DESIGN AND ANALYSIS OF A VENTED DISC BRAKE ROTOR BY USING DIFFERENT MATERIALS THROUGH ANSYS

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Abstract
The disc brake rotor is a rotating device. Braking is a process which converts the kinetic energy of the vehicle into mechanical energy which must be dissipated in the form of heat. This paper presents the analysis of the contact pressure distributions at the disc interfaces using a detailed 3-dimensional finite element model of a real car disc brake rotor. Finite element (FE) models of the brake-disc rotor are created using CATIA V5R20 and simulated using ANSYS R23 Workbench. which is based on the finite element method (FEM). It is also investigates different levels in modeling a disc brake rotor system and simulating contact pressure distributions. It covers the contact analysis, thermal analysis and topology optimization. The effect of the angular velocity and the contact pressure distribution on disc brake rotor are investigated. In our project we take different materials like Gray Cast Iron, Aluminium Alloy, Titanium Alloy and Composite materials Carbon Fibre Reinforced Silicon Carbide. Finally comparison between these materials and carried out stresses, strains and deformations level maximum and minimum. By topology optimization the software determines which areas of a part can be removed to maximize stiffness while reducing weight and keeping maximum stress.

Keywords: Disc, Brake, Catia V5R20, ANSYS R23 Workbench, Materials, Stresses, Deformation.

Introduction
In order to increase the braking stability of vehicles at high speeds, disc brakes have become the mainstream of current braking systems. Because the disc of the disc brake system is exposed to the air, the disc has excellent heat dissipation. When the vehicle brakes suddenly at a high speed or brakes several times in a short time, the brake performance is less likely to decline as shown in fig-1.1.Better braking effect to improve vehicle safety.

Fig-1.1: Vented disc brake rotor of a car

1.1 History Of Vented Disc Brake Rotor:
Our journey begins in the early days of automotive history when the concept of braking was a far cry from today's advanced systems. Mechanical brakes were the norm, relying on external shoe brakes

and drum rotors. These early drum rotors, resembling the components found in today's lawnmowers, were simple yet effective for their time.
During the late 19th and early 20th centuries, drum brakes were the industry standard. As the name suggests, they utilized a drum-shaped rotor housing that encased brake shoes. When drivers applied the brakes, friction between the shoes and the inside of the drum rotor generated the stopping force. While functional, these early drum rotors had their limitations.

1.2 How The Disc Brake Works:

In simple terms, disc brakes use stationary brake discs to clamp the brake discs that rotate with the tires to generate friction and make the wheels turn slower.
When the brake pedal is depressed, the piston in the brake master cylinder will be pushed to build up pressure in the brake oil circuit. The pressure is transmitted to the piston of the brake wheel cylinder on the brake caliper via the brake fluid as shown in fig-1.2. When the piston of the brake wheel cylinder is under pressure, it will move outward and push the brake pads to clamp the brake disc, causing friction between the brake pads and the brake disc to reduce the wheel speed to slow down or stop the car.

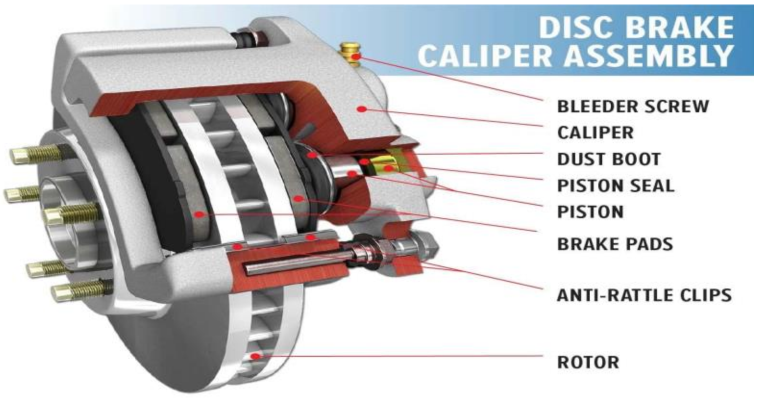

Fig-1.2: Main parts of a vented disc brake

1.3 Types Of Materials Used To Make Disc Rotors:

1.3.1 Gray Cast Iron

This is the very definition of old school when it comes to a brake rotor. It's one or two pieces and gets the job done. In fact, it's the most common material for brake rotors. The right design (usually two-piece) can even work well in a performance vehicle. However, it's also the heaviest option, which affects the overall weight of your car and its handling, since that weight is right up there with your front wheels.

1.3.2 Steel

Steel has been the racer's choice for years, because a steel brake rotor is thinner, weighs less and handles heat better. The downside: Steel rotors aren't as durable as some others, and warped rotors can cause noise and a pulsating pedal when you brake.

1.3.3 Aluminium

Aluminum brake rotors dissipate heat quickly, but they also melt at a lower temperature than other options. Aluminum is a favorite for motorcycles, which weigh less and are easier on the rotors when braking than a heavy car, truck or SUV.

1.3.4 High Carbon

These are iron, but with a lot of carbon mixed in. They can take a lot of heat and dissipate it quickly. The metallic content helps the rotor avoid cracking under high stress, and brake noise and vibration are reduced as well. The only downside is price, which is significantly higher than straight iron or aluminum.

1.3.5 Carbon Fiber

As with any high-quality vehicle part, PartsAvatar has you covered every day of the year. If you're curious about the upgrade to carbon-ceramic brakes, give them a look. The extreme durability, efficiency, performance, and resilience of carbon-ceramic brakes are certainly appealing.

1.4 Types of Disc Brakes:

There are four main types of disc brakes commonly used in vehicles: Slotted, drilled, wave, drum brakes. Wave-type disc brakes are a type of disc brake that features a wavy or undulated design on the friction surface for improved performance and heat dissipation. Slotted disc brakes have slots on the friction surface to prevent gas and debris buildup. Drilled disc brakes have holes drilled into the friction surface for enhanced cooling and gas release. Each type offers specific advantages in terms of performance and durability.

The main types of Disc Brakes are discussed below:

- Slotted Disc Brakes
- Drilled Disc Brakes
- Wave –Type Disc Brakes
- Drum Brakes.

Literature

This literature review of Design and Analysis of a Vented Disc Brake Rotor By Using Different Materials Through ANSYS software. In this we considered 20 journals to analysis the Disc Brake Rotor with different Composite materials.

Pandya Nakul Amrish et. al.,[1] The purpose of this research is to analyze different types of disc brake rotors, which are commonly used in automobile industry and to propose a new design of brake rotor. Analysis of brake rotor includes Structural analysis and Steady state Thermal analysis for each design. A comparison between the existing brake rotors and proposed new design is carried out and based on the results the best design is found out by ANSYS software.

Ali Belhocine et. al.,[2] The main purpose of this study is to analyze the thermo mechanical behavior of the dry contact between the brake disc and pads during the braking phase. The simulation strategy is based on softawe ANSYS11. The modeling of transient temperature in the disc brake is actually used to identify the factor of geometric design of the disc to install the ventilation system in vehicles. The thermal-structural analysis is then used with coupling to determine the deformation established.

