ISSN No:-2456-2165

# Analyzing the Car Disc Brake using a Combination of Modelling and Static Structural Techniques

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**Abstract:- A brake is a device that uses friction to slow or stop the motion of a vehicle or machine. component. The brakes take on either the kinetic energy of a moving element or the potential energy released by items during the process of exhibiting this trait. This paper seeks to analyze the thermal and mechanical properties of brake discs and pads made of Aluminum oxide when subjected to different levels of force, and assess the impact of these forces on the driver's experience. We analyze the total deformation of disc-pads during braking, plus the stress distribution of brake pads, through a purely mechanical method. It found out that Equivalent stress and total deformation are in direct proportional when applying different force values.**

***Keywords:-** Brake Pads and Discs; Aluminum Oxide; Total Deformation; Equivalent Stress.*

## I. INTRODUCTION

The brake system of a car is vital for providing protection and managing the vehicle's movement. The brake disc with pad assembly is one of the most vital elements of the brake system [1]. The brake disc, or rotor, is necessary for slowing or stopping the car by turning kinetic energy into heat energy[2]. The brake pad produces friction against the brake disc to slow down the vehicle. Research has been conducted to improve the performance and durability of car brake discs and pads over many years. Research has been conducted to evaluate the characteristics of brake disc and pad assembly, including its thermal performance and structural response[3]. Selecting and optimizing materials for car brake discs and pads is a fundamental part of their structural analysis. Investigations of various materials and their properties is being done to improve the brake system's performance and longevity. A study was done by [4] regarding the influence of different materials on brake disc thermal and mechanical characteristics. They contrasted cast iron, carbon ceramic and aluminum composites, assessing which would work best in different environments. Brake discs are typically constructed of cast iron, while some luxury cars feature aluminum alloy, ceramic, or composite oxide film[4]. Considering brake discs' functioning, it's clear that higher-end cars' base materials are superior[4]. While, ceramics are better at withstanding high temperatures. The temperature range for liquifying is 1850-3000◦C [4]. It is both lightweight and strong[5]. The thermal performance of brake discs and pads is essential for keeping braking effectiveness and avoiding thermal deterioration [6]. Researchers studied heat transfer, cooling, and ventilation to improve brake disc thermal performance. A numerical model was created to analyze the heat transfer and temperature distribution in a brake disc and It has been noticed that the maximum temperature increase of a cast iron disc is significantly lower than that of stainless steel, thus, based on its thermal properties, cast iron is the ideal material for disc brake production [7]. Cast iron disc brake is prone to corrosion when it comes in contact with moisture, making it unsuitable for two wheelers, so stainless steel is preferred [7].In addition, it has observed that the peak temperature measured on cast iron disc brake was 56.93 ◦C, with a temperature decrease of 33.67 ◦C. While, the maximum heat recorded on a stainless steel disc brake was 69.81 ◦C and it cooled by 25.64 ◦C[7]. Hence, stainless steel disc exhibited maximum temperature drop, therefore making it ideal for design purposes[7]. [8] studied thermomechanical behavior of disc brake rotor and pads while braking using a mechanical analysis. The model disc-pads' total deformation and stress distribution when braking is ascertained by [8], the data from the thermoelastic coupling, such as contact pressure field, total deformations of the disc and pads, and Von Mises stress were studied and evaluated[8]. It has been discovered that the Von Mises stress, deformation of the disc and contact pressure of the pads all go up significantly when thermomechanical conditions are combined[8]. Accurately modeling car disc brakes is a must for static structural analysis. Researchers have employed various modeling techniques, including finite element analysis (FEA) and analytical modeling, to represent the complex geometries and loading conditions of disc brakes. Understanding the structural behavior and analysis of the brake disc with pad assembly is essential for optimal performance and safety. Examining the abilities of the brake disc and pad to withstand different weights and performance while in use is an essential part of structural analysis [9]. This leads to optimize performance, and boosting the security of automobiles. The purpose of this paper is to examine the thermal and mechanical characteristics of the disc brake rotor and pads during braking by using Aluminum oxide and to examine the performance of the brakes when exposed to different intensities of force, and analyze the effect it has on the driver's experience. We establish the extent of the model disc-pads' total deformation while braking, as well as the brake pads' stress distribution, through a strictly mechanical analysis.

## II. DESIGN AND ANALYSIS OF DISC BRAKE

### *A. Modeling of Disc Brake*

This work uses Aluminum oxide for the disc brake system. Solid works employed to create disc brake, ANSYS used to analyze mechanical properties. The application of FEA (Finite Element Analysis) is an effective technique to solve practical problems. The automotive industry has been utilizing FEA extensively. Design engineers commonly use this tool when enlarging products. Design engineers can use FEA to assess their designs while they are still in the process of creating a modifiable CAD (Solidworks) model. It allows the design engineers to move back and forth to utilize FEA outcomes in the design process and enhance the model. To use FEA as a successful design tool, it is critical to comprehend the underlying principles, modeling techniques, errors, and their ramifications on the accuracy of the output. FEA is used for problem solving in engineering contexts. It is a powerful computational tool. to examine the influence of the car brake pad and disc when 10 N, 30 N and 50 N of force are applied to the pad and it is achieved first in modeling in Solidworks and then in ANSYS as in the following steps:

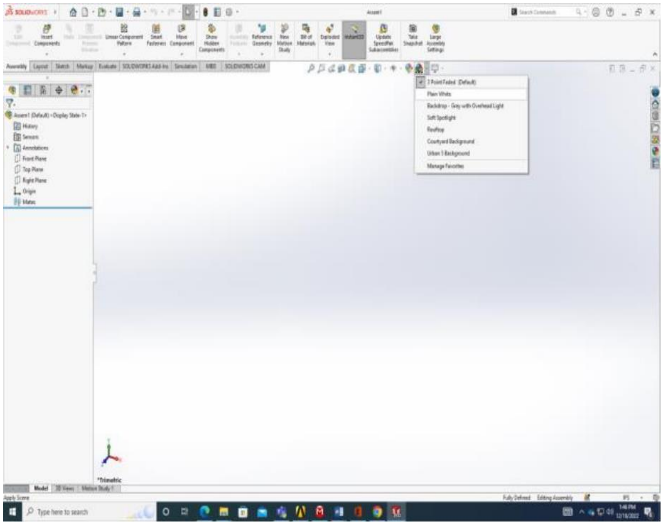


Fig 1 Launch Solid Works and Select the Plain White Option

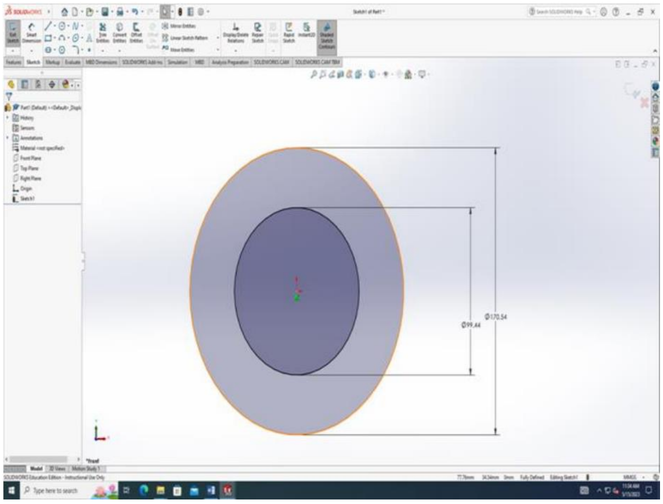


Fig 2 Create Two Circles

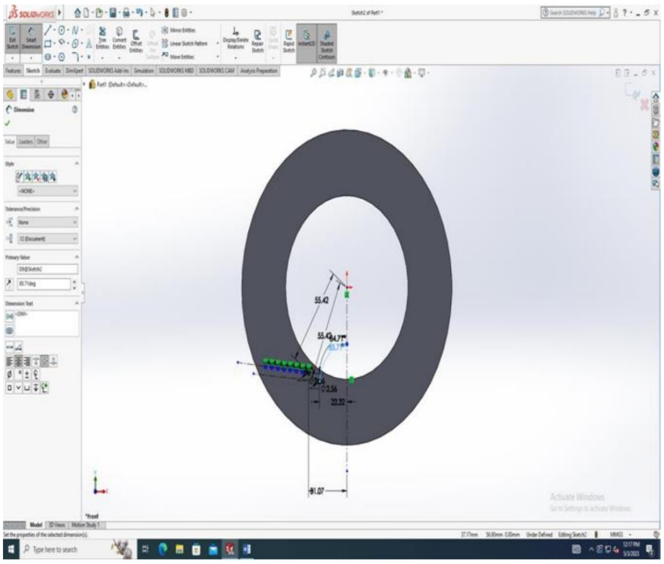


Fig 3 Extrusion Step

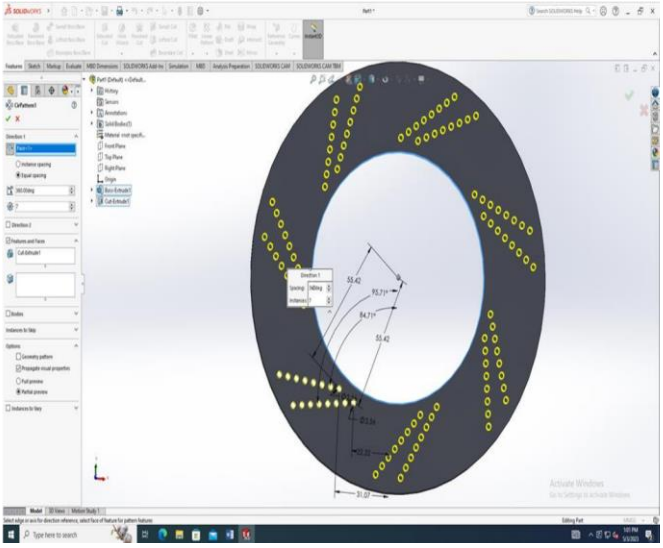


Fig 4 Boss-Extrusion Step

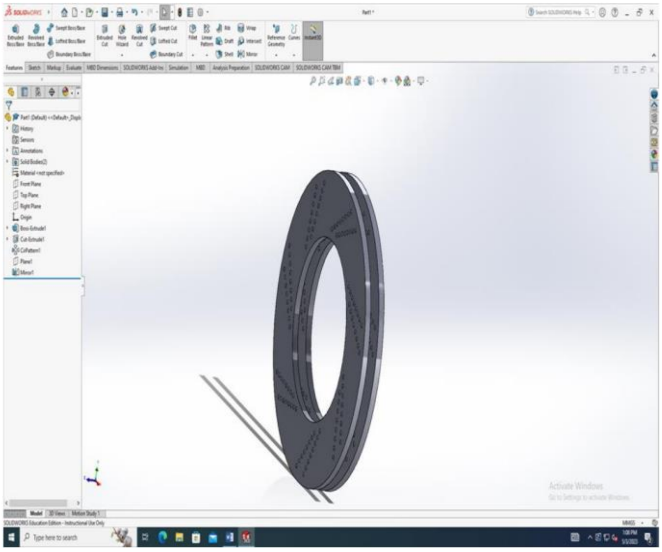


