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Bachelor Work

Investigation of Performance and Possible Improvements of the Braking System

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DECLARATION

I declare that I worked on this thesis independently, assuming that the results of the thesis can also be used at the discretion of the thesis's supervisor as its co-author. I also agree to the potential publishing of the thesis's results or a large portion of it, if I am identified as a co-author.

Prague, … … … … … … … …

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ABSTRACT

The disc brake is a device for slowing or stopping the rotation of a wheel. Breaks convert friction into heat. If brakes get too hot, they will be exposed to large thermal stress during the rotation of breaking. A break is a mechanical device that is used to stop the slowing of a vehicle during motion. The main aim of this project is to minimize the temperature and thermal stress with the best material analysis. This is done on both ventilated and normal discs. The actual disc brake has no holes. The design is changed by giving holes in the disc brake for more heat dissipation.

Analysis is done in Catia v5 and analysis is done in ANSYS (finite element analysis software). Thermal and structural analysis is done by providing materials like grey cast iron and stain less steel and comparing both results and providing the best suited material.

Kotoučová brzda je zařízení pro zpomalení nebo zastavení otáčení kola. Brzdy přeměňují tření na teplo. Pokud se brzdy příliš zahřejí, budou vystaveny velkému tepelnému namáhání. Brzda je mechanické zařízení, které se používá k zastavení zpomalování vozidla během pohybu. Hlavním cílem tohoto projektu je minimalizovat teplotu a tepelné namáhání pomocí nejlepší materiálové analýzy. To se provádí jak na ventilovaných, tak na normálních discích. Skutečná kotoučová brzda nemá žádné otvory. Design je změněn tím, že jsou v kotoučové brzdě otvory pro lepší odvod tepla.

Analýza se provádí v Catia v5 a analýza se provádí v ANSYS (software pro analýzu konečných prvků). Tepelná a strukturální analýza se provádí použitím materiálů, jako je šedá litina a nerezová ocel, a porovnáním obou výsledků a použitím nejvhodnějšího materiálu.

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SYMBOLS AND ABBREVIATIONS

FEA	finite element analysis
CMM	Coordinate Measuring Machine
CAD	Computer Aided Design

1. INTRODUCTION

1.1 BRAKING SYSTEM

Brakes are the most important safety components in a vehicle. all vehicles have their own safety devices to stop the car. The function of brakes is to slow and stop the rotation of the wheel. To stop the wheel, braking pads are forced mechanically against the rotor disc on both surfaces. They are compulsory for all modern vehicles and the safe operation of vehicles. Brakes transform the kinetic energy of the car into heat energy.

Brakes have been retuned and improved ever since their invention. Brakes increase the speed of travel. An effective braking system is needed to accomplish this task with challenging terms where material needs to be lighter than before, and the performance of the brakes must be improved. Today's cars often use a combination of disc brakes and drum brakes.

Disc brakes are located on the front two wheels, and drum brakes on the back two wheels. clearly shows that, together with steering components and tiers, they represent the most important accident-avoidance systems present on motor vehicles.

In order to understand the behaviour of the braking system, you have to satisfy the following three functions.

- The braking system must permit the vehicle to maintain a constant speed when travelling.
- The break should control the vehicle in a repeatable fashion and cause the vehicle to stop.
- The break should hold the vehicle stationary when on the flat or on a gradient.

1.1.1 PRINCIPLE OF BRAKING SYSTEM

A brake is a device by means of which artificial frictional resistance is applied to a moving machine member in order to stop the motion of a machine. Breaks play a major role in moving auto-motive vehicles.

A disk brake consists of a cast iron disc bolted to the wheel hub and a stationary hose called a calliper. The calliper is connected to some stationary part of the vehicle, like the axle casing or stub axle, as in two parts, each part containing a piston. In between each piston and the disc, there is a friction pad held in position by retaining pins, spring plates etc. Passages are drilled in the calliper

For the fluid to enter or leave each housing, the passages are also connected to another one for bleeding. each cylinder and piston.

When the brakes are applied, hydraulically actuated pistons move the friction pads into contact with the rotating disc, applying equal and opposite forces on the disc. Due to the friction between disc and pad surfaces, the kinetic energy of the rotating wheel is converted into heat, which causes the vehicle to stop after a certain distance. On releasing the brakes, the brake rubber-sealing ring acts as a return spring and retracts the pistons and the friction pads away from the disc. In the course of brake operation, frictional heat is dissipated mostly between the pad and disc, which causes uneven temperature distribution on the components and could induce severe thermo elastic distortion of the disc. The thermal distortion of a normally flat surface into a highly deformed state is called the thermo elastic transition. It sometimes occurs in the sequence of stable, continuously related states that operating conditions change. At other times, however, the stable evolution behaviour of the sliding system crosses the threshold where a sudden change of contact conditions occurs in a sequence of stable, continuously related states.

When this process leads to an accelerated change of contact pressure distribution, the unexpected hot roughness of thermal distortion may grow unstably under some conditions, resulting in local hot spots and leaving thermal cracks on the disc. This is known as thermo elastic stability. The thermo elastic instability phenomenon occurs more easily as the rotating speed of the disk increases. This region where the contact load is concentrated reaches very high temperatures, which causes a deterioration in braking performance. Moreover, in the course of their presence on the disk, the passage of thermally distorted hot spots moving under the brake pads causes low-frequency brake vibration.

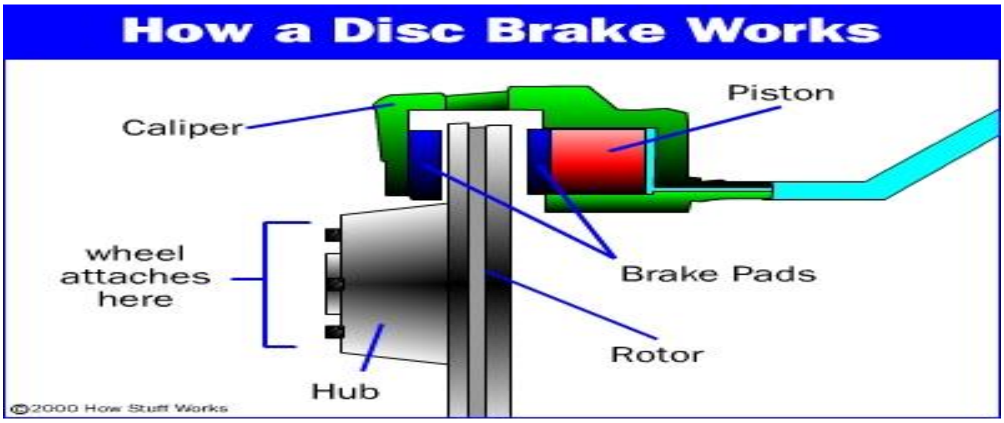


Figure 1.1hydraulic disc brake

1.2 AIM & OBJECTIVE

Aim: The main aim of this project is to minimize the temperature and thermal stress with the best-suited material analysis. This analysis was done on both ventilated and normal discs.

OBJECTIVE:

- To increase heat dissipation on the disc,
- Determine the best material to use on the disc based on the application.
- to improve braking system efficiency by increasing heat dissipation
- To reduce the overall cost of disc material
- to improve braking system efficiency by increasing heat dissipation
- To optimize the braking system,
- To know the heat distribution on a disc of different materials
- Based on heat distribution on disc, material is decided.

2 LITERATURE REVIEW

In 2020, Fatigue fracture analysis of brake disc bolts under continuous braking conditions, Zhou Suxia, Guo Zihao, Xiaoyu Bai [1] In this study, material characteristics and numerical simulations were performed to investigate the reasons for the brake disc bolt fractures in the Lanzhou-Wulumuqi high-speed railway line. The FE model of the bolt thread with hexahedral meshes was established to obtain the stress states, temperature, and change of bolt performance during continuous braking. Based on the obtained results, the following conclusions can be drawn: Through physical and chemical analysis, there is no obvious material defect or discontinuity at the bolt fracture area. It was shown that the temperature of the first thread root increases gradually and stabilizes at about 185 °C. And the thermal expansion makes the clamping force and bolt bending moment increase, which leads to more severe stress concentration at the tread root. The continuous braking leads to an overload of brake disc bolts, which contributes to the low-cycle fatigue fracture. The predicted fatigue life shows good agreement with the actual cases.