Oleg Babak et. al.,[3] This paper describes the study of ventilated car disc brakes stress-strain conditions and friction under the pressure using the ANSYS environment. Such influencing factors are taken into account in the course of research as angular speed value, the pressure of the pads on the disk, the nature of the load application, convection, thermal expansion, etc. Computer modelling of the stress field and the transient thermal field in the area of contact between the pads and the disk.

Abdulwahab et. al.,[4] The results showed that the PEO alumina layer adhered well to the Al-alloy substrate and was more uniform and durable when compared to that on the Al-MMC. The PEO layer significantly improved the hardness of the rotor surface for both Al-alloy and Al-MMC substrate. The coated Al-alloy disc brake rotor was demonstrated to give good thermal and friction performance up to high rubbing surface temperatures of the order of 550oC but the rotor eventually failed due to temperature build-up at a critical location.

Mr.Dharamkar S et. al.,[5] In today's developing automobile sector, there is drastic change in the technology from transmission system to braking system. The braking system is considered as one of the most important system from performance as well as safety point of view. When the brakes are applied to the moving vehicle, all the kinetic energy of the vehicle gets converted into equivalent amount of heat generation.

Rakesh Jaiswal et. al.,[6] Braking system represents one of the most fundamental safety critical components in modern vehicles. Brake absorbs kinetic energy of the rotating parts (Wheels) and the energy is dissipated in the form of heat energy to the surrounding atmosphere. It decelerates or stops the vehicle. When brake is applied to the disc brake it is subjected to high stress, thus it may suffer structural and wear issues. Hence for the better performance, structural, stress and the thermal analysis is preferred to choose low stress material.

Mr. Aaqeebsohaib et. al.,[7] The principle of disc brake is to offer simulated frictional resistance to revolving disc directed to slow down the vehicle by the conversion of kinetic energy of the motor vehicle into heat energy which increase the extreme high temperature raise and sequentially directed to detrimental effects such as thermal resilient volatility, untimely wear, fluid vaporization and thermally disturbed vibration. This heat temperature can be dissolute into close surrounding by using thermal solidity materials.

Kankanala Sai Krishna et. al.,[8] The disc rotor is a mechanical component used in automobiles. It is used to reduce the speed of the rotating wheel and the rotor is squeezed between the brake pads. Continuous braking leads to heat generation in the disc rotor and it may also subject to wear and thermal issues.The disc rotor was modelled in SolidWorks and analysis was done on Ansys Workbench 2019 R3.

Naveed et. al.,[9] The braking system is an important and indispensable part of an automotive. The brake disc rotor forms part of the braking system and plays a significant role to effectively stop the vehicle. Therefore, the investigation of rotor design and analysis is important towards attaining optimal braking performance. In this research, three designs of vented rotor geometry were tested, namely normal vented, vented and cross-drilled and vented and slotted, and subjected to coupled thermal-structural analyses using ANSYS Workbench.

Deovrut D. Jadhav et. al.,[10] Braking is a process which converts a vehicle’s kinetic energy into mechanical energy which must be dissipated in the form of heat. During the braking phase, the frictional heat generated at the interface of the disc and pads can lead to high temperatures. The frictional heat generated on the rotor surface can influence excessive temperature rise which, in turn, leads to undesirable effects. In this project, solid type disc brake rotor of a vehicle.

G.Ranjith Kumar et. al.,[11] A brake is a mechanical device which simulated frictional safety is connected to moving machine part, to stop the movement of a machine. At present performing this function, the brakes take in either kinetic energy of the moving part or the potential energy surrendered by items being brought down by lifts and so forth. The energy absorbed by the brakes is scattered as heat. Disc brake is a recognizable car application where they are utilized broadly for car and bike wheels.

Shailendra Pratap Gautam et. al.,[12] The aim of this paper was to investigate the structural fields of the solid disc brake during short and urgent situation braking with structural material. We will take down the value of friction contact power nodal displacement and buckle for different pressure conditions using analysis software ones the value at the hand we can determine the best suitable material for the disc brake with higher life distance.We did this investigation by using WORK BENCH ANSYS 15.0 .

Prashant Patel et. al.,[13] This work is presented with “Design modification & optimization in stress, improvement in thermal behavior, and weight & cost reduction of Disc brake rotor” which studies about on disc brake rotor by modeling & analysis of two different shapes brake disc. Two Different disc brake rotors with same outer diameter & inner mounting position of holes on wheel hub as like four wheeler.

Saurabh Pachauri et. al.,[14] The present paper discusses and examine a comparative study of the materials of the carbon ceramic matrix and the gray cast iron disk. This disk brake research is used to develop the braking mechanism of passenger cars. The Ansys package used to determine the distribution of temperature, induced heat flux, equivalent stress and deformation due to heat through the disk brake. To analyze the temperature distribution across the disk using axis symmetric components, steady state thermal analysis was performed. Further structural analysis is often performed through thermal coupling analysis.

Syed Abdul Afiq Wan Sakawi et. al.,[15] In terms of temperature range, disc brakes have been used for several years and are still improving. To simulate and predict the temperature range of the disc brake, many techniques have been developed. Over time, disc brakes have evolved to be a reliable system for decelerating and stopping a car. For various applications, there have been different prototypes of disc brake systems.

Vishnu Manikeri et. al.,[16] A disc brake is a wheel brake that slows rotation of the wheel by the friction caused by pushing brake pads against a brake disc with a set of calipers. Disk brake offer higher performance, light weight, simpler design and better resistance to water interface than drum brakes. The brake disc is usually made of cast iron, but may in some cases be made of composites such as reinforced carbon–carbon or ceramic matrix composites. This is connected to the wheel and/or the Axle.

Amit Kumar et. al.,[17] Braking system is one of the most important systems in an automobile. The basic work of this system is to make the vehicle stop within a minimum distance. Disc Brake is a type of braking system which involves components like disc brake rotor, callipers, brake pads and other support components. In the braking operation, the disc rotor of this type of braking system gets heated up and over its service life.

S.Suresh Balaji et. al.,[18] In All Terrain Vehicle (ATV), each single system has been studied and developed in order to meet safety requirement. Instead of having air bag, good suspension systems, good handling and safe cornering, there is one most critical system in the ATV vehicle which is brake systems. Without brake system in the vehicle will put a passenger in unsafe position. In this project, the optimized design.

Madu Gowrisankar et. al.,[19] Brakes are most important safety parts in the vehicles. Generally all of the vehicles have their own safety devices to stop their car. Brakes function 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 of the modern vehicles and the safe operation of vehicles. In short, brakes transform the kinetic energy of the car into heat energy, thus slowing its speed.

S. Udhaya Kumar et. al.,[20] The Disc Brake is a device to halt the movement of a vehicle, a brake is a mechanical device that simulates frictional safety and is attached to a moving machine part for slowing or halting the spinning of a wheel. when brakes work, they either absorb the kinetic energy of the moving component or the potential energy released by objects being lowered by lifts and other mechanisms.

By considering all the above-mentioned journals, The disc brake rotor is a rotating device. Braking is a process which converts the kinetic energy of the vehicle into mechanical energy which must be dissipated in the form of heat. Finite element (FE) models of the brake-disc rotor are created using CATIA V5R20 and simulated using ANSYS R23 Workbench.

