International Journal of Engineering Inventions
e-ISSN: 2278-7461, p-ISSN: 2319-6491
Volume 12, Issue 6 [June. 2023] PP: 06-10

Application of Solid works Software to Simulate Heat Transfer in Disc Brake Mechanism

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ABSTRACT: *The braking performance of a vehicle could be significantly influenced by the temperature rise in the brake components. In order to investigate the heat transfer process, a disc brake mechanism was constructed using Solidworks software. The finite element method was employed as the basis for calculation. The results indicate that the highest temperature zone occurs at the brake pad and disc contact area. The research findings provide a foundation for the design and optimization of the brake mechanism to minimize heat generation in the brake system.*
KEYWORDS: *Disc Brake, Heat transfer, Simulation*

Date of Submission: 20-05-2023 Date of acceptance: 03-06-2023

I. INTRODUCTION

Heat generated during braking can have several effects on the disc brake mechanism. The primary effect is that it causes thermal expansion, which can result in warping or distortion of the brake rotor. This warping can cause brake pulsation or vibration, which can lead to decreased braking performance and increased stopping distances. Additionally, prolonged exposure to high temperatures can cause brake pads to glaze over or harden, reducing their ability to grip the rotor and slowing the vehicle down. This phenomenon is known as brake fade and can be particularly dangerous when driving downhill or on long descents. Therefore, the study of heat transfer in brake mechanisms is always of great interest to scientists and designers.

Thermomechanical modeling plays a crucial role in optimizing disc brake designs, enhancing performance, and ensuring the durability and safety of the brake system. Ali Belhocine et al. have been discussed the thermal effects in disc brakes, such as heat generation, temperature distribution, thermal expansion, and material deformation [1]. The authors utilized finite element analysis (FEA) and computational fluid dynamics (CFD) techniques to simulate temperature distribution, stress levels, and fluid flow within the brake system. Welteji Bena et al. have been identified the critical areas prone to thermal stress-induced failures, such as thermal cracking and deformation. The authors employed finite element analysis (FEA) to model and simulate the thermal and stress distribution within the disc brake system. They consider factors such as material properties, geometry, and operating conditions. The results of the article showed the importance of considering the coupled thermal and stress behavior in disc brakes, and how such analysis can contribute to improving the design and reliability of braking systems in Volvo trucks[2]. Gongyu et al. have been utilized a numerical approach to model the thermal and stress distribution in the disc brake system. They considered the effect of a moving heat source, such as frictional heat generated during braking. The research findings offered valuable information for optimizing the design and performance of ventilated disc brakes. By understanding the thermal stress coupling, engineers can enhance the durability, reliability, and braking performance of the system [3]. Bouchetara Mostefa et al have been employed a thermoelastic analysis to investigate the temperature distribution and resulting deformation in disk brake rotors. The analysis considers factors such as material properties, braking conditions, and heat transfer mechanisms. By understanding the thermoelastic behavior, the research contributed to the development of more reliable and efficient disk brake systems [4]. R.A.García-León et al have been utilized numerical simulations to examine the heat transfer characteristics and airflow patterns surrounding the disc brake. Factors such as brake geometry, operating conditions, and airflow velocity were taken into consideration. The study revealed a correlation between temperature distribution, cooling efficiency, and braking performance, emphasizing the significance of optimizing the airflow design to facilitate efficient heat dissipation [5]. Anant W. Nemade et al have been analyzed the heat conduction characteristics within the disk braking system through numerical simulations. The study reveals the significant impact of heat conduction on the longevity of friction pads. It highlights how heat transfer affects the temperature distribution and thermal stresses in the pads, ultimately influencing their wear and lifespan [6]. The main idea of this article is to develop a disc brake mechanism model using CAD software. Subsequently, the heat transfer process is analyzed and evaluated using SolidWorks software. The results highlight the region where the highest temperature is generated, providing a basis for design considerations.

II. MATERIALS AND METHODS

2.1. Model of a disc brake system

In order to simulate and analyze the heat transfer phenomenon, a disc brake mechanism is constructed using Solidworks software as shown in Figure 1. The software provides a platform to accurately model the geometry and material properties of the brake components. This allows for detailed analysis and understanding of the heat transfer process within the brake system. The constructed disc brake mechanism serves as a valuable tool for investigating thermal behavior and optimizing the design for efficient heat dissipation.