Fig 5 Mirror Step

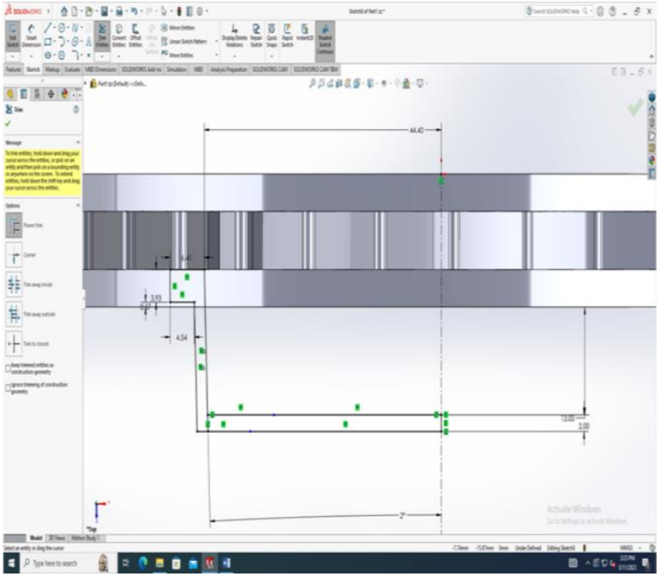


Fig 6 Dimension to Wheel Hub

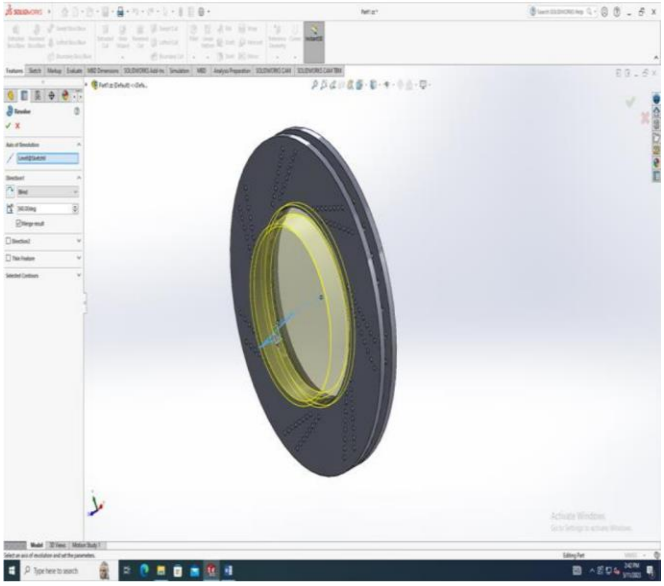


Fig 7 Creating a Wheel Hub

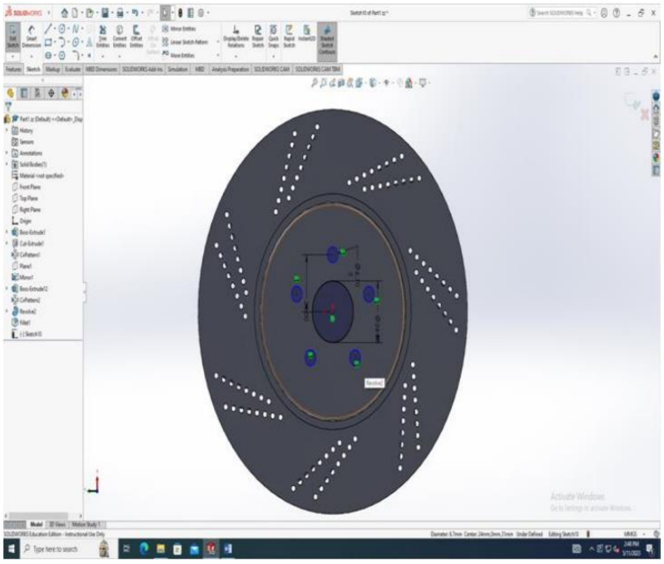


Fig 8 Developing the Wheel Stud and Cap

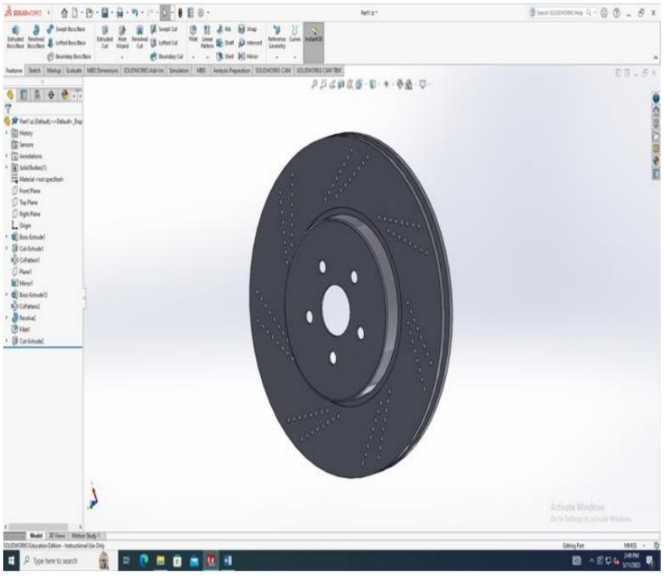


Fig 9 Creating a Wheel Hub and Dust Cap