Modelling of A Vented Disc Brake Rotor Of Two Different Dimensions Using Catia V5 Software:

The main goal of this investigation is to investigate the temperature distribution, stresses and deformations of vented disc brakes of two designs with different materials and their dimensions. The dimensions and models are given below of Audi A3 and A6.

CATIA V5 is Computer-aided design (CAD) software which is used to build the geometry model. The geometry model of a vented disc brake rotor is drawing according to the actual dimensions of the cars. These are the two vented disc brakes which we choose and modeling in the catia software as shown in fig 3.1 and fig 3.2.

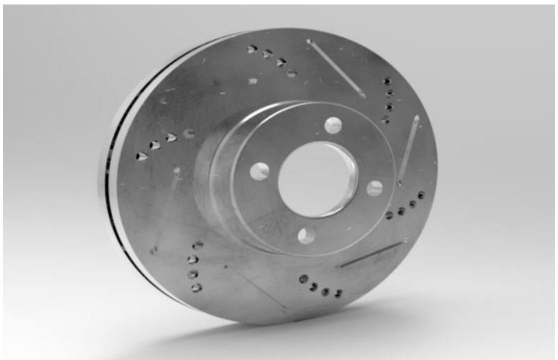

Fig-3.1: Audi A3 Vented disc brake

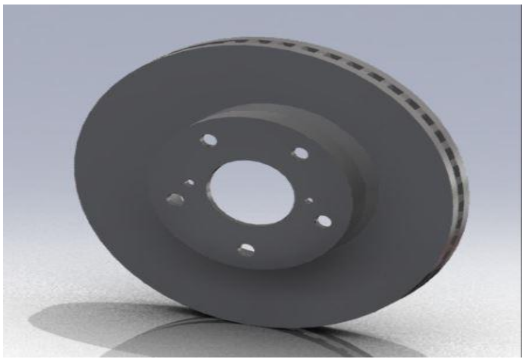

Fig-3.2: Audi A6 Vented disc brake

3.1 Dimensions of the disc brake rotor Audi A3 and Audi A6:

Table-3.1: Dimensions of the disc brake rotor Audi A3

Parameter name	Parameter value (units)
The outer diameter of the disc rotor (D_r)	330 (mm)
The inner diameter of the disc rotor	80 (mm)
Hole diameter	180(mm)
The thickness of vented with drilled holes disc rotors	30 (mm)
Drilled hole diameter	10 (mm)
Mass of the vehicle (M)	1340 (Kg)
Top Speed (V)	1738 (rpm)
Rim diameter	0.4318 (m)

Table-3.2: Dimensions of the disc brake rotor Audi A6

Parameter name	Parameter value (units)
The outer diameter of the disc rotor (D_r)	252.1 (mm)
The inner diameter of the disc rotor	141.67 (mm)
Hole diameter	58.88 (mm)
The thickness of vented with drilled holes disc rotors	23.5 (mm)
Drilled hole diameter	11.27 (mm)
ss of the vehicle (M)	1350 (Kg)
Top Speed (V)	1738 (RPM)
Rim diameter	0.4318 (m)

3.2 A 2D Dimensioning diagram of AUDI A3 vented disc brake rotor:

We are using Audi A3 and A6 model vented disc brake for modeling and for analysis as shown in fig 3.3 and 3.4

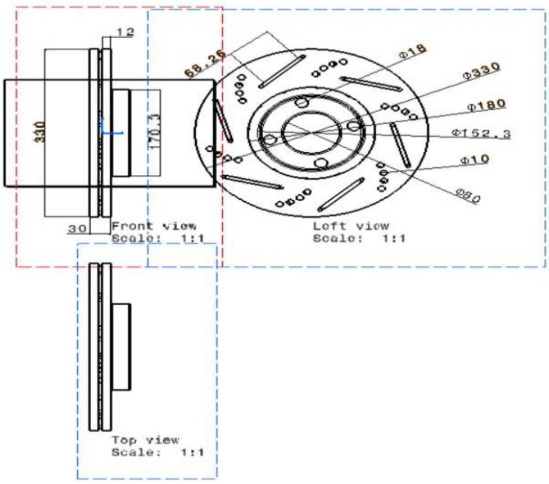

Fig-3.3: Audi A3 Disc Dimensions

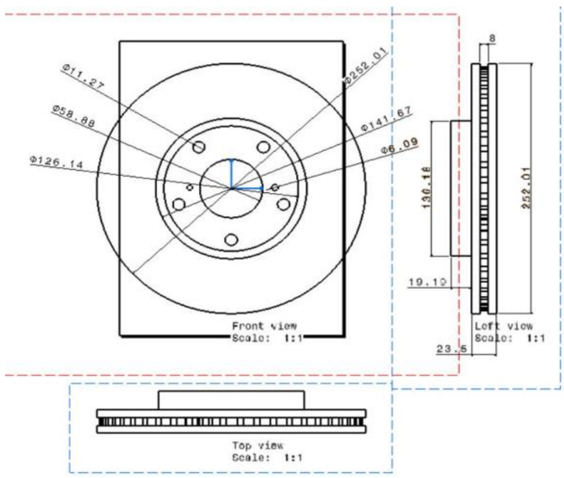

Fig-3.4: Audi A6 Disc Dimensions

3.8 Steps Involed To Draw The Design Model In Catia V5:

Drawing a vented disc brake in CATIA V5 involves several steps.

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3.8.1 Create a New Part:
- Open CATIA V5 and create a new part document.

3.8.2 Sketch the Brake Disc:
- Enter the "Sketch" workbench.
- Create a new sketch on the XY plane.
- Sketch the basic shape of the brake disc profile, considering its dimensions and features.

3.8.3 Extrude the Brake Disc:
- Exit the sketch and enter the "Part Design" workbench.
- Use the "Pad" command to extrude the sketch into a 3D solid. Specify the desired thickness.

3.8.4 Sketch the Ventilation Holes:
- Create a new sketch on the brake disc surface.
- Sketch the pattern of ventilation holes. You can use circles or other shapes for the holes.

3.8.5 Create a Hole Pattern:
- Exit the sketch and use the "Hole" or "Hole & Thread" command to create a pattern of ventilation holes on the brake disc. Specify the type, size, and pattern of holes you want.

3.8.6 Create the Ribs:
- If the brake disc has ribs or fins for cooling, create a new sketch and use the "Rib" command to extrude the ribs from the brake disc surface.

3.7.7 Add Chamfers or Fillets:
- Apply chamfers or fillets to smooth the edges and corners of the brake disc, giving It a realistic appearance.

3.8.8 Assign Material:
- Use the "Material" command to assign a material to the brake disc. This step is important for simulations and analysis.