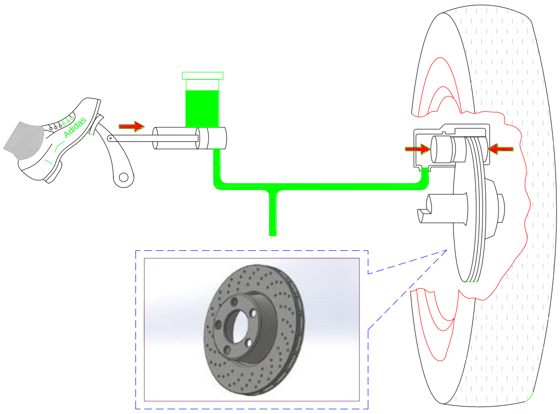

Fig. 1. Disc brake mechanism model

2.2. Governing equations

The heat balance equation in case of emergency braking is written as follows

$$\frac{G}{g}\frac{V_0^2 - V^2}{2} = m_t cT + A_t \int_0^{tp} k_t T dt \quad (1)$$

Where: c is the specific heat capacity of the drum material; m_t is the brake drum mass; T is the increase in temperature compared to the surrounding environment; A_t is the cool almf area of the brake drum; k_t coefficient of heat transfer from the brake drum to the air; t_p braking time

In the case of tight braking, the braking time is short, so the amount emitted to the air is small, so the heat balance equation (1) is rewritten as follows:

$$T = \frac{G.(V_0^2 - V^2)}{2gm_t c} \quad (2)$$

III. RESULTS AND DISCUSSION

To simulate and analyze the heat transfer process of the brake mechanism in this study, the software SolidWorks was chosen. The simulation results are shown in Figure 2 and Figure 3.

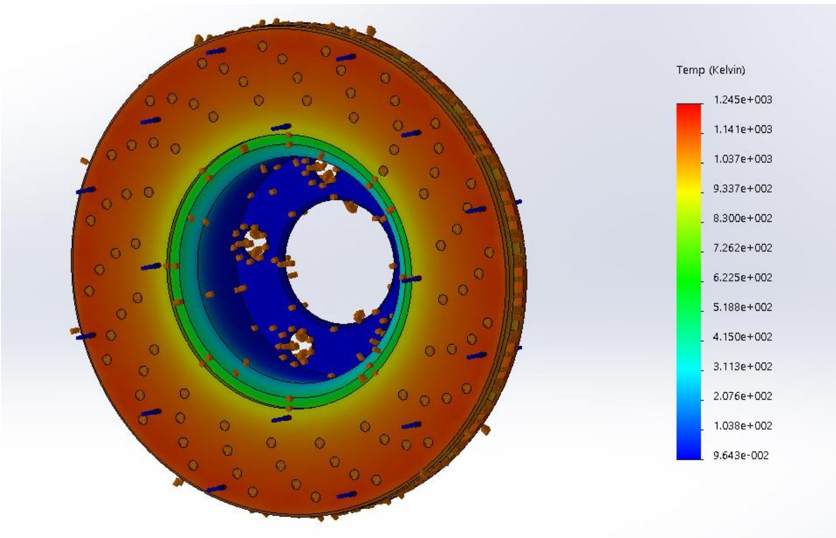

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Fig. 2. Temperature distribution on brake disc