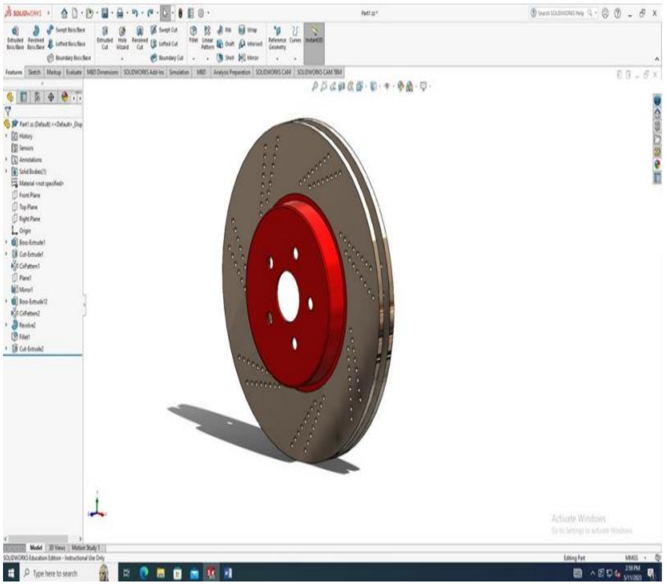


Fig 10 Assembly of Wheel Stud and Cap

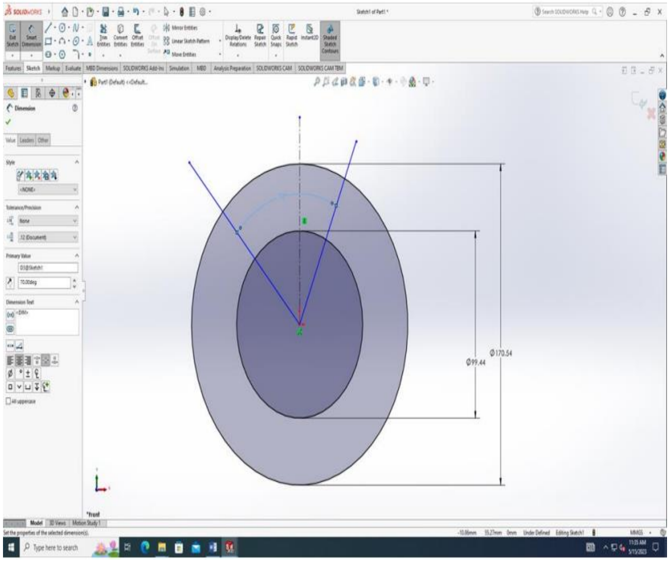


Fig 11 Dimensions to Create Pad

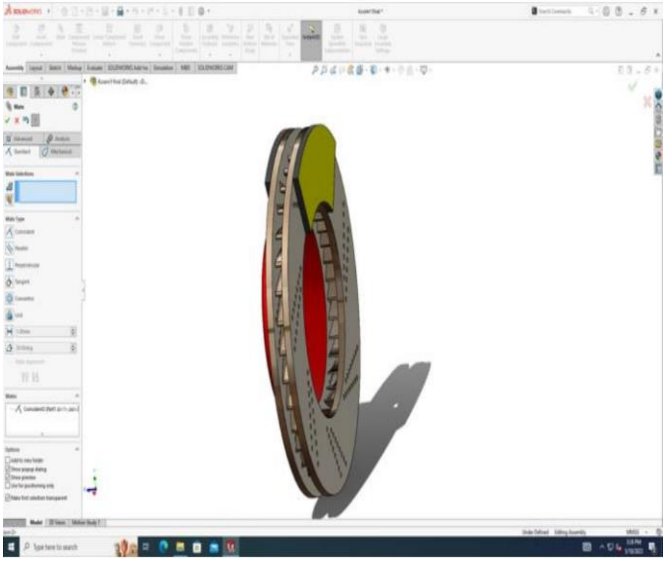


Fig 12 Pads and Disc Assembly

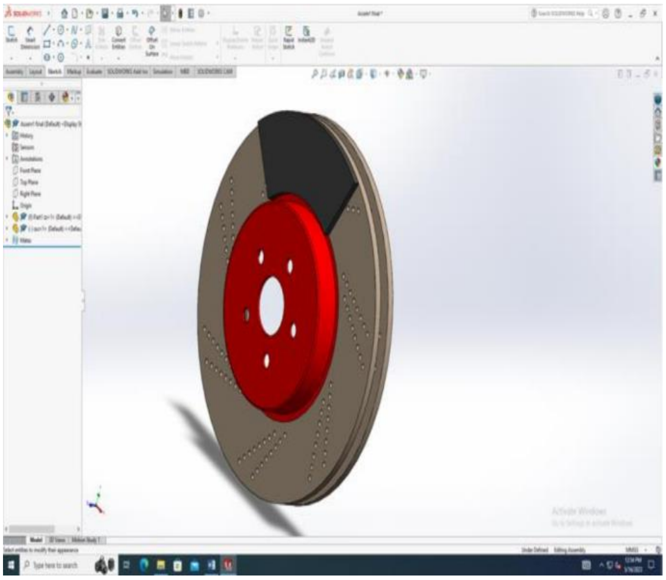


Fig 13 Pads and Disc Assembly

Table 1 Material Assignment in ANSYS