3.8.9 Save and Document:
- Save your work regularly and create appropriate documentation for your design.

3.3 Final Model of A Vented Disc Brake Rotor Audi A3, A6:

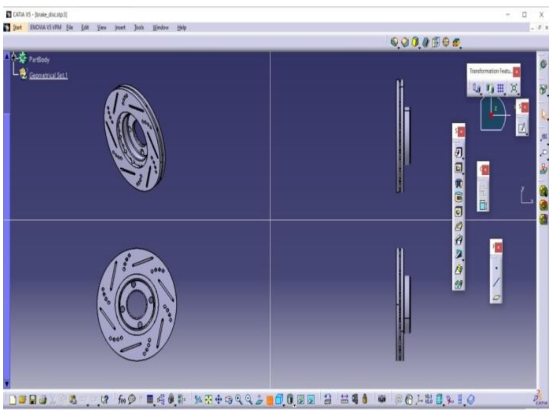

Fig -3.5: Final Model of A Vented Disc Brake Rotor A3

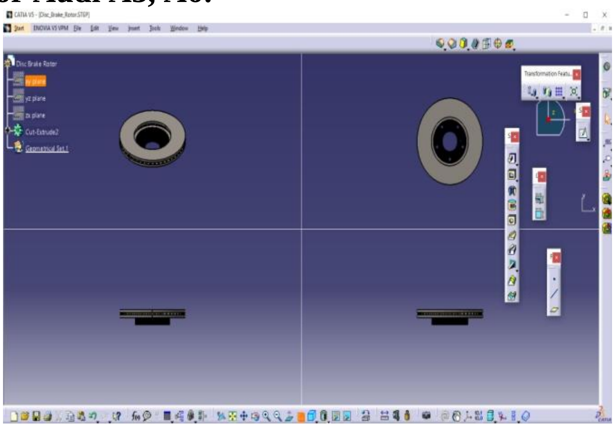

Fig -3.6: Final Model of A Vented Disc Brake Rotor A6

The above fig 3.5 and3.6 as shown that the overall design of a Audi A6 car vented disc brake rotor is ready to do analysis and analyze the results. The two different types of vented dics are created with their dimensions by using CATIA V5 software are done.

ANALYSIS

4.1 SOFTEARE USED FOR ANALYSIS:

ANSYS WORKBENCH R2 is a CFD tools utilized by engineers or researchers for design and analysis the performance of model. ANSYS can work integrated together with another employed

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engineering software program on computer with the addition of CAD and FEA connection modules. ANSYS can import model designs from the CAD program and also can develop geometry in the pre-processing step.
The software is continually updated to incorporate new features and improvements. Users can choose specific modules based on their simulation needs, and the software is known for its accuracy and reliability in providing realistic simulation results.

4.2 STEPS USED IN ANSYS:

The procedure utilized to simulate the vented disc brake rotors with different materials by ANSYS Transient Thermal and Static structural simulation software is presented below:

- Design of disc brake rotor.
- Material selection.
- Analysis of disc brake rotors.
  - Transient thermal analysis.
  - Static structural analysis.
- Evaluating results from the analysis.
- Comparing the results of different materials for different iterations.

4.3 STEPS INVOLVED IN ANALSYS:

Analyzing a vented disc brake using ANSYS software involves several steps.

❖ Including geometry creation,
❖ Meshing,
❖ Material assignment,
❖ Boundary Conditions, sand Solution setup.

In this analysis we are taken two different cars of vented disc brake rotors to find which material is best for thermal and static analysis. We are taken four different materials to do the analysis.
The materials are taken:

1. Gray cast iron
2. Carbon fiber reinforced silicon carbide
3. Aluminium alloy
4. Titanium alloy.

Both disc brake rotors have the same materials and same analysis are done in this projet to identify which material is best for Heat dissipation and Deformation.

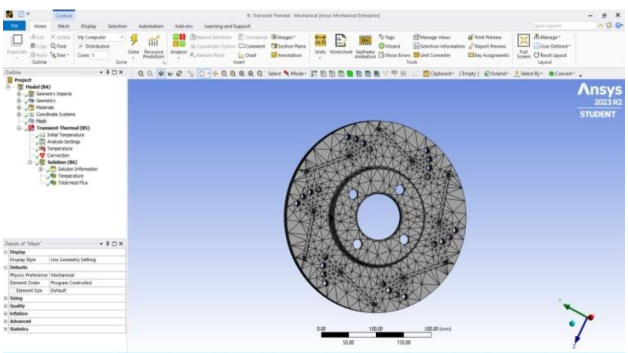


Fig-4.1: Audi A3 Vented disc brake rotor fine meshing in ansys software

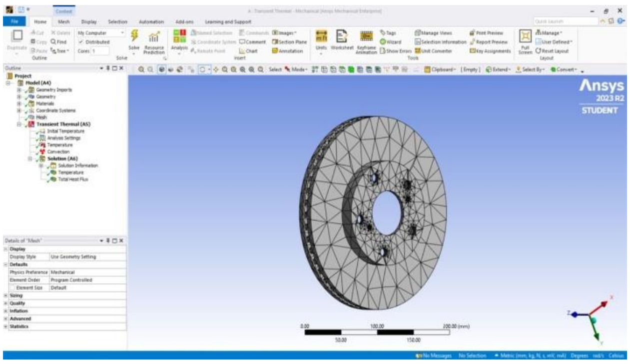


Fig-4.2: Audi A6 Vented disc brake rotor fine meshing in ansys software

Generate an automatic mesh in the Model part as shown in fig-4.1 and fig 4.2. In the context of simulation software like ANSYS, a mesh is a discretized representation of the geometry.
Take the Transiant thermal analysis and give the boundary conditions. As shown in fig 4.3 and fig 4.4. Which the initial temperature of the disc is given 22(°C) and final temperature is 220(°C). Apply in a table manner which the temperature is run along with the time and give the required results apply all

the boundary conditions.

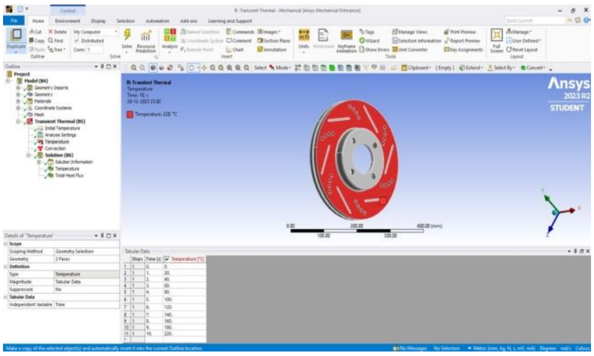


Fig-4.3: Audi A3 Vented disc brake rotor boundary conditions are applied in ansys

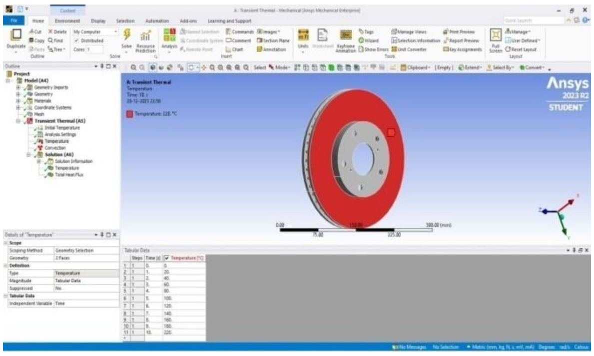


Fig-4.4: Audi A6 Vented disc brake rotor boundary conditions are applied in ansys

4.4 ANALYTICAL CALCULATIONS:

To Find The Static Structural Analysis We Need Some Loads To Apply On The Disc And Analyze The Total Deformation, Stresses And Strains.