Design and analysis of disk rotor brakes under tribological material behaviour by 2020Balaji Naga Sai Abhishikt, Balaji Ramachandran, Ganti Naga Alekhya ([2] On keen sight of the results, it is straightforwardly unambiguous that the newly designed ventilated disc rotor exhibits a more suited temperature gradient than the drilled contour disc irrespective of the three metals which have been used in this analysis, that is, Grey Cast Iron, Titanium Ti-6Al-4V (Grade 5) and Chromium-Vanadium Steel. However, out of these three materials, Chromium-Vanadium steel constructed a smaller maximum temperature in the ventilated disc, about 216.22°C. The drilled contour disc with grey cast iron as the material produced the best temperature gradient among the other materials, with a maximum temperature of 320.01 _C, followed by the Chromium-Vanadium steel drilled contour disc with 329 _C as the maximum temperature. The temperature difference between the ventilated and drilled contour disc was found to be roughly 100 C higher for the grey cast iron and Chromium-Vanadium steel materials. Whereas the temperature difference between the two designs in Titanium Ti-6Al4V (Grade 5) is approximately 500 _C.

Investigation of temperature and thermal stress in ventilated disc brakes using a 3D thermo-mechanical coupling model, published in 2012.Mostefa Bouchetara (3rd) In this study, we presented a numerical simulation of the thermal behaviour of a full and ventilated disc in a transient state. By means of the computer code ANSYS 11, we were able to study the thermal behaviour of three types of cast iron (AL FG 25, FG 20 and FG 15) for a determined braking mode. In addition to the influence of the ventilation of the disc, we also studied the influence of the braking mode on the thermal behaviour of the disc brake. The obtained results are very useful for the study of the thermo-mechanical behaviour of the disc brake (stress, deformations, efficiency, and wear). Technological parameters are illustrated by the design. Numerical parameters are represented by the number of elements and the step of time. With regard to the results of the coupling, we made the following conclusions: The Von Mises stress and the total deformations of the disc and contact pressures of the brake pads increase in a notable way when the thermal and mechanical aspects are coupled.

In 2017, Squeal Analysis of a Modal-Parameter-Based Rotating Disc Brake Model, Yongchang Du, Yujian Wang [4] This paper presents a novel method to construct a modal parameter-based disc brake model that involves rotation effects and solves the system instabilities in relation to mode-merging, rotation, and negative slope friction effects. A complex eigenvalue analysis was performed on the system eigenfunction in state-space. However, this destabilizing effect decreases due to the descending friction coupling effect as the rotation speed increases. Therefore, it is believed that, as a self-excited vibration issue, the mode-merging induced by the friction coupling is the major mechanism for brake squeal. In comparison, the destabilizing effects on the system that stem from the split of repeated-root modes caused by rotation, as well as the negative damping effect caused by velocity-dependent negative slope friction, are relatively limited.

In 2017, Numerical and experimental analysis of the transient temperature field of ventilated disc brakes under the condition of hard braking, Qifei Jian, Yan Shui [5] During hard braking, temperature variation trend curves of the brake disc in the form of saw teeth increase first and then decrease a little; In the radial direction, the temperature of the middle position is higher than that of both sides. What it means is that the high temperature areas are in the effective friction zones. In the circumferential direction, the temperature always reaches the maximum at different times, but the maximum temperature of each node tends to be uniform; in the axial direction, the temperature always presents a large fluctuation in the frictional contact surfaces. As a result, thermal fatigue is more likely to occur in the surface layer; the temperature gradient of the contact areas is larger than that of the non-contact areas, and the distribution of temperature in all directions is not symmetrical; The simulation results are in agreement with the experimental results, which demonstrate that the FE model is correct.

In 2017, A Simulation-Based Approach to Model Design Influence on the Fatigue Life of a Vented Brake Disc was published. Ebiakpo Kakandar, Rajkumar Roy, and Johann Mehnen [6]. This paper presents a CAE/FEA simulation and design of experiment methodology using the Taguchi method to study the influence of geometric design factors on the fatigue life at selected critical areas of a vented brake disc and the axial deflection of the vented brake disc due to thermal inputs. The results obtained indicate that two important geometric features that influence these life performance measures are the inboard plate thickness and the length of the effective offset. In the design of the vented brake disc, more design effort should be concentrated on these features so as to obtain the best service life. Future work would be carried out to determine the influence of uncertainties on the fatigue life of the vented brake discs due to the identified significant geometric design features.

In 2020, regenerative braking system modelling by fuzzy Q-Learning, Ricardo Maia, Jérôme Mendes, Rui Arajo, Marco Silva, Urbano Nunes. [7]. The paper presented BFQL, a batch RL approach applied to fuzzy Q-Learning to model the RBF by learning the consequents of the FLmRB. The table of q-values is initialized with zeros, so the agent has no *a priori* knowledge about the best fuzzy rules' consequents. This means that, although the RMSE values obtained in the tests are similar to the ones obtained with the FLmRB, using an adequate number of episodes, the RL agent can learn the best consequents, speeding up the modelling process and using much less time than an expert. In future work, the authors plan to include (1) the automatic determination of the number of fuzzy rules and (2) the automatic determination of the position of the fuzzy rules' membership functions in the input space, and also (3) to use the method presented in the paper to make the RBF model more complete by including additional input variables such as the weight, SOC, and motor operating point.

In 2018, A method for reliability improvement in the air brake systems of compressed air cars, Dmitriy Nikitin, Artur Asoyan, Ludmila Nikitina [8]. In this paper, the ring construction that comprises good operational characteristics, low production cost, and good adaptability to manufacture is described. The comparative analytical calculations showed that using the rings of the proposed design, due to a lower friction factor between the contacting surfaces of the piston ring and the cylinder bushing, and the calculated shape of the highly adaptable elastic insert in the free state, makes it possible to increase the service life of the cylinder-piston group of the compressor by at least 20%.

In 2020, the implementation of vacuum braking systems in four-wheelers, V.S. Shaisundaram, S. Karthick, and L. Karikalan [9]. The vacuum brake has tremendously limited application due to its functions and is inappropriate for high speeds. The air brake is well organized as compared to the vacuum brake. Though it requires substantial stopping distance, Hence, it is not suitable for emergency braking. The mechanical brake must be kept in reserve in parallel with other breaking techniques that should be used to totally stop the engine at lower speed. The requisite braking force can be obtained in a wide speed range with regeneration braking. The electro-dynamic brake system intermittently malfunctions due to compound circuits. As a result, it cannot be used as an emergency brake. At high speeds, the electro-magnetic break is a competent method of breaking.

In 2019, FEA on different disc brake rotors, S.A.M. Da Silva, DVV Kallon [10]. A grooved-disc brake rotor and a drilled-grooved disc rotor were designed in Autodesk Inventor 2016. The grooved brake was designed with grooves on the surface and vanes between the plates. The holes and grooves were designed not only to provide a cooling method and reduce resin on the braking component but to allow a greater grip during braking. A simulation was performed using ANSYS on the brake system with a point load exerted tangent to both brake discs on the centre line of the rotors. The point load exerted a linear force on the system simulated with the following loads: 20KN, 23KN, 26KN, 29KN, 32KN, and 35KN. Section B-B and C-C were positioned on the hub surface, which was fixed during the simulation. Section D-D was also positioned on the filleted section around the hub of the rotors. Section A-A had the greatest displacement, measuring 0.04,1395 mm for the grooved and 0.035575 mm for the drilled and grooved. This can be attributed to a flaw within the created design. The simulation allows these flaws and critical areas to be determined to better the required design without having to apply destructive testing on the disc brake rotor.

3 METHODOLOGY

3.1 STATEMENT OF PROBLEM

If looking at the overall automotive parts, besides engines, there are more crucial parts that engineers need to take into consideration. Suspension, brake, electrical, hydraulic, and gear are all the crucial systems in the automotive area. Each system has its own functionality, which brings life to the automation industry. Brakes are such a crucial system in stopping the vehicle on all moving stages, including braking during high speed, sharp cornering, traffic jams, and downhill. All of those braking moments give a different value for temperature distribution and thermal stress. Good performance of the disc brake rotor comes from good material with better mechanical and thermal properties. Disc brake rotor designs vary depending on the vehicle. There are differences in the design and performance of disc brake rotors if compared between passenger, commercial and heavy-duty vehicles. There are also cost, weight, manufacturing capability, robustness and reliability, packaging, maintenance, and servicing constraints.