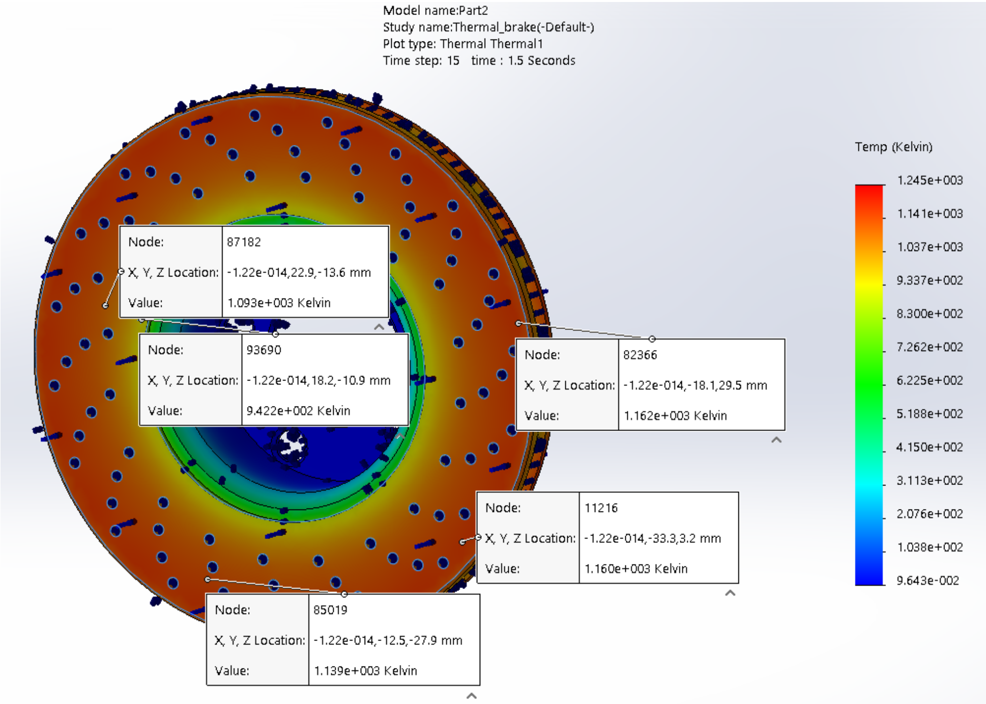

Fig. 3. Temperature values of different element nodes

Figure 2 and Figure 3 are illustrated the temperature distribution within the brake mechanism, highlighting the areas with the highest temperature generation. This information is crucial for identifying potential thermal issues and optimizing the design to manage heat effectively

Continuing the investigation, the study further explores the influence of braking time on the heat generation process of the brake mechanism. Three braking times, namely t = [3, 5, 7] (s), were selected for analysis. The simulation results are presented from Figure 4 to Figure 6.

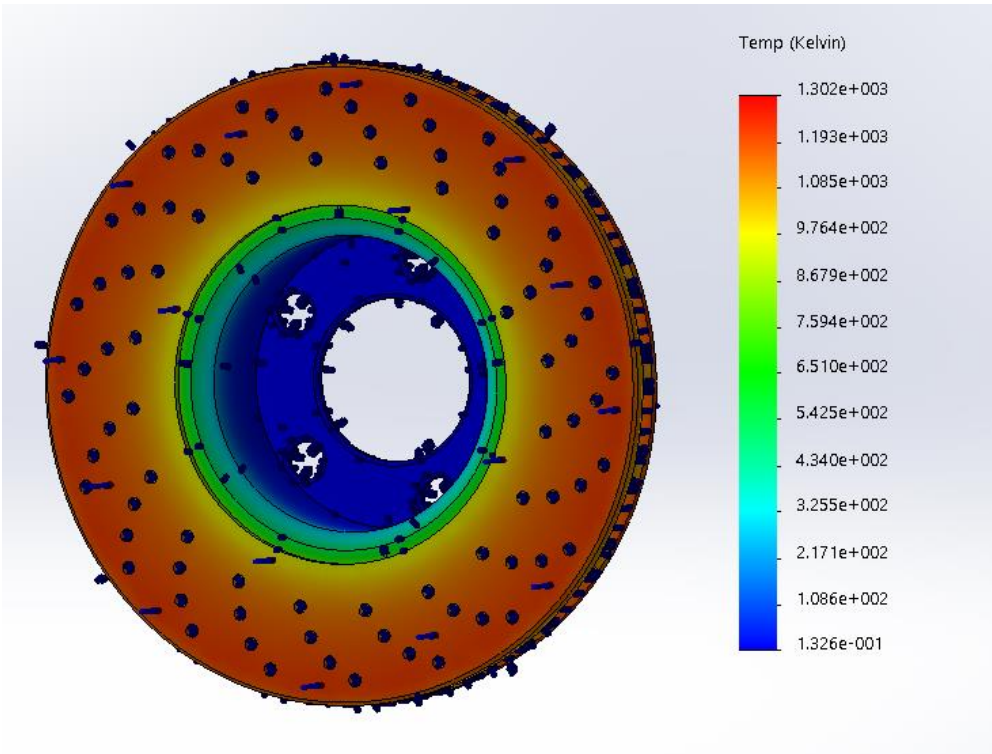

Fig. 4. Temperature distribution on brake disc(t=3s)