Car kerb weight = 1340 kg

Velocity v = 100 km/hr = 27.77 m/sec

KE = $1/2\ mv^2 = 1/2 \times 1250\ (27.77)^2 = 5.1 \times 10^5$ Joules

Braking force (F_B) = work / Displacement = W/s = $5.1 \times 10^5/55.2$ = 9360.25 N Now we take 60% and 40% ratio

So 60% (5616.15 Non front Two wheels) and (3744 Non rear two wheels) For Single wheel (Front) Force = 5616.15/2 = 2808.05 N

Force by one piston = 1674/4 = 418N

Velocity (v) = ΠDN/60 = 27.77 = Π X 0.300 X /60 N = 1767.89 say = 1768 RPM

W = 2ΠN/60 = 2 X 3.14 X 1768 /60 = **185.144** rad/sec

Piston Pressure = Force/Area P = F /A

Area = $\Pi / 4 \times d^2 = \Pi / 4 \times (28)^2 = 615.75\ mm^2$ P_1= 702.018/615.75 = **1 MPa**

P = P1 + P2 = 1 +1 = **2 MPa**.

4.5 STATIC STRUCTURAL ANALYSIS:

In static structural which can find out the Total deformation, Stresses, and Strains of both disc brake for same materials.

1. By continuing the process we need to fixed the body at one direction of both disc brake rotor.
2. After fixed support we have to apply pressure on both sides on the disc rotor as. We are applied 1Mpa on each side of the disc P1 = 1Mpa, P2 = 1Mpa are applied for both Audi A3 and A6 disc brake rotors.
3. After applying the pressure on both sides we have to applied rotational velocity on both disc rotors of 185.144 rad/sec and selecting the central axis respectively.

The transiant thermal and static structural analysis is done by the required boundary conditions and loads to analyze the results to found out which materials are suitable for making disc brake rotors. The results are shown below.

5.1 Results of Transiant Thermal, AUDI A3:

By this analysis we are finally found that the best material for making vented disc brake rotors. The temperature dissipertion, stresses, strain and total deformations are analyze with different composite materials and finalize which material were shown better results in both Audi A3, A6 to make vented disc brake rotors.

We are taken four types of composite materials generally used to make disc brakes they are:

- Gray Cast Iron
- Aluminium Alloy
- Titanium Alloy
- Carbon Fiber Reinforced Silicon Carbide

The boundary conditions were applied on the disc brakes are initial temperature 22(°C) minimum and 220(°C) maximum. The results of temperatures and Total heat flux are shown in fig 5.1 to fig 5.8.

