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Design and Analysis of Disc Brake Rotor Using Different Geometry & Material

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ABSTRACT

As the most critical system in a car, this study studies how to build a system that allows the smooth application of the brakes within a specified distance and deceleration, while taking into account thermal considerations. The brake disc is designed with the least amount of human effort as possible in mind to guarantee easy braking. The purpose of this study is to develop a brake disc and perform static testing on it. Thermal analysis and structural analysis are both used to determine temperature gradients and heat fluxes during deformation. Siemens NX and Fusion 360 are utilised for analysis as well as Solidworks for design. Under typical working settings, the findings were judged to be safe for the corresponding disc structure. The disc did not exhibit any notable deformations or hotspots.

Keywords:Disc brake, Static Analysis, Thermal analysis, Stress, CATIA V5, ANSYS..

1. Introduction:

Brakes are devices that provide artificial friction to moving machine parts in order to halt a machine's movement. The brakes absorb the kinetic energy of the moving part as well as the potential energy released by the items as they accomplish this duty. The heat generated as a result of the brakes' energy absorption is then expelled from the vehicle. Heat is released into the atmosphere as a result of this process. It is a form of disc brake that employs callipers to push pads against a disc to generate friction that retards the rotation of a shaft, such as a vehicle axle, either to lower its rotational speed or to keep it in place.

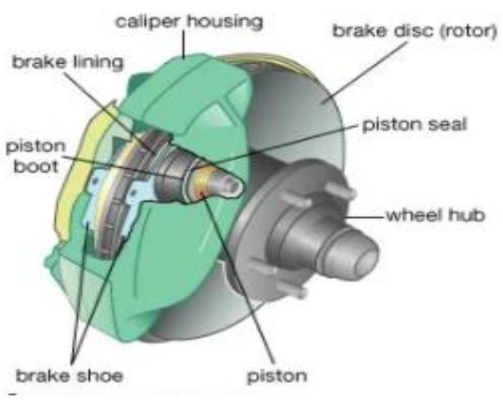


Figure 1- Disc Break

WORKING PRINCIPLE OF DISC BREAK

With each depressed depressing of the brake pedal or lever, the push rod that is connected to the master cylinder piston and the pedal or lever pushes the master cylinder piston back into position. Because of this motion, the master cylinder piston is able to glide and drive the return spring into the bore of the master cylinder, so increasing the pressure in the reservoir tank. This allows the brake fluid from the reservoir tank to pass through a main seal and into the hoses during this period of operation. In order to keep brake fluid from leaking from one side of the vehicle to the other, a secondary seal is installed. When the fluid reaches the cylinder bore of the calliper assembly, it causes one or more of the calliper pistons to be pushed. At this time, the piston ring and the piston roll together as a single unit. As a consequence, the brake pad is pressed by the calliper piston. The friction created by this movement causes the brake discs/rotors to get attached to one another, preventing them from rotating. A disc braking system may be used to bring the vehicle to a complete stop or to slow it down.

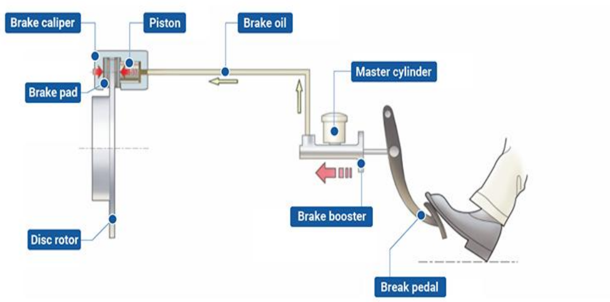


FIGURE 2- WORKING OF DISC BREAK

In order for the calliper piston and ring to return to their normal form after releasing the brake lever or pedal is a complex process. The brake pads are pushed back into place by the retraction spring at this point. It is via the hosepipe and master cylinder bore that fluid is returned to the reservoir by the return springs in master cylinder assemblies.

2. LiteratureReview

Manjunath et al [1] To better understand how a car's disc brake rotor performs under extreme braking situations, researchers conducted a transient thermal and structural investigation of the disc brake rotor-disc. Modeling and analysis were performed using ANSYS workbench 14.5. An important aim was to examine the dry brake disc contact's thermomechanicalbehaviour during the braking period. For both solid and vented discs with two distinct materials, a combined thermal-structural analysis was utilised to calculate the disc deformation and Von Misses stress.