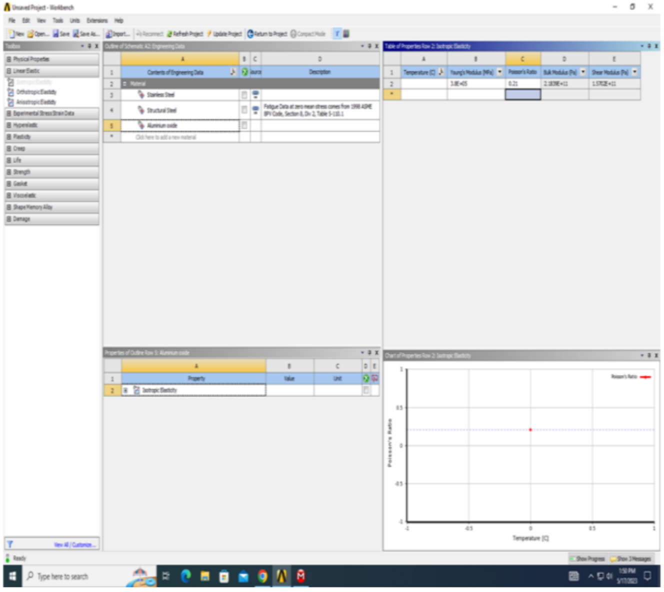
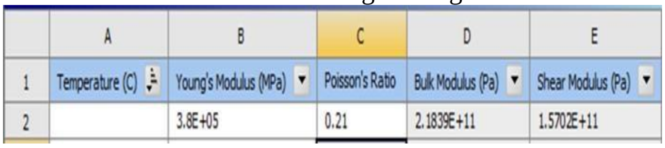


Table 2 Material Engineering Data



| | A | B | C | D | E |
|---|---|---|---|---|---|
| 1 | Temperature (C) | Young's Modulus (MPa) | Poisson's Ratio | Bulk Modulus (Pa) | Shear Modulus (Pa) |
| 2 | | 3.8E+05 | 0.21 | 2.1839E+11 | 1.5702E+11 |