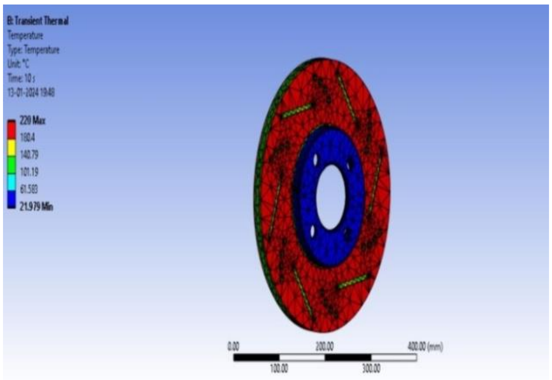


Fig-5.1: AUDI A3, Temperature of Gray Cast Iron

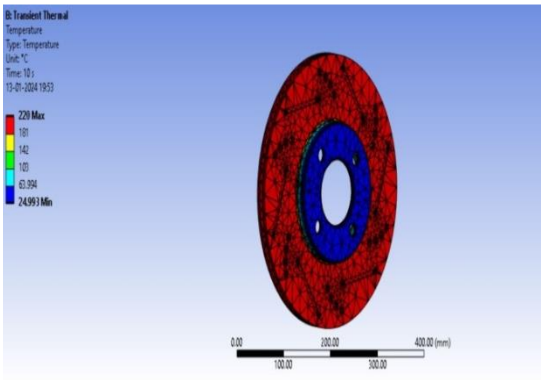


Fig-5.2: AUDI A3**,** Temperature of Aluminium

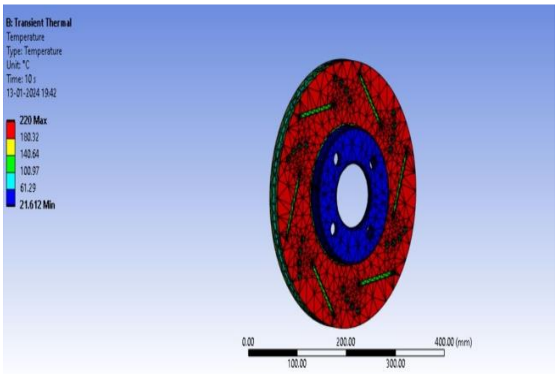


Fig-5.3: AUDI A3**,** Temperature of Titanium Alloy

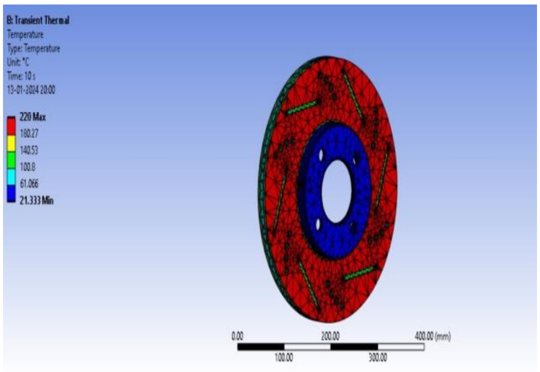


Fig-5.4: AUDI A3**,** Temperature of Carbon Fiber Reinforced Silicon Carbide

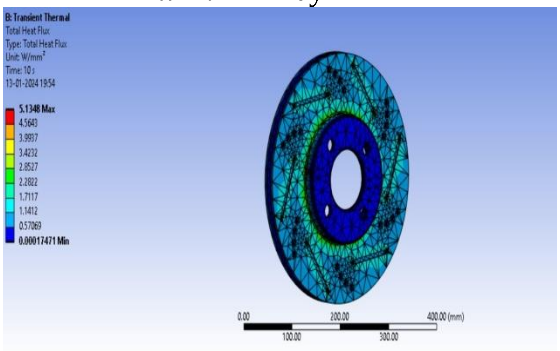


Fig-5.5: AUDI A3**,** Heat flux of Gray Cast Iron

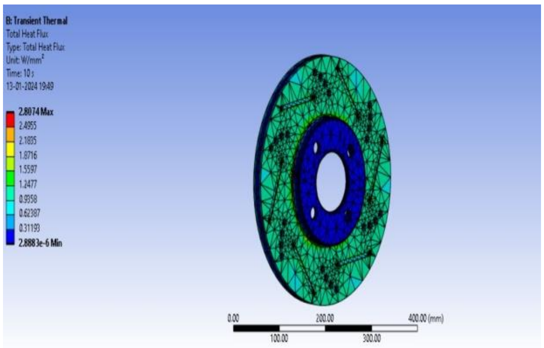


Fig-5.6: AUDI A3**,** Heat flux of Aluminium Alloy

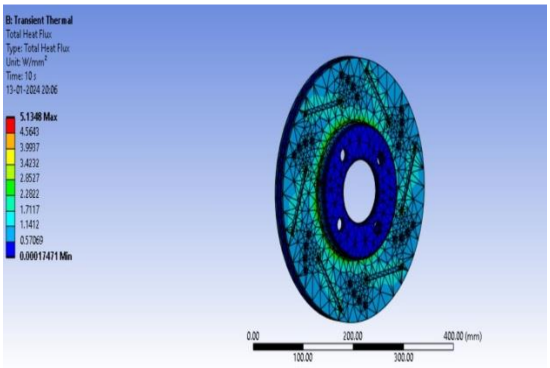


Fig-5.7: AUDI A3, Heat flux of Titanium Alloy

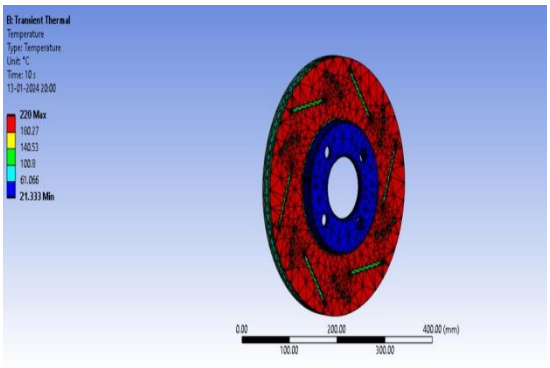
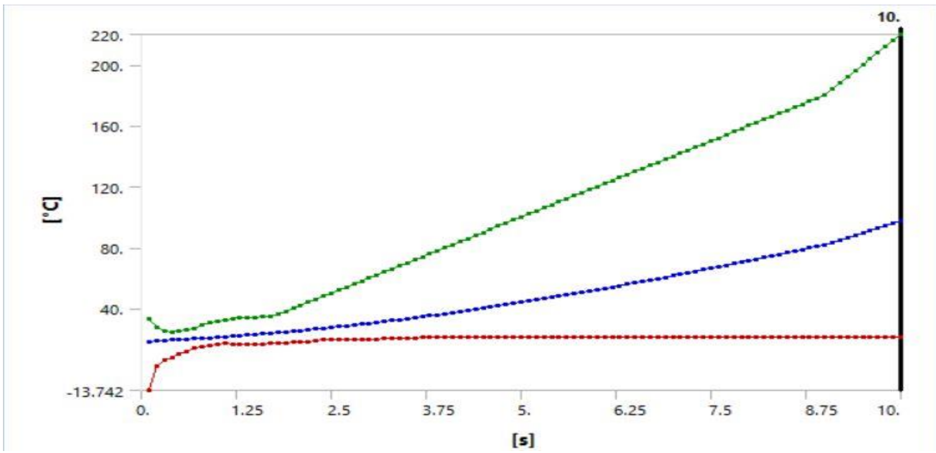


Fig-5.8: AUDI A3, Heat flux of Carbon Fiber Reinforced Silicon Carbide

The temperatures and Heat Flux are different for all types of materials. The desired values are shown in the below table 5.1. Carbon fiber shows the better heat dissipertion.

Table-5.1: Audi A3, disc brake temperatures and heat flux respect to time

SNo	Materials	Temperatures (°c)	Heat Flux (W/mm²)
1	Gray Cast Iron	21.979 (Min)	2.8074
2	Aluminium Alloy	24.993 (Min)	5.1348
3	Titanium Alloy	21.612 (Min)	1.396
4	Carbon Fiber Reinforced	21.333 (Min)	3.3254



Graph-5.1: Audi A3, Graph for temperatures respect to time

The above table shows that the temperatures are different from each other. As shown in graph 5.1. The material which gives the better results is Carbon fiber. The composite materials which are used in Audi A3 vented disc brake gives the analysis that the carbon fiber dissipates the more heat.

5.2 Results of Static Structural, AUDI A3:

By applying the loads as shown in fig 5.9 to 5.11 on the disc brake rotor pressure, rotational velocity, and fixed support to find the total deformation, stress, strain for different composite materials and the results are given below. These are carbon fiber composite material results.

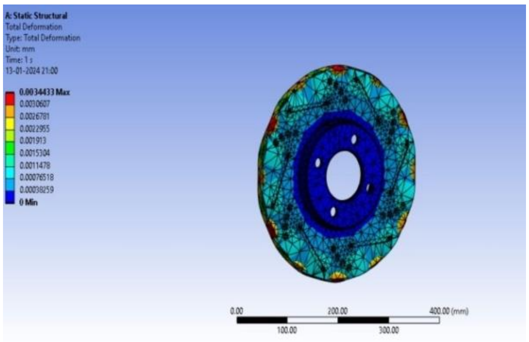


Fig-5.9: AUDI A3, Total Deformation of Carbon Fiber

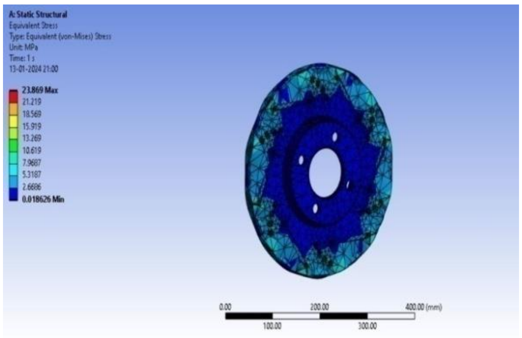


Fig-5.10: AUDI A3, Total Stress of Carbon Fiber

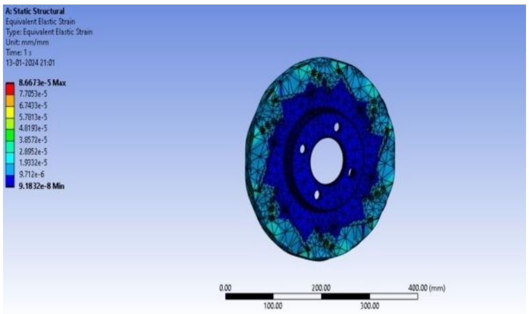


Fig-5.11: AUDI A3, Total Strain of Carbon Fiber

Table-5.2: Audi A3, disc brake Total deformation, Stress, Strain

S.No	Materials	Total Deformation (mm)	Equivalent Stress (Mpa)	Equivalent Strain
1	Gray Cast Iron	0.017326	24.0168	0.00024075
2	Aluminium Alloy	0.016534	23.58	0.003616
3	Titanium Alloy	0.015503	23.24	0.0002646
4	Carbon Fiber Reinforced Silicon Carbide	0.0034433	28.869	8.6673e-5

By observing these results all the composite materials are shown better performance. As shown in the table 5.2. But carbon fiber shows the more better than other materials. The temperature, total deformation, stress and strain values are more efficient than remaining materials. By using carbon fiber composite material the heat dissipation is fast compare to other materials the carbon fiber vented disc brake are showing better results in audi a3 car.

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5.3 Results of Transiant Thermal, AUDI A6:

The boundary conditions were applied on the disc brakes are initial temperature 22(°c) minimum and 220(°c) maximum. The results of temperatures and Total heat flux are shown below fig 5.12 to 5.15.