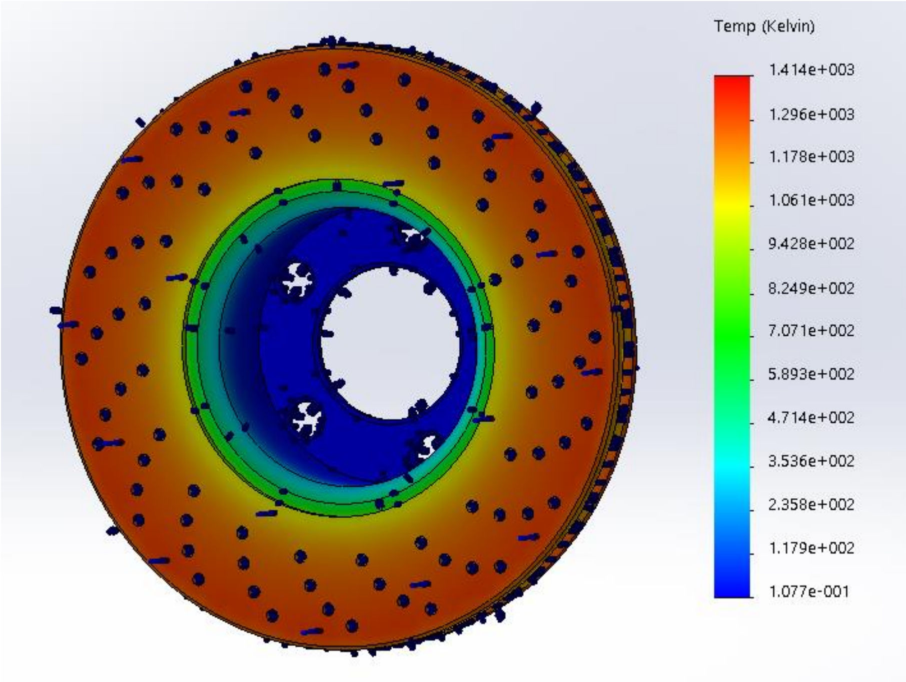

Fig. 5. Temperature distribution on brake disc(t=5s)

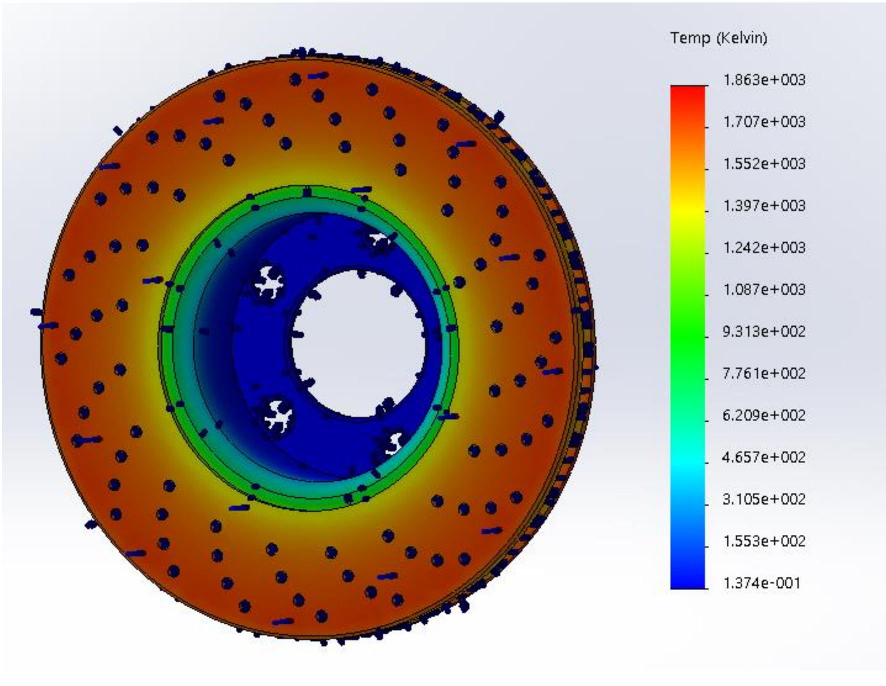

Fig. 6. Temperature distribution on brake disc(t=7s)

Figure 4, Figure 5 and Figure 6 are illustrated the temperature distribution within the brake mechanism for different braking times. It clearly demonstrates the increasing trend of heat generation with longer braking times, emphasizing the importance of considering the duration of braking in managing the thermal effects of the brake system.

IV. CONCLUSION

In this paper, the use of SolidWorks software allows for accurate modeling and analysis of the heat transfer process, providing valuable insights into the thermal performance of the brake mechanism. By examining the impact of braking time on heat generation, this study sheds light on the relationship between braking parameters and the thermal performance of the brake mechanism. These simulation results serve as a foundation for further design improvements and optimization to enhance the efficiency and reliability of the brake system.

Acknowledgment
The authors wish to thank the Thai Nguyen University of Technology for supporting this work.

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