For example, heavy duty vehicles need a larger size of disc brake rotor compared to passenger vehicles. Due to that, it will increase the total weight of the vehicle as well as fuel consumption and reduce the performance of the vehicle. Moreover, the high weight of the vehicle induces high temperature increases during braking, where the higher value of temperature during braking could lead to braking failure and cracking of the disc brake rotor.

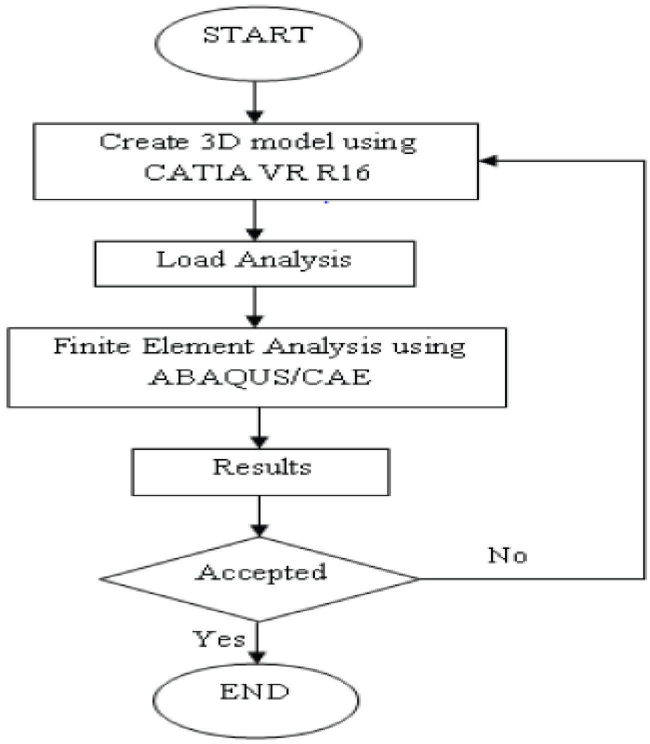
This project concerns the temperature distribution and constraint of the disc brake rotor. Most passenger cars today have disc brake rotors that are made of grey cast iron. Grey cast iron is chosen for its relatively high thermal conductivity, high thermal diffusivity, and low cost. The author will investigate the thermal issues of a normal passenger vehicle disc brake rotor, where the investigation will be to determine the temperature behaviour of the disc brake rotor due to severe braking of the disc brake rotor by using Finite Element Analysis (FEA).

3.2 RESEARCH METHODOLOGY

Beginning with a literature review, many papers and journals were read, and a portion of them were considered for this project. Coordinate Measuring Machine (CMM) has been used to measure the major coordinate of a real disc brake rotor. CMM has been used in order to get an accurate dimension of the disc brake rotor. The precise dimensions have been translated into 2D and 3D drawings by using CATIA.

In the second stage, load analysis has been done, where the heat flux and convectional heat transfer coefficients have been calculated. Load analysis is calculated based on the full load of passengers in the normal passenger vehicle. Later, the value of load analysis has been applied to finite element analysis.

Next, the fractional 3D model of the disc brake rotor has been transferred to finite element software, which is ANSYS. Thermal analysis has been done on steady state and transient responses. Assigning material properties, load and meshing of the model have been done in these stages. Then, the completed meshing model will be submitted for analysis. Finally, an expected result from the steady state and transient responses of thermal analysis has been obtained. A flow chart below shows a better understanding of the overall contents of this project.



4 MODELLING

4.1 MODELLING SOFTWARE

There are different software packages available for modelling; some of them are:

1. Solid work
1. Pro-E
1. Ideas
1. inventor
1. Mechanical desktop
1. Unigraphics
1. Catia v5

In this project, the design is developed by using **CATIA V5** software.

4.1.1 INTRODUCTION TO CATIA V5

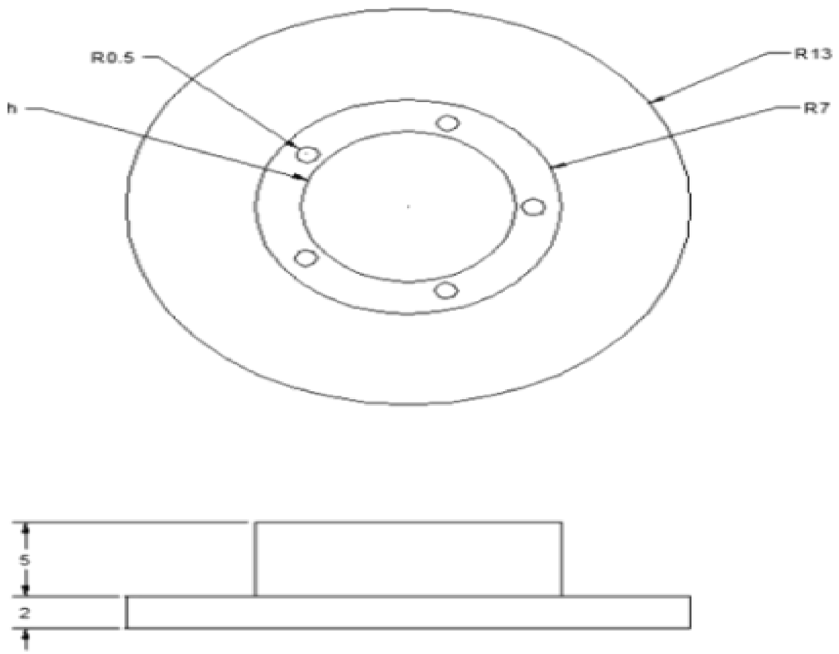
CATIA V5 provides the power of parametric design. With parametric, we define the modal according to the size and positional relationship of its parts.

PART MODELLING

Many technical designs consist of complex assemblies made from angular-shaped parts. This type of design work can be made easier by part and assembly modelling capabilities that are well integrated. The CATIA V5 is a 3-D parametric solid modeler with both part and assembly modelling capabilities. You can see how the CATIA V5 can model piece parts and then combine them into more complex assemblies. With CATIA V5, a part is designed by sketching its components' shapes and defining their size, shape, and intersegments. By successfully creating these features, you construct the part in a building block fashion. Since CATIA V5 has parametric features, you can change one feature and all related features are automatically updated to reflect the change and its effects throughout the piece. It can be used to create an angular-shaped part, to which a 3D surface can be applied to create hybrid parts consisting of a mixture of angular and curved shapes.

CATIA V5 has two operating modes for part modelling: one for modelling 3D parametric parts and another for creating 2D drawings of them. These modes operate independently but share the same design data. Part modelling requires beginning the design work in model mode, where a model of the part is immediately built. Then the drawing mode can be used at any point to document the design. In traditional CUMPUTER AIDED DESIGN, a 2D drawing is created at the beginning and then a 3D model is built to analyse and verify the initial concept.