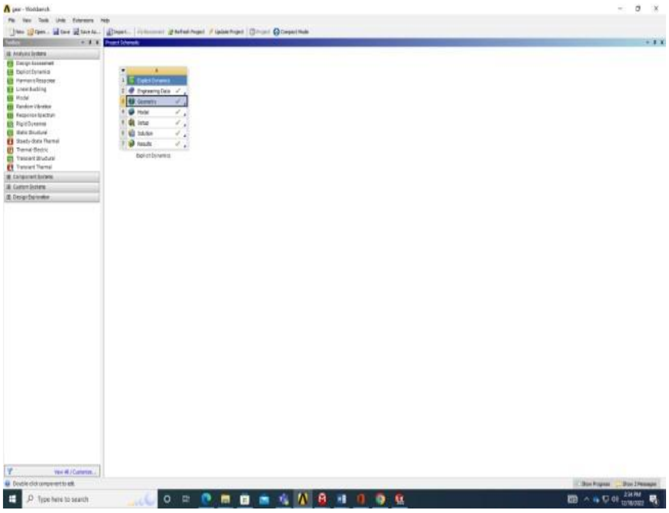


Fig 14 Geometry Step

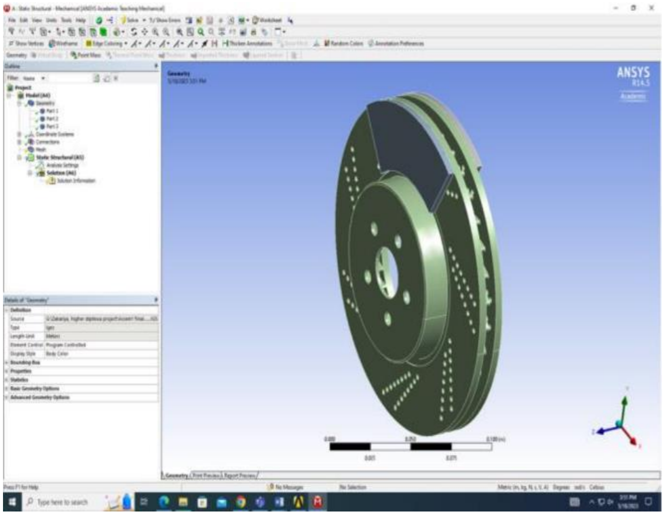


Fig 15 Model Import from Solid Works

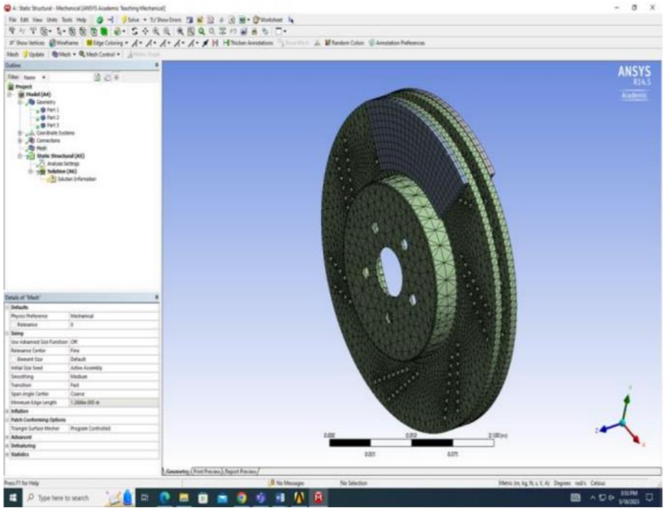


Fig 16 Mesh Step

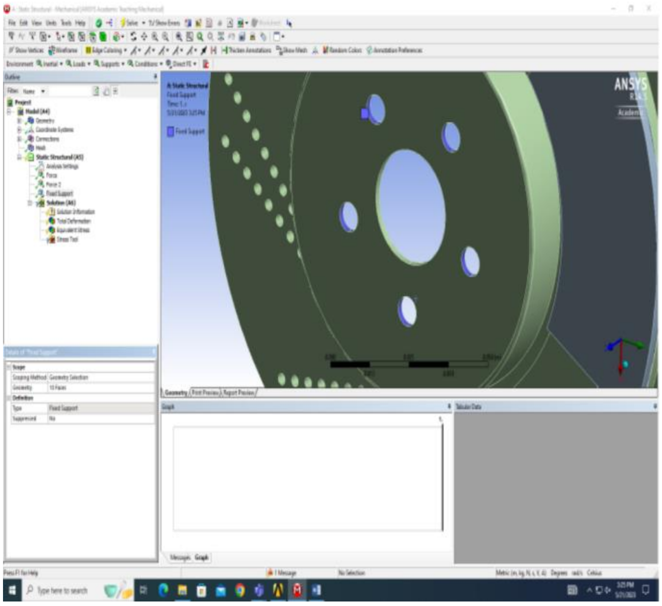


Fig 17 Boundary Conditions (Fixed Support)

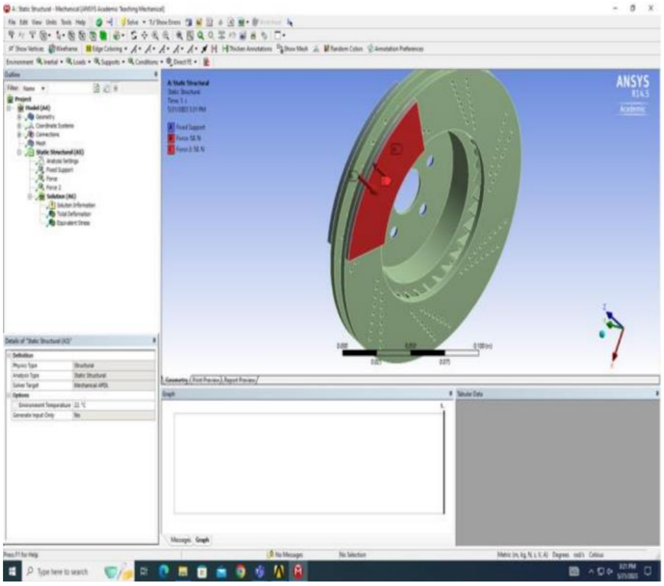


Fig 18 Boundary Conditions (Force Input Value)

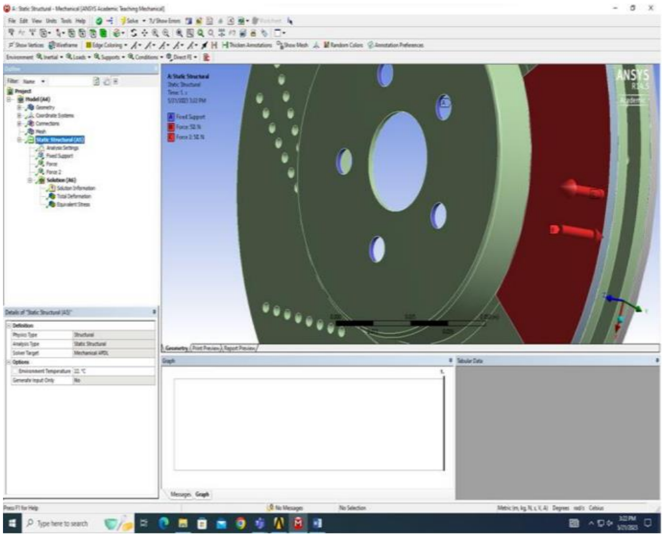


Fig 19 Solution Information (Total Deformation And Equivalent Stress)