Venkatramanan R et al [2] ANSYS was used to explore and evaluate the rotor disc's temperature distribution during operation. This was done to get a better understanding of the disc brake material's pressure and friction forces, which may assist minimise the number of accidents that occur each day. It was found that adding a copper liner lowered the maximum temperature that could be reached by the disc in this study, based on the calculations of heat transfer between an existing disc and a hybrid disc.

A. Belhocine et al [3] An ANSYS-based numerical simulation of the linked transient heat field and stress field was done sequentially to analyse the stress fields of deformations created in the disc as a result of the pressure exerted on its pads, and the results were compared. When compared to the findings from the specialist literature, the simulation's outcomes seem convincing.

3. ProposedWork

The brake rotor is design to carry maximum load and stand with varying loading condition. In this project we studied two types of geometry first issimple, vented and other one is vented & drilled and also studied three different material Stainless steel, Gray Cast Iron. Setting boundary condition and compare the results.

4. Methodology

The FEA process involves CAD modeling of piston in CATIA V5 design modeler.The model is developed as shown in figure3 to 5 below.The model developed in CATIA V5 Simulation design modeler is imported in ANSYS for meshing.

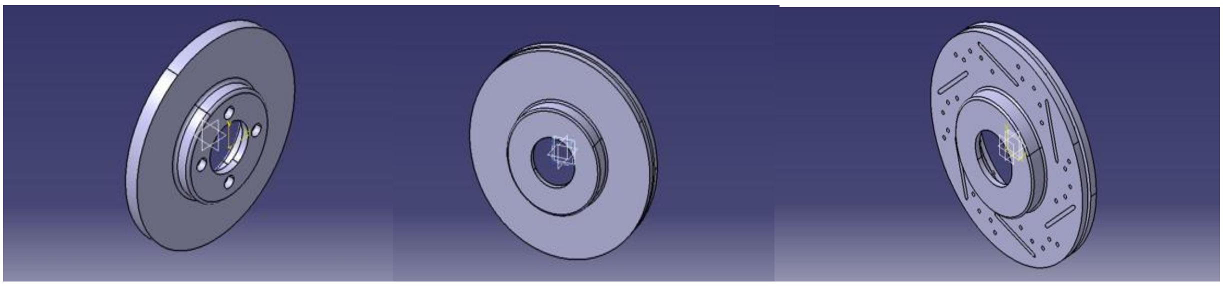


Figure2:Solid disc brake rotor(Model-1) Figure 3: Vented type disc brake rotor (Model-2) Figure4:Vented & Drilled type (Model-3)

The CAD model is meshed using tetrahedral components and exact scaling with curvature effects. Model-1 creates 73139 elements and 73139 nodes, while model-2 generates 183223 elements and 336260 nodes, and model-3 generates 185197 elements and 343667 nodes, as seen in the picture above. A tetrahedral element is seen in the illustration. It consists of four nodes connected by a tetrahedral form. The CAD model of the suspension is then applied with the relevant loads and boundary conditions after meshing.

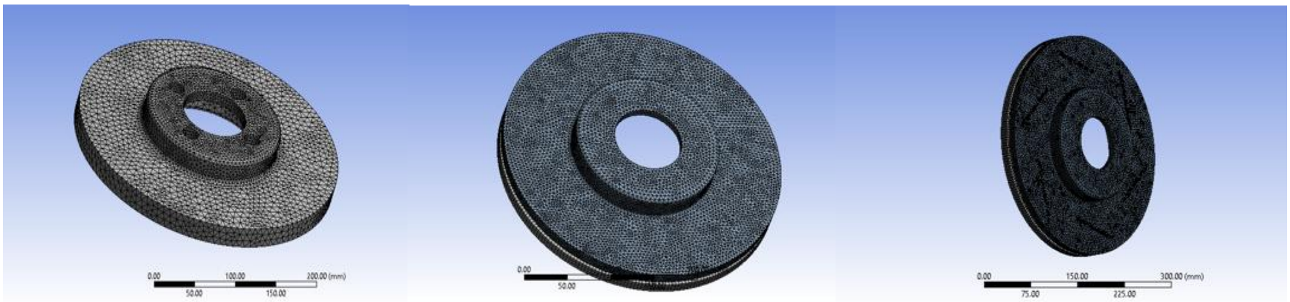


Figure5:Model-1MeshedFigure6:Model-2Meshed **Figure7:Model-2 Meshed**

5. ResultsandDiscussion

The results of steady state thermal analysis on different profile of disc brake rotor generated are shown below.