4.1.2 DIMENSIONS OF DISC BRAKE ROTAR
SOLID TYPE



All Dimensions are in cm

Figure 4.1 solid disc dimensions

4.1.3 MODELLING OF SOLID DISC BRAKE USING CATIA V5

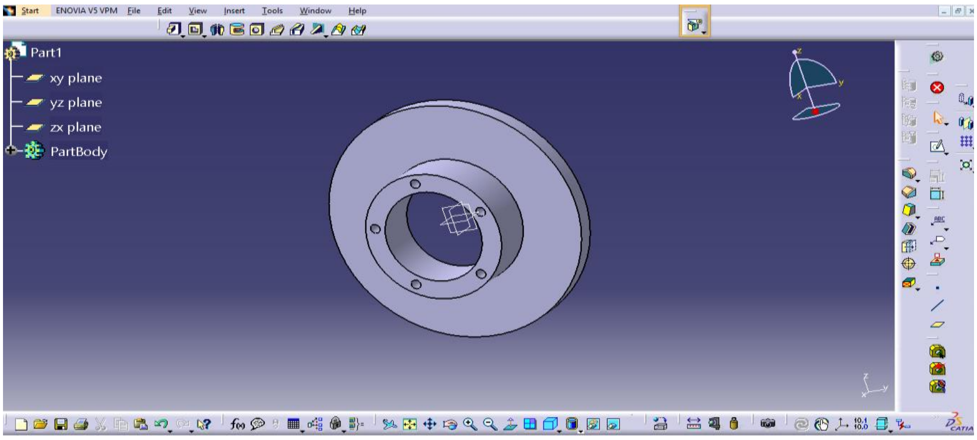


Figure 4.2 modelling of solid disc brake modelling

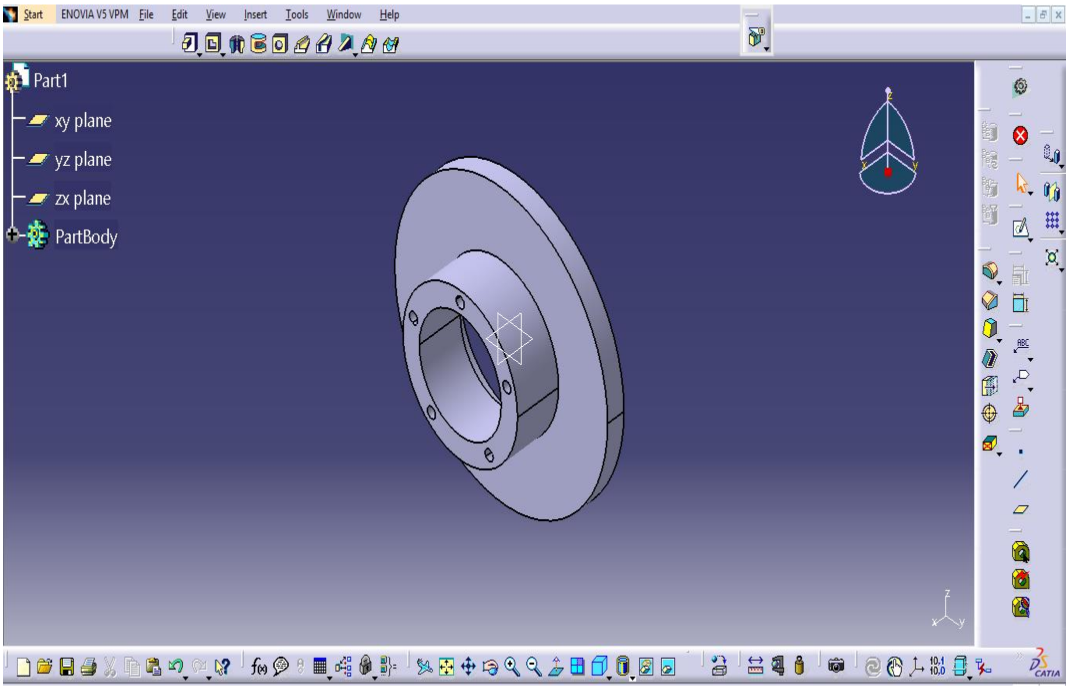


Figure 4.3 modelling of solid disc brake modelling

4.1.4 DIMENSIONS OF VENTEAD TYPE DISC BRAKE

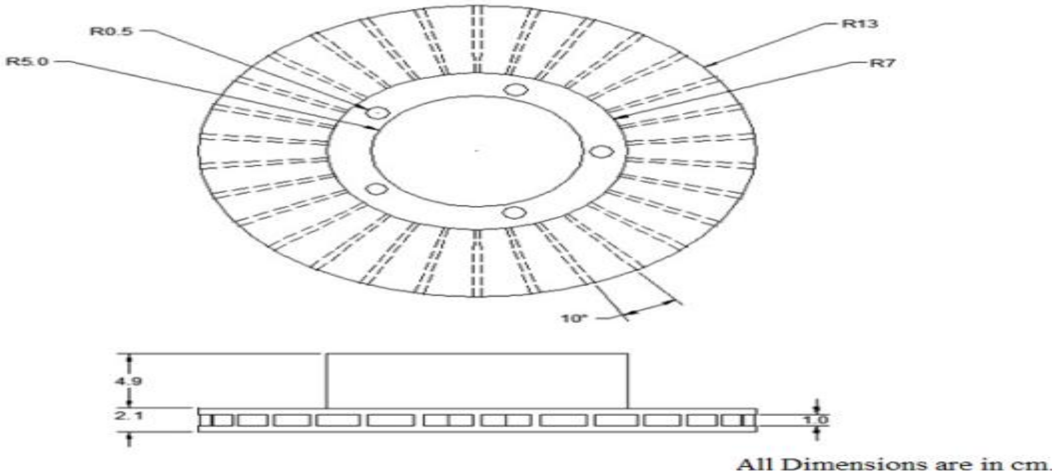


Figure 4.4 vented type disc brake

4.1.5 MODELLING OF VENTD DISC BREAK

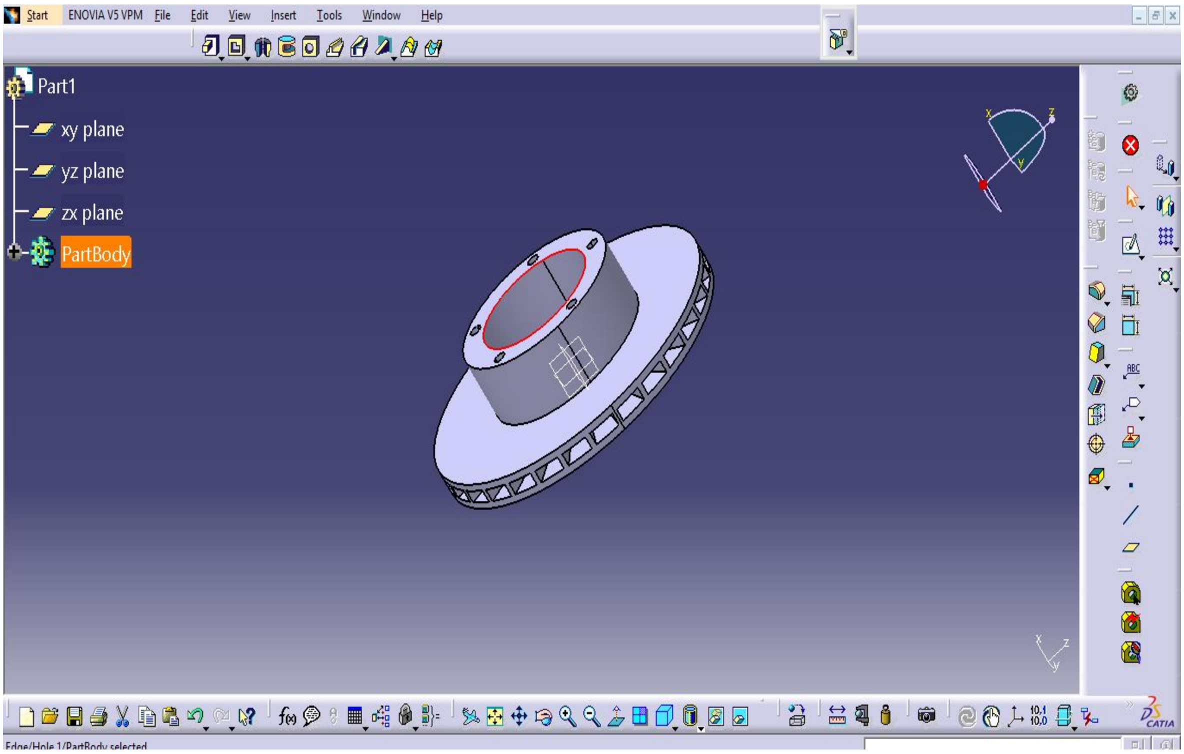


Figure 4.5 modelling of vented disc brake

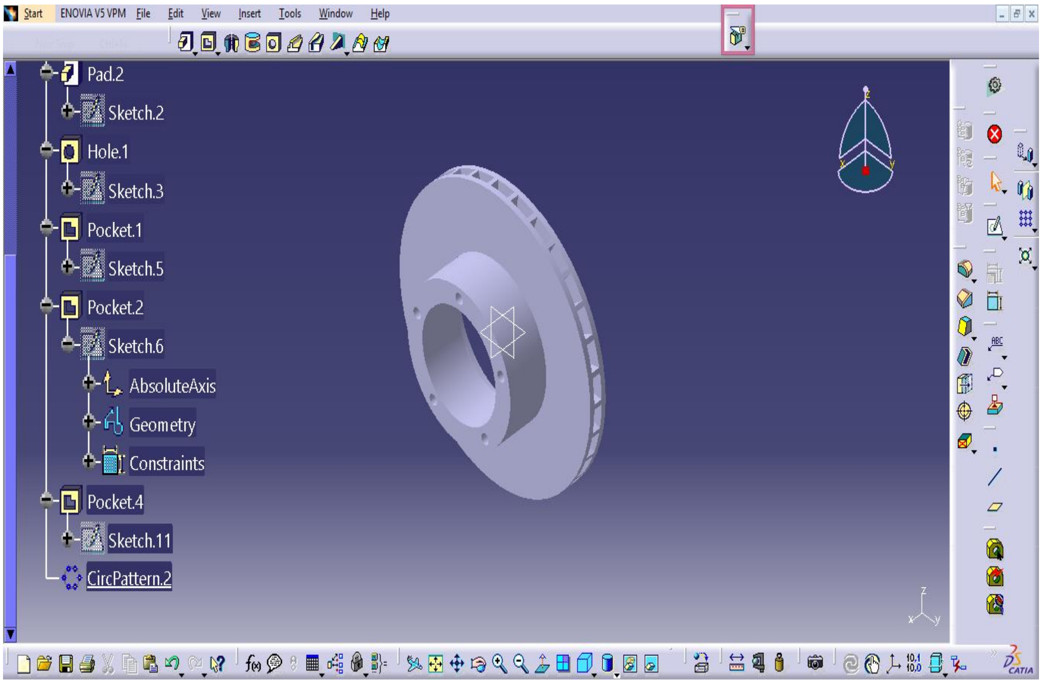


Figure 4.6 modelling of vented disc brake

4.1.6 INTRODUCTION OF FINITE ELEMENT ANALYSIS

The finite element method is a numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in almost every industry. In more and more engineering situations today, we find that it is necessary to obtain approximate solutions to problems rather than exact closed-form solutions.

It is not possible to obtain analytical mathematical solutions for many engineering problems. An analytical solution is a mathematical expression that gives the values of the desired unknown quantity at any location in the body. As a