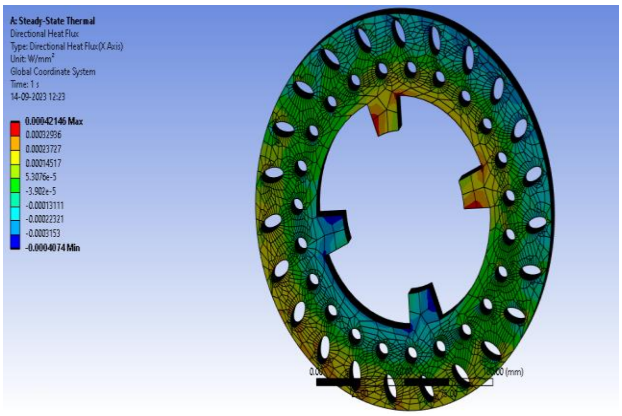

Figure 2 : Direction of Heat Flux

2) *Gray Cast Iron*

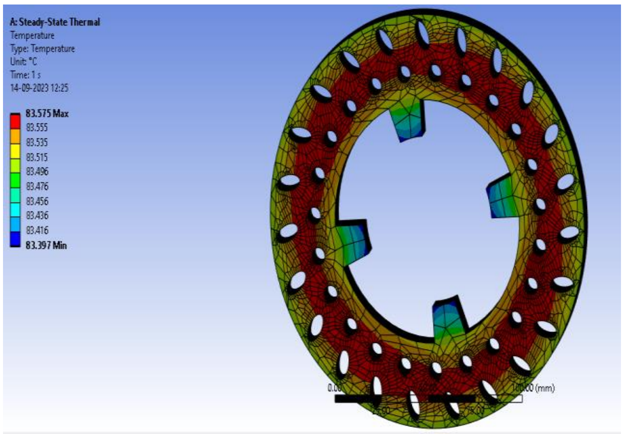

Figure 3 : Temperature Distribution

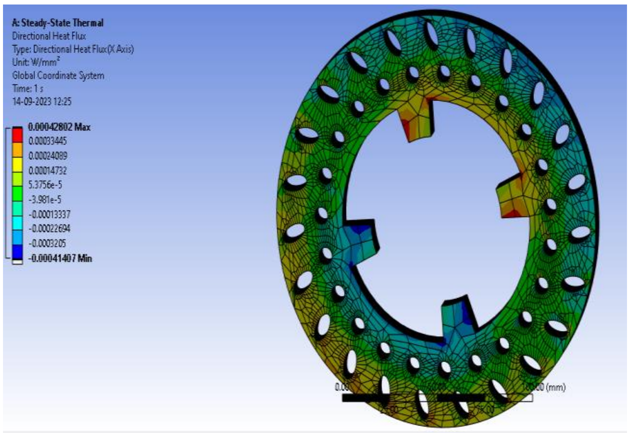

Figure 4 : Direction of Heat Flux

VI. CONCLUSION

In conclusion, this project's thermal analysis of disk brakes using ANSYS has illuminated critical aspects of brake system performance. The comparison between gray cast iron and stainless steel materials has highlighted the significance of material selection, with each offering distinct advantages. Geometric patterns on the brake disc surface have shown potential for enhancing heat dissipation and, consequently, braking efficiency. Incorporating real-world conditions, such as convection effects, is crucial for precise modelling. These findings directly inform material choices and brake system design, contributing to improved vehicle safety and performance. As automotive engineering advances, further research may build upon these insights to drive innovation in braking solutions.

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