Model-1

Gray Cast Iron

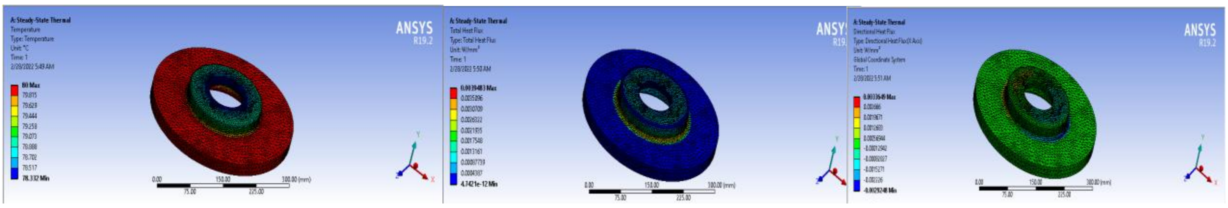


Figure:Temperature **Figure: Total Heat Flux** **Figure: Heat Flux Direction**

Stainless Steel

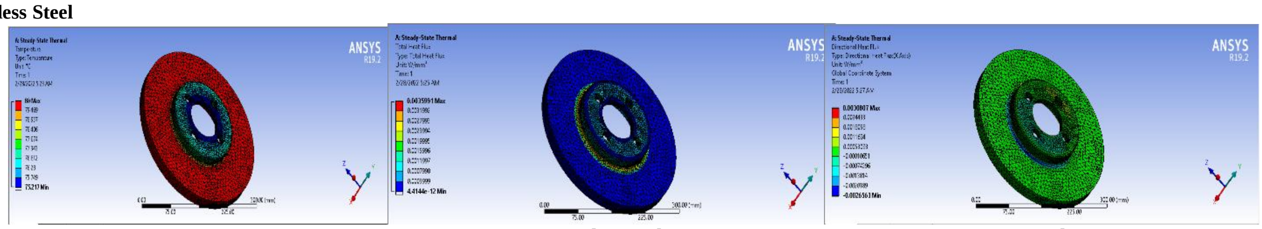
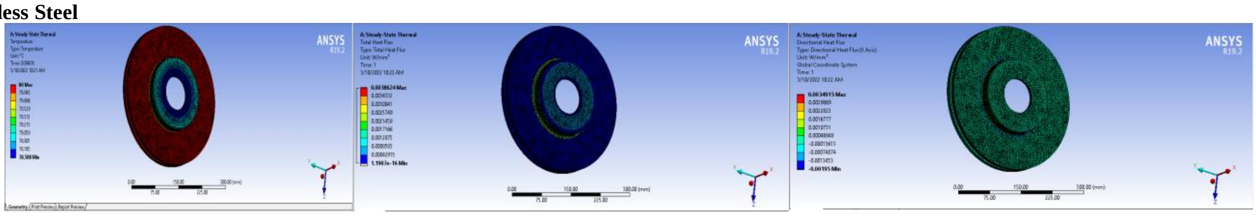