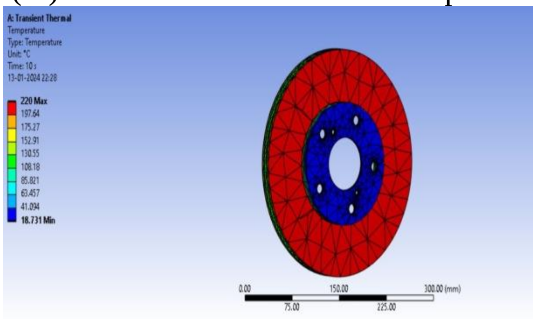


Fig-5.12 : AUDI A6,Temperature of Gray Cast Iron

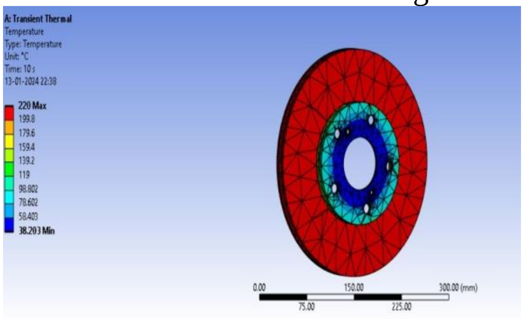


Fig-5.13: AUDI A6**,** Temperature of Aluminium Alloy

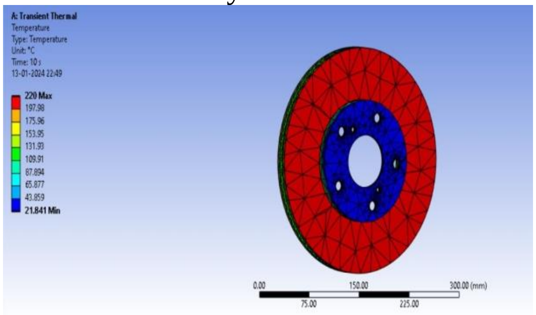


Fig-5.14: AUDI A6**,** Temperature of Titanium Alloy

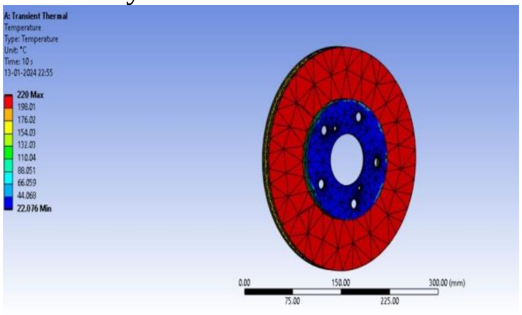
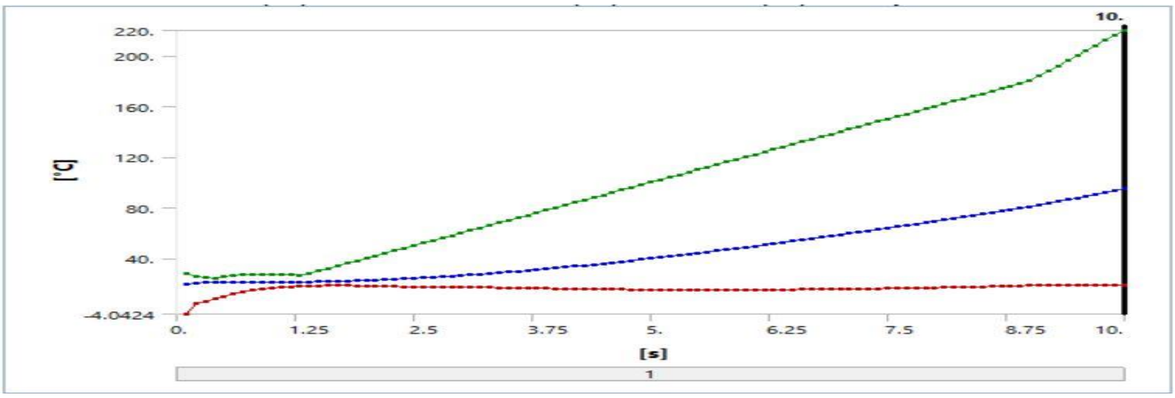


Fig-5.15 : AUDI A6**,**Temperature of Carbon Fiber Reinforced Silicon Carbide

The temperatures and Heat Flux are different for all types of materials. The desired values are shown in the below table-5.3. Carbon fiber shows the better heat dissipation. The temperature dissipation, stresses, strain and total deformations are analyze with different composite materials and finalize which material were shown better results in Audi A6 to make vented disc brake rotors.

Table-5.3: Audi A6, disc brake temperatures and heat flux respect to time

S.No	**Materials**	**Temperatures (°C)**	**Heat Flux (W/mm²)**
1	Gray Cast Iron	21.841 (Min)	1.3566
2	Aluminium Alloy	38.203 (Min)	0.83238
3	Titanium Alloy	21.841 (Min)	1.3419
4	Carbon Fiber Reinforced Silicon Carbide	18.731 (Min)	0.53219



Graph-5.2: Audi A6, Graph for temperatures respect to time

The above table shows that the temperatures are different from each other. The material which gives the better results is Carbon fiber. The composite materials which are used in Audi A6 vented disc brake gives the analysis that the carbon fiber dissipates the more heat.

5.4 Results of Static Structural, AUDI A6:

By applying the loads on the disc brake rotor pressure, rotational velocity, and fixed support to find the total deformation, stress, strain for different composite materials and the results are given below as shown in fig 5.16 to 5.18. These are carbon fiber composite material results.