consequence, it is valid for an infinite number of locations in the body. For problems involving complex material properties and boundary conditions, the engineer resorts to numerical methods that provide approximate but acceptable solutions.

The finite element method has evolved into a powerful tool for numerically solving a wide variety of engineering problems. It has been developed simultaneously with the increasing use of high-speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis. This method started as a generalization of the structural idea to some problems of elastic continuum problems, starting in terms of different equations.

4.1.7 BRIEF INTRODUCTION OF ANASYS

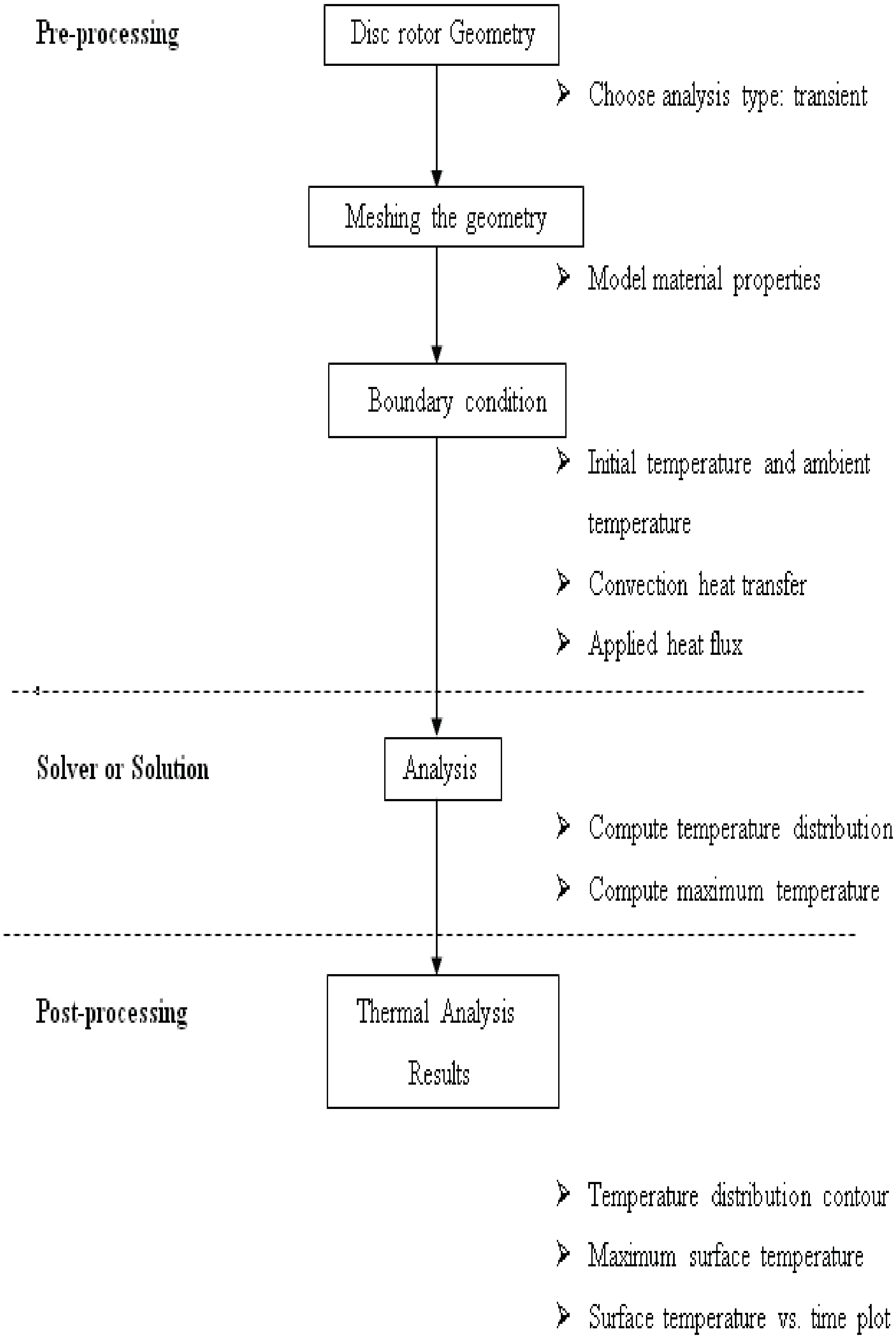


Figure 4.7 ansys introduction

4.1.8 PROCEDURE FOR ANSYS

Static analysis is used to determine the displacements, stresses, stains, and forces in structures or components due to loads that do not induce significant inertia and damping effects. Consistent loading in

response conditions are assumed. The kinds of loading that can be applied in a static analysis include externally applied forces and pressures; steady state inertial forces such as gravity or rotational velocity imposed (non-zero) displacements; temperatures