Figure:Temperature **Figure: Total Heat Flux** **Figure: Heat Flux Direction**

Model-2

Stainless Steel



Gray Cast Iron

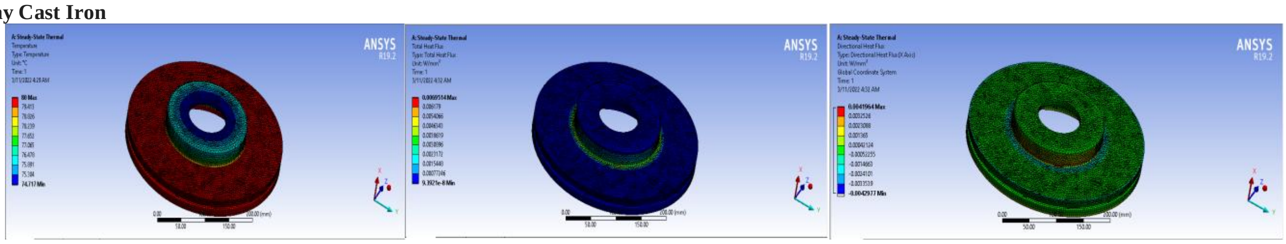


Figure:Temperature **Figure: Total Heat Flux** **Figure: Heat Flux Direction**

Model-3

Gray Cast Iron

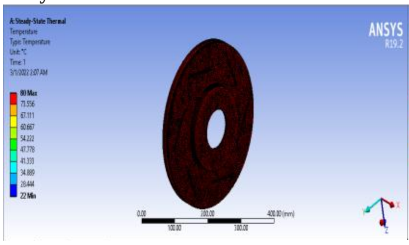


Figure:Temperature

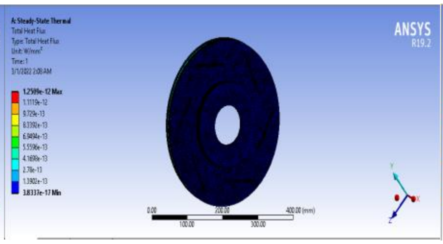


Figure: Total Heat Flux

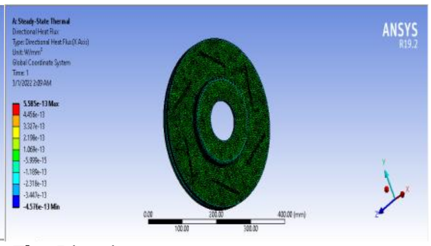


Figure: Heat Flux Direction

Stainless Steel

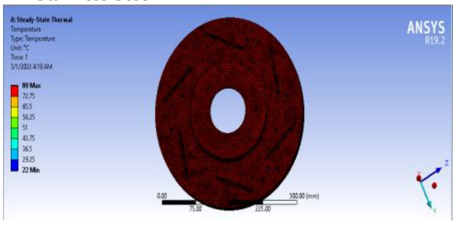


Figure:Temperature

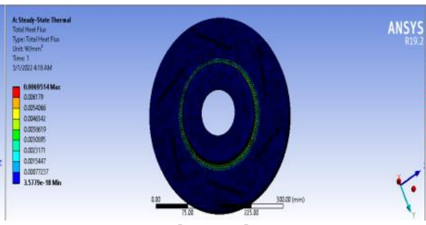


Figure: Total Heat Flux

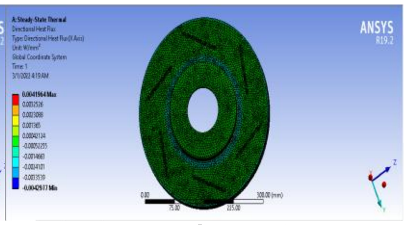


Figure: Heat Flux Direction

Model-1AnalysisResult

Table 1: Gray Cat Iron

Results	Minimum	Maximum	Units	Time (s)
Temperature	78.332	80.	°C	1.
Total Heat Flux	4.7421e-012	3.9483e-003	W/mm²	1.
Directional Heat Flux	-2.9248e-003	3.3649e-003	W/mm²	1.

Table 2: Stainless Steel

Results	Minimum	Maximum	Units	Time (s)
Temperature	75.721	80.	°C	1.
Total Heat Flux	1.9043e-007	3.4375e-003	W/mm²	1.
Directional Heat Flux	-2.5275e-003	2.924e-003	W/mm²	1.

Model-2AnalysisResult

Table 1: Gray Cat Iron

Results	Minimum	Maximum	Units	Time (s)
Temperature	78.588	80.	°C	1.
Total Heat Flux	1.1907e-016	3.8624e-003	W/mm²	1.
Directional Heat Flux	-1.95e-003	3.4915e-003	W/mm²	1.

Table 2: Stainless Steel

Results	Minimum	Maximum	Units	Time (s)
Temperature	74.717	80.	°C	1.
Total Heat Flux	9.3921e-008	6.9514e-003	W/mm²	1.
Directional Heat Flux	-4.2977e-003	4.1964e-003	W/mm²	1.

Model-2AnalysisResult

Table 1: Gray Cat Iron

Results	Minimum	Maximum	Units	Time (s)
Temperature	22.	80.	°C	1.
Total Heat Flux	3.8337e-017	1.2509e-012	W/mm²	1.
Directional Heat Flux	-4.576e-013	5.585e-013	W/mm²	1.

Table 2: Stainless Steel

Results	Minimum	Maximum	Units	Time (s)
Temperature	22.	80.	°C	1.
Total Heat Flux	3.5779e-018	6.9514e-003	W/mm²	1.
Directional Heat Flux	-4.2977e-003	4.1964e-003	W/mm²	1.

6. Conclusion

Disc brake rotors made of grey cast iron and stainless steel have the following characteristics: temperature distribution, total heat flux, and heat flux direction. These characteristics are shown in the figures and tables above. When it comes to disc brake rotors (vented with drilled), grey cast iron will provide the best results out of all the materials considered because it can withstand the highest thermal stresses induced by friction between the brake pad and the surface of the disc rotor and it also dissipates the heat generated at the fastest rate. The usage of grey cast iron is preferred over other materials because it has less deformation, high strain and stress, and a high heat flux when compared to the other materials.

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