## III. RESULT

- *For 10 N:*

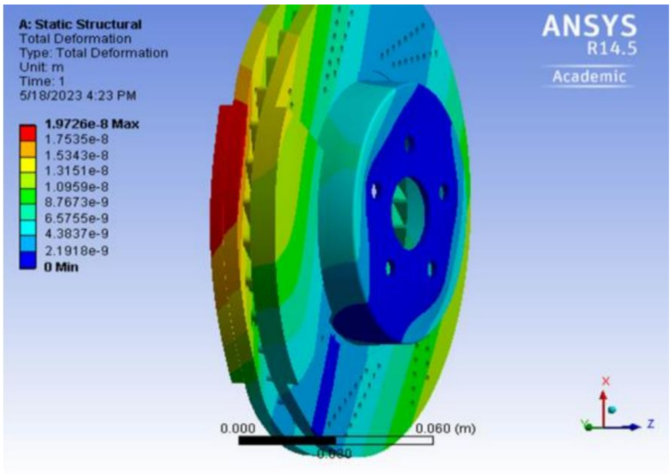


Fig 20 Solution of Total Deformation when Applied Force is 10 N

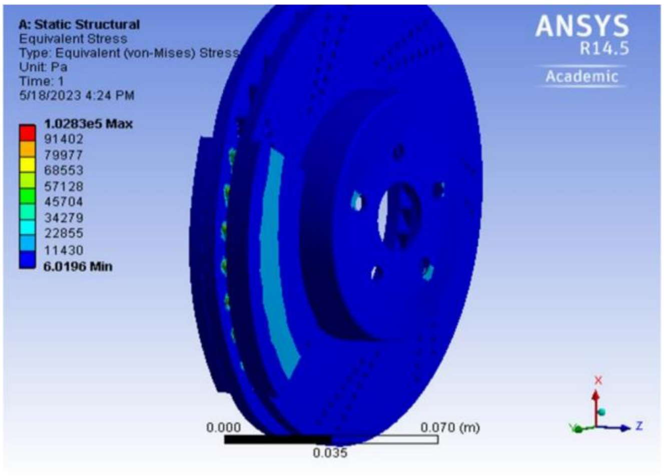


Fig 21 Solution of Equivalent Stress when Applied Force is 10 N

- *For 30 N:*

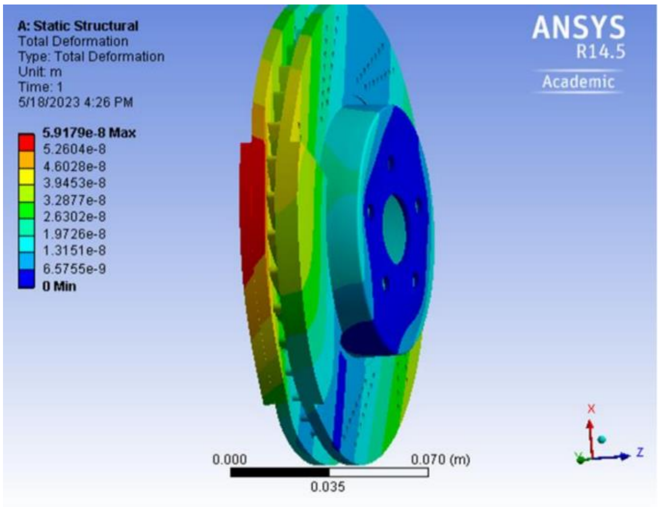


Fig 22 Solution of Total Deformation when Applied Force is 30 N

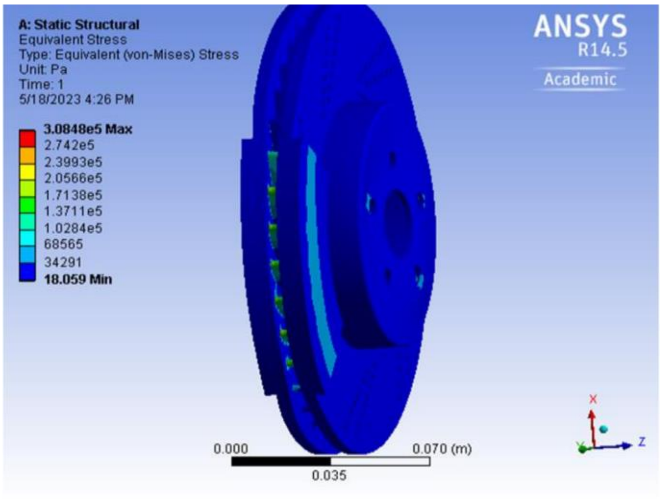


Fig 23 Solution of Equivalent Stress when Applied Force is 30 N

- *For 50 N*

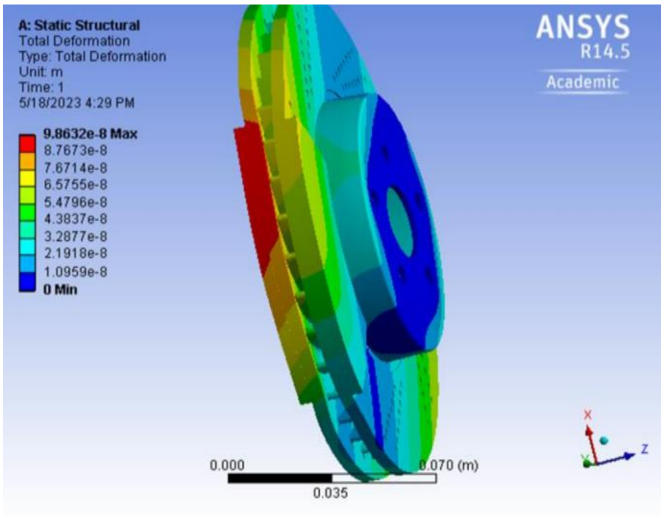


Fig 24 Solution of Total Deformation when Applied Force is 50 N

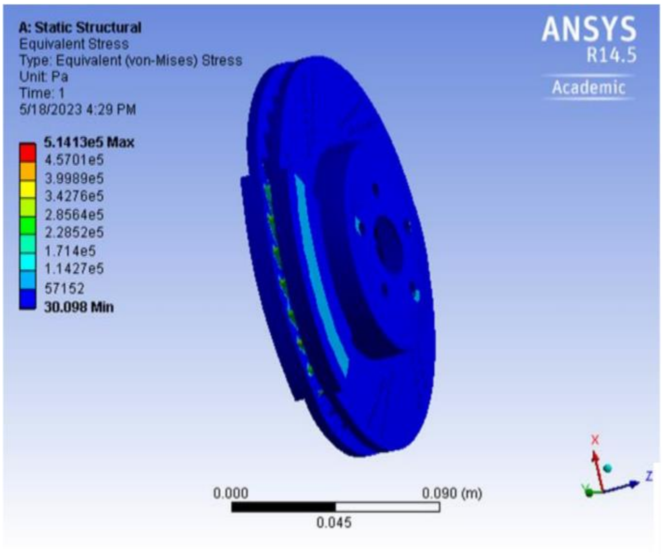


Fig 25 Solution of Equivalent Stress when Applied Force is 50 N

## IV. DISCUSSIONS

The temperature fluctuates depending on the duration of contact between the pad and disc, revolutions per minute of the disc, and the material used to make the brake. The rapid physical action during braking, primarily friction, causes a noticeable expansion in performance due to the small plastic deformation of the surface it touches. The thermometer goes up to 401.55°C, its highest point. It diminishes rapidly. Consequently, the range of heat is relatively sluggish. The ventilated disc shows a cooling of roughly 60° C when compared to other scenarios. The design of the brake disc's ventilation has a large effect on the cooling efficiency of the system. In addition, total deformation occurred with respect to varying forces. Total deformation at a minimum and maximum force. This implies that the brake disc needs to be able to withstand deformation. This study indicates that force and deformation are usually proportional as shown in Table 3 and Figure 26

Table 3 Force (N) Versus Total Deformation (m)

| *Force (N)* | *Total deformation (m)* |
|---|---|