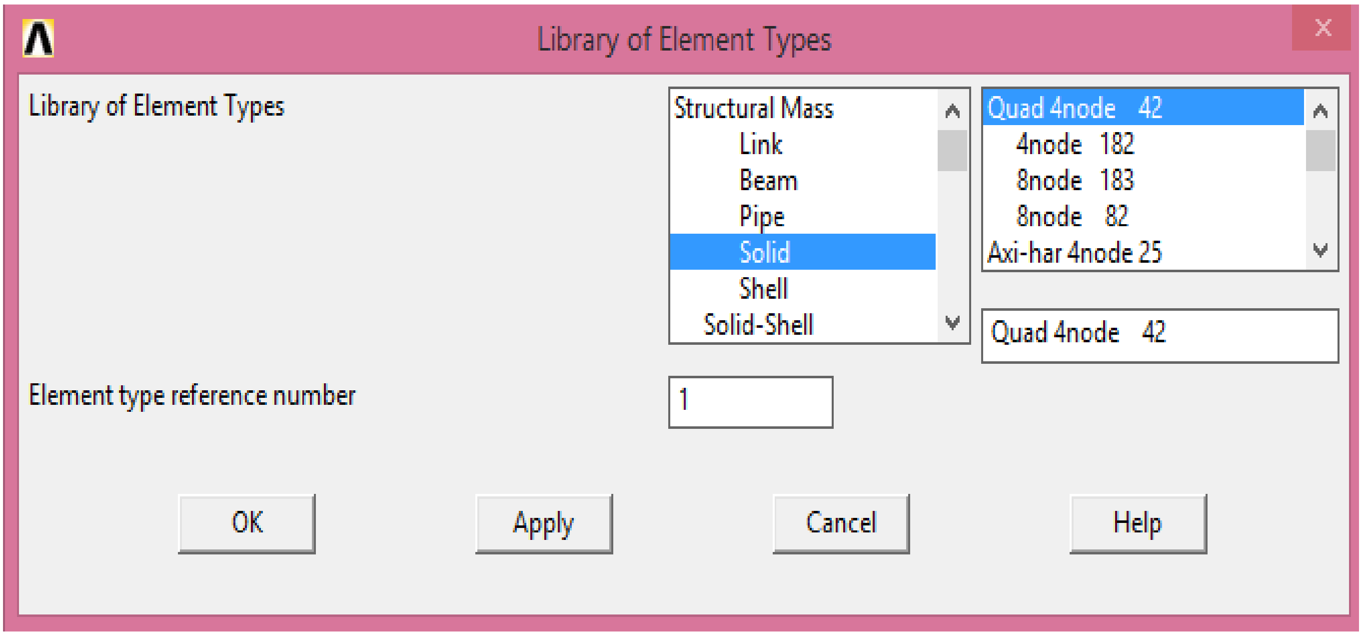
The procedure for static analysis consists of these main steps.

- Building the mode
- Obtaining the solution
- Reviewing the results

4.1.9 BUILD THE MODEL

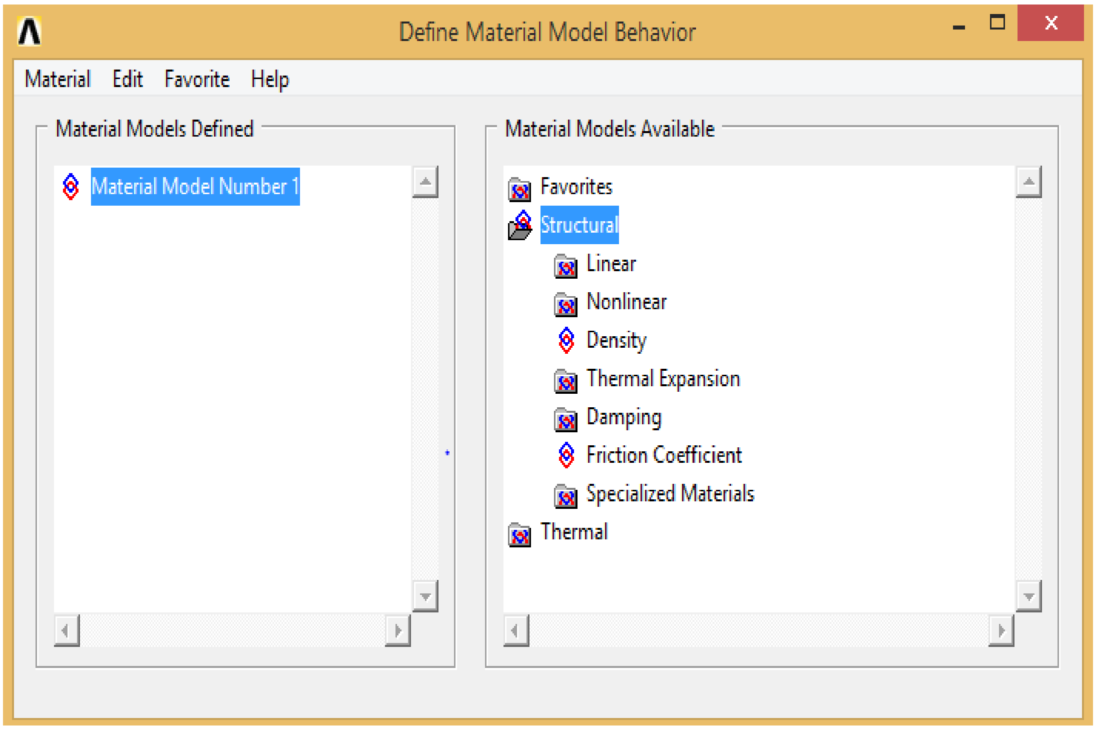
In this step, we specify the job name and analysis title. We use PREP7 to define the element types, element real constants, material properties, and model geometry element types. Both linear and non-linear structural elements are allowed. The ANSYS elements library contains over 80 different element types. A unique number and prefix identify each element type.

E.g. BEAM 94, PLAN 71, SOLID 96, and PIPE 16E



4.2.0MATERIAL PROPERTIES

A Young's modulus (EX) must be defined for a static analysis. If we plan to apply inertia loads (such as gravity), we define mass properties such as density (DENS). Similarly, if we plan to apply thermal loads (temperatures), we define the coefficient of thermal expansion.



S.NO	MATERIAL PROPERTIES	STAIN LESS STEEL	GRAY CAST IRON
1	Thermal conductivity, *k*(W/mC)	36	57
2	Density (kg/m3)	7100	7250
3	Specific heat, *c* (J/KgC)	320	460
4	Poisson's ratio	0.12	0.28
5	Thermal expansion (1/C)	10	10-85
6	Elastic modulus E (Pa)	210	138
7	Coefficient of friction	0.5	0.2

4.2.1 IMPORTING OF CATIA MODEL I N TO ANSYS

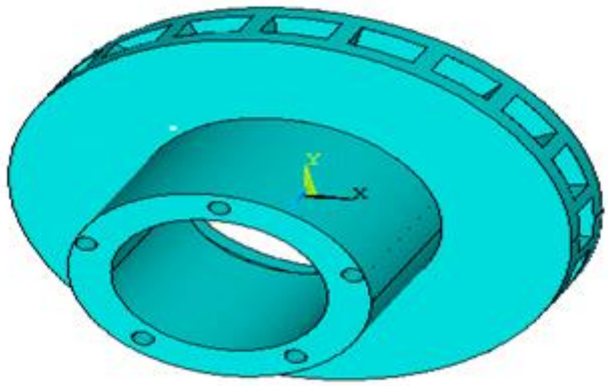


Figure 4.8 Catia model in to ANSYS

4.2.2 MESHING OF DISC BRAKE ROTAR

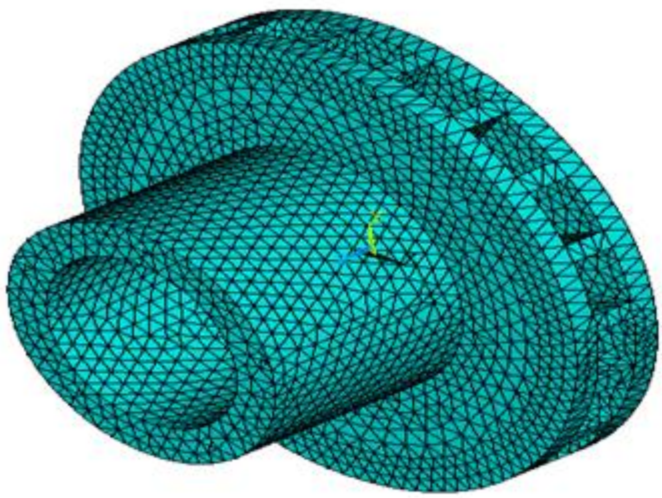


Figure 4.9 meshing of disc brake rotor

4.2.3 MESHAING DETAILS

DISC TYPE	ELEMENTS	NODES
SOLID DISC	35011	43733
VENTED DISC	14463	24832

4.2.4 SOLUTION

In this step, we define the analysis type and options, apply loads, and initiate the finite element solution. This involves three phases:

- Pre-processor phase
- Solution phase
- Post-processor phase

5 RESULT AND DISCUSSION

5.1 STAIN LESS STEEL SOLID DISC RESULTS

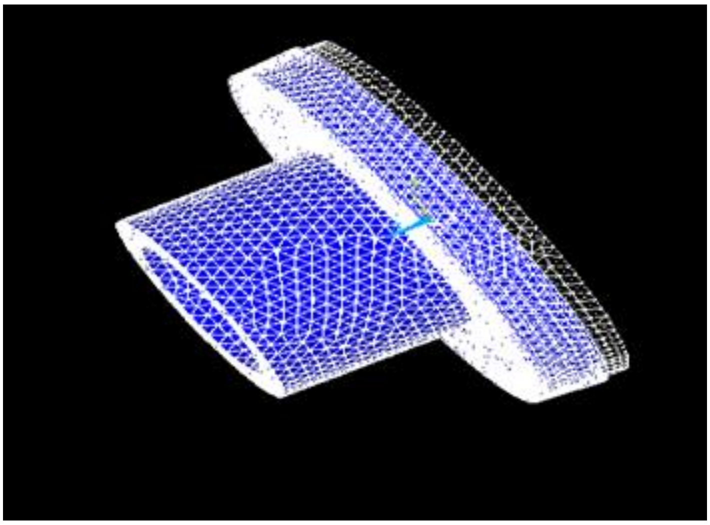


Figure 5.1 Deformation in stainless steel

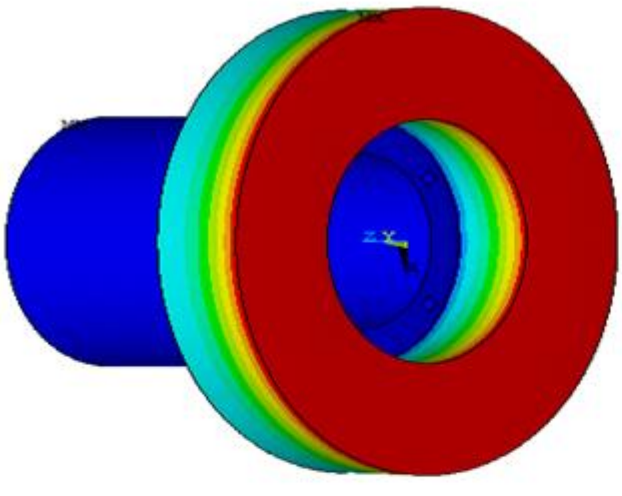


Figure 5.2 displacement sum in stain less steel

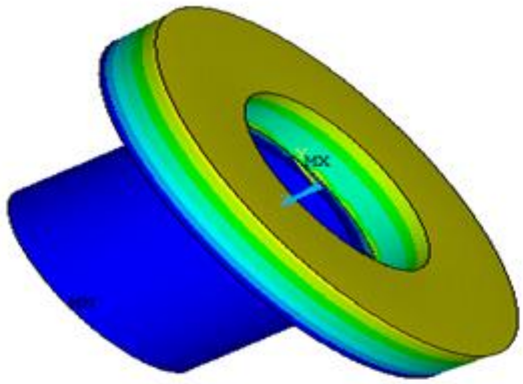


Figure 5.3 von mises stress stain less steel

(The high amount of distortional energy is being observed for stainless steel)

(Note: Von mises only considers distortion energy i.e., change in shape)

5.2 STAIN LESS STEEL VENTED DISC RESULTS

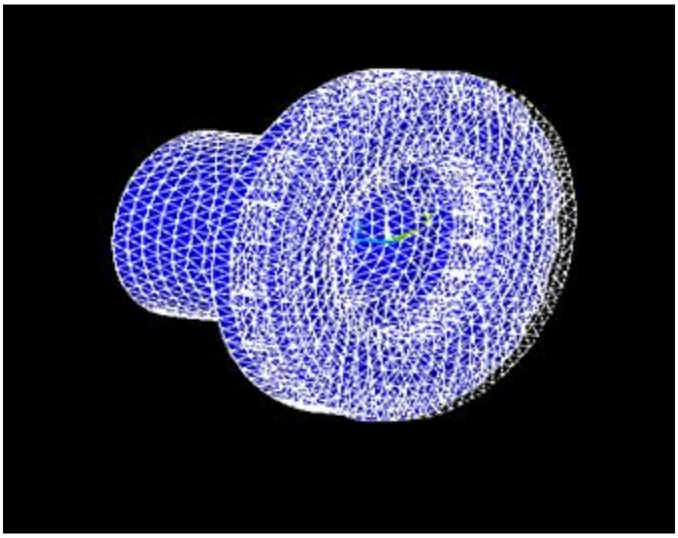


Figure 5.4 Deformation in stainless steel

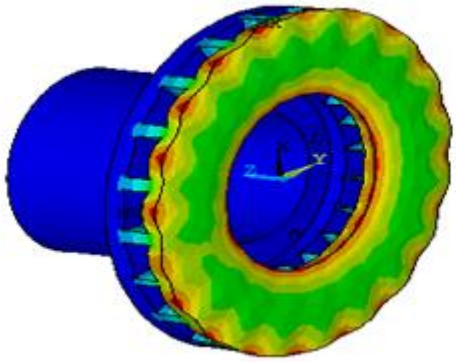


Figure 5.5 displacement sum in stain less steel

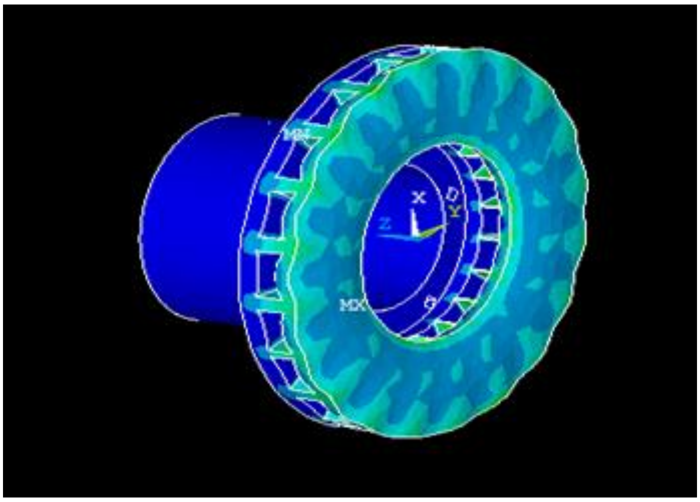


Figure 5.6 von mises stress stain less steel

Discussion:

The equivalent stress state of the material before the distortional energy reaches its yielding point is in high proportion for stainless steel, as seen in the diagram above.