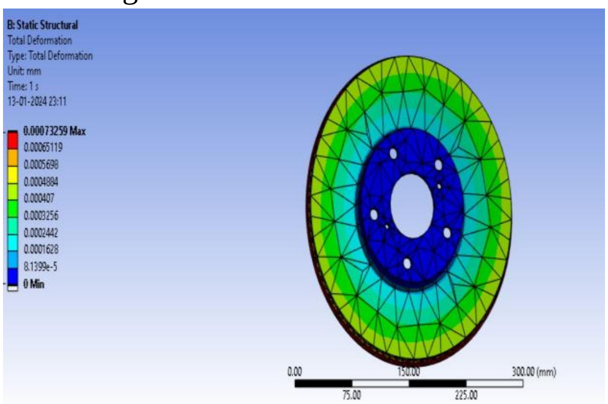


Fig-5.16: AUDI A6, Total Deformation of Carbon Fib

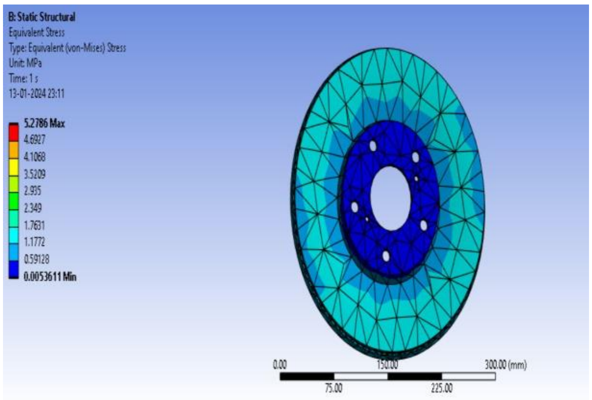


Fig-5.17: AUDI A6, Total Stress of Carbon Fiber

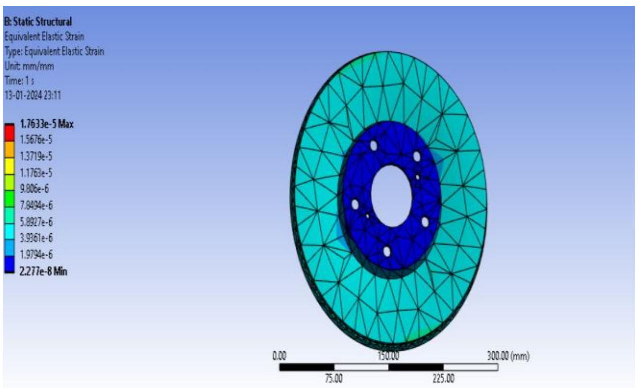


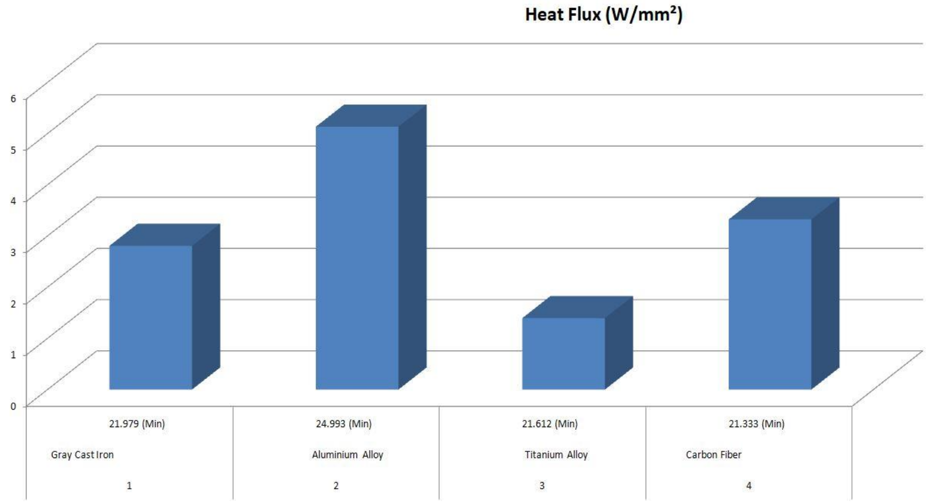
Fig-5.18: AUDI A6, Total Strain of Carbon Fiber

Table-5.4: Audi A3, disc brake Total deformation, Stress, Strain

SNo	Materials	Total Deformation (mm)	Equivalent Stress (Mpa)	Equivalent Stress
1	Gray Cast Iron	0.00273259	6.6186	1.7633e-5
2	Aluminium Alloy	0.0053496	7.5649	7.5649e-5
3	Titanium Alloy	0.0043639	5.6924	6.0386e-5
4	Carbon Fiber Reinforced Silicon Carbide	0.00073259	8.2786	1.7633e-5

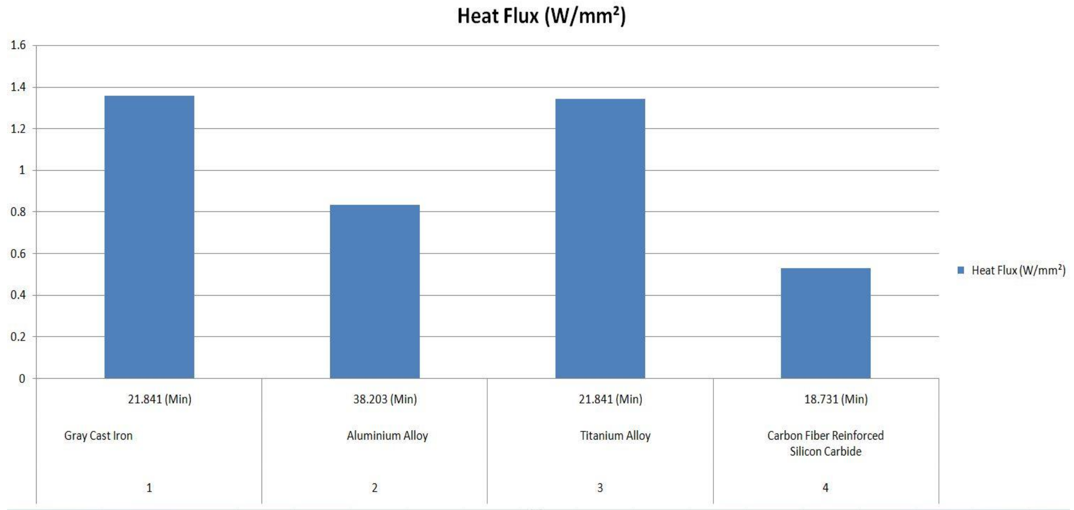
By observing these results all the composite materials are shown better performance. but carbon fiber shows the more better than other materials. The temperature, total deformation, stress and strain values are more efficient than remaining materials. By using carbon fiber composite material the heat dissipation is fast compare to other materials the carbon fiber vented disc brake are showing better results in audi A6 car.

5.5 DISCUSSION:



Temperature

Graph-5.3: AUDI A3, Disc brake Temperature and Heat Flux Comparision chart



Temperature

Grap-5.4: AUDI A6, Disc brake Temperature and Heat Flux Comparision chart

In above Graphs 5.3, 5.4 and table 5.4 its cleared that we are taken different four materials and seen that the maximum temperatures, heat flux, von misses stress, total deformation and strain value for All material like Gray Cast Iron, Titanium Alloy, Aluminium Alloy and Carbon Fiber respectively are 6.6186MPa, 7.5649MPa, 5.962MPa and 8.2786MPa and temperatures are 21.841(°C), 38.203(°C), 21.841(°C), 18.731(°C). Here we can clearly observed that Carbon Fiber has considerable value of stresses compare to other materials.

We get maximum deformation value for all material like Gray Cast Iron, Titanium Alloy, Aluminium Alloy and Carbon Fiber respectively are 0.00273259 mm, 0.0053496 mm, 0.0043639 mm and 0.00073259 mm .The values are for both AUDI A3, A6 got effiecinetly.

Here we can clearly observed that Carbon fiber has very less value of deformation compare to other materials and it is desirable under the limit. So it is safe for future design.

So we suggest Carbon Fiber for brake rotor design in future . Because it is light weight and durable material.

Carbon Fibers needs to be layered in multiple directions to be useful (some what like ply wood).If not, all the fibers will be going in one direction and the material will be prone to splitting because there will be no strength in the cross- wise direction, just like wood veneer. If you layer carbon fiber in such as way as to have most uniform properties (also-called “quasi-isotropic” laminate) you end up with overall properties somewhat like Aluminium. In fact, if you do this, you will end up with a laminate that’s a bit heavier than Aluminum.

So, after all that, how much lighter and stiffer is it? Well, the better answer is if you have a structure that can take advantage of the directional properties of carbon Fiber, like a bicycle wheel or frame tube, or a helicopter blade, where certain pieces of it can be aligned with the flexing or stress that the part will see, you can get up to about a 30% weight savings over Aluminum.

CONCLUSION

The disc brake is a device for decelerating or stopping the rotation of a wheel. Braking is a process which converts the kinetic energy of the vehicle into mechanical energy which must be dissipated in the form of heat. This paper presents the analysis is of the contact pressure distributions at the disc interfaces using a detailed