| *10* | $1.9726*10^8$ |
| *30* | $5.9179*10^8$ |
| *50* | $9.8632*10^8$ |

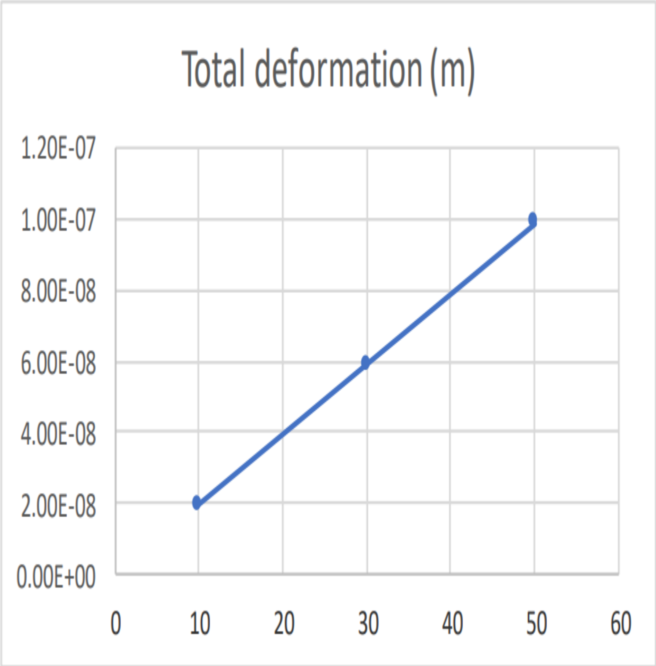


Fig 26 Force (N) Versus Total Deformation (m)

Equivalent Stress occurred with respect to varying in force. Equivalent Stress at minimum and maximum force range. In this research work, equivalent stress increases as force increases as shown in Table 4 and figure 27.

Table 4 Force (N) Versus Equivalent Stress (Pa)

| *Force (N)* | *Equivalent stress (Pa)* |
|---|---|
| *10* | $1.0283*10^5$ |
| *30* | $3.0848*10^5$ |
| *50* | $5.1413*10^5$ |

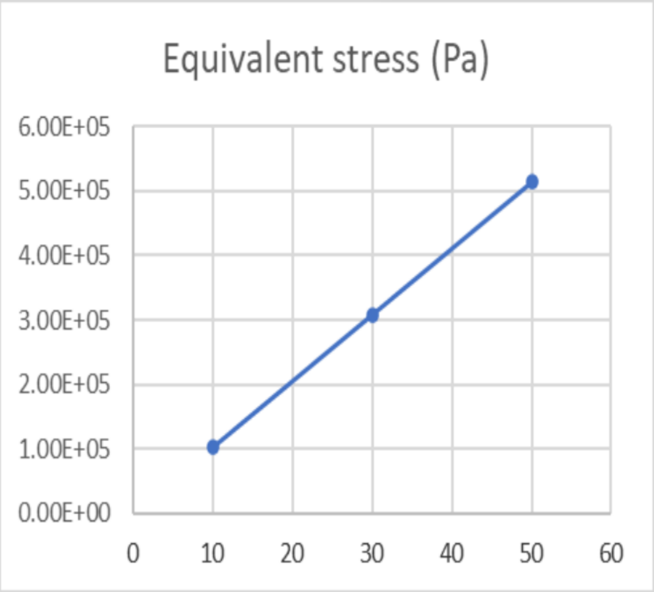


Fig 27 Force (N) Versus Equivalent Stress (Pa)

## V. CONCLUSION AND SUGGESTION

This article discussed analyzing the thermal and mechanical behavior of the dry contact between the pads and disc when braking. It is demonstrated that the ventilation system is critical to the cooling of the discs and offers good high temperature resistance The study revealed a perfect partnership between the temperature and stress fields during braking. The temperature, Von Mises stress, total disc deformations, and pad contact pressures all rise as the temperature rises. Results of this evaluation are in agreement with other literature. For instance, Equivalent stress and total deformation are in direct proportional when applying different force values. In order to gain a better understanding of the thermomechanical contact between the disc and pads, three suggested methods of expanding the next disc brake research have been compiled. The following are some suggestions:

- *Examining the model's performance through experimentation*
- *Investigation of friction and vibration of the contact disc-pads*
- *Interference created by frictional impact forces.*

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