5.3 GRAY CAST IRON SOLID DISC RESULTS

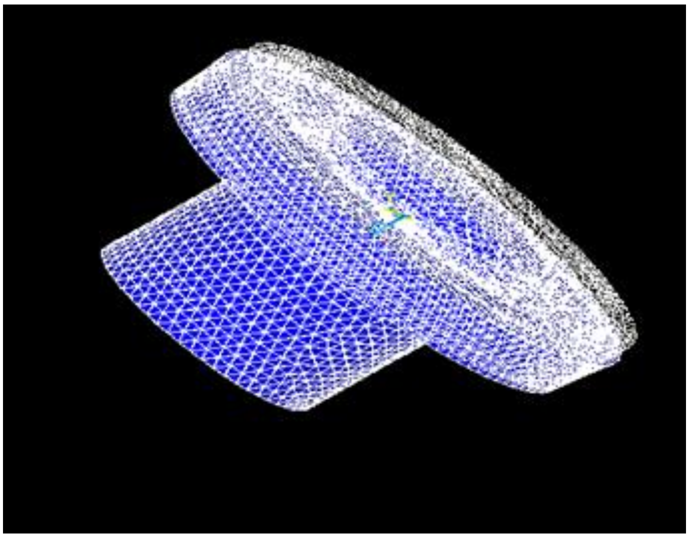


Figure 5.7 Deformation in gray cast iron

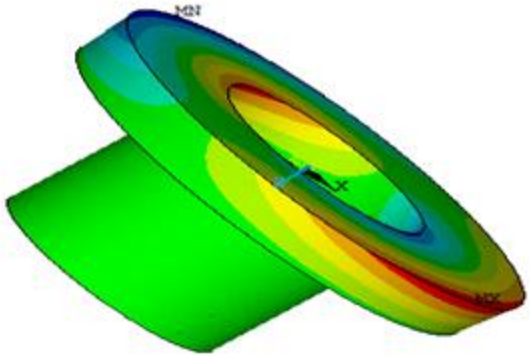


Figure 5.8 displacement sum in gray cast iron

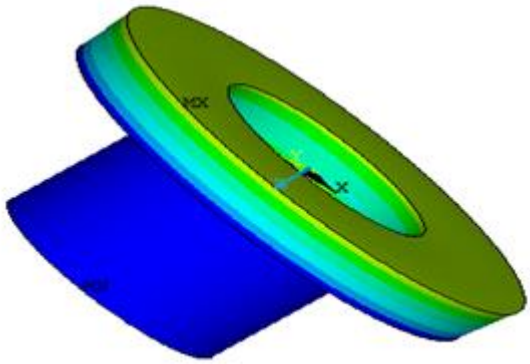


Figure 5.9 von misses in gray cast iron

5.4 GRAY CAST IRON VENTED DISC RESULTS

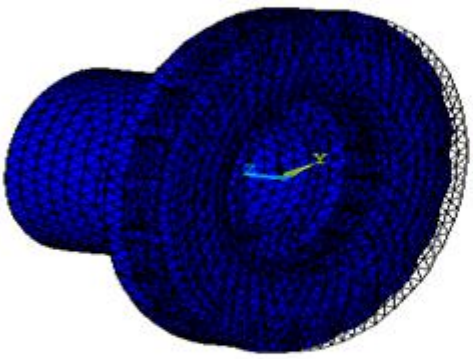


Figure 5.10 deformation in gray cast iron

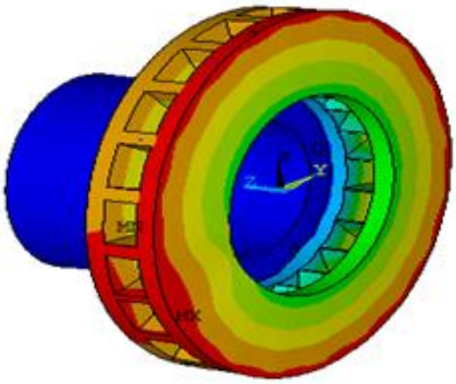


Figure 5.11 displacement sum in gray cast iron

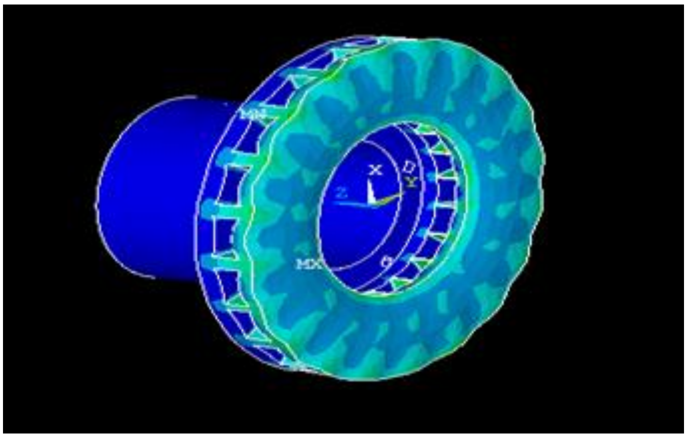


Figure 5.12 von misses in gray cast iron

Discussion:

According to the graphic above, the ratios of stress levels and total displacement for Grey Cast Iron are relatively minimal.

5.5 Table of Result Analysis (Gray Cast Iron)

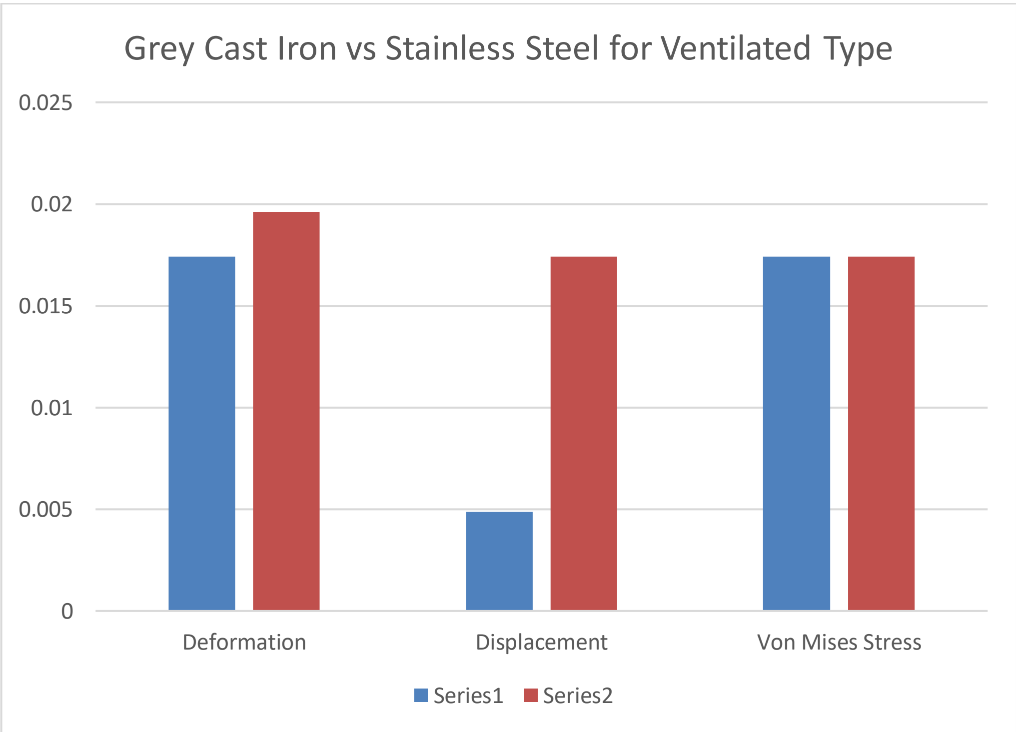
Table 5.1 Table of Result Analysis (Gray Cast Iron)

s.no	Parameters	Solid type	Ventilated type
1	**Deformation**	0.01833	0.01740
2	**Displacement**	0.00561	0.00488
3	**Von misses stress**	0.01833	0.01740

5.6 Table of Result Analysis (stain less steel)

Table 5.2 Table of Result Analysis (stain less steel)

s.no	Parameters	Solid type	Ventilated type
1	**Deformation**	0.02142	0.019606
2	**Displacement**	0.02107	0.017400
3	**Von misses stress**	0.021426	0.017405



Discussion:

The data above clearly illustrates that grey cast iron performs better in terms of deformation, total displacement, and Von Mises stress.

6. CONCLUSION & FUTURE SCOPE

- The Total Deflection (in mm) is less in vented disc brakes and the best suited material is Grey Cast Iron.
- Stresses (in MPa) are very small in Grey Cast Iron, so the best suited material is Grey Cast Iron.
- Total displacement is less in the ventilated disc and the best suited material is grey cast iron.

It is observed that the vented type of disk brakes can provide better heat dissipation than the solid ones. The present study can provide useful design tools and improve the brake performance in disk brake systems. We can say that from all the values obtained from the analysis, i.e., the Total Deformation, Von Misses Stress exhibits that the vented disc is the best suited design. After comparing the various results obtained from the analysis, it is determined that a disk brake with vents and made of Grey Cast Iron is the best possible combination for the current application.

Future Scope

Due to their excellent strength and heat dissipation, vented grey cat iron disc brake rotors have gained popularity in the automotive sector in substitute of solid disc brake rotors.

Gray cast iron materials are lightweight and sturdy, and they are employed in a wide range of goods. Gray cast iron material has greater heat dispassion and less deformation than stainless steel.

As a result, grey cast iron disc brake rotors are expected to have a bright future in the automobile sector. Because of their excellent strength-to-weight ratio, vented disc brake rotors are now used in high-end vehicles. Gray cast iron disc brake rotors will play a major part in vehicles in the future when their usage becomes economically possible due to their superior characteristics.

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LIST OF ACHIEVEMENTS

Project Achievements

- Thermal and structural analysis is done by providing materials grey cast iron and stain less steel and comparing both results and providing best suited material.
- Design & Analysis of disc brake

Learning Achievements

- Break is a mechanical device is used stop are slowing of vehicle during the motion
- Modelling is done in Catia v5 and analysis is done in analysis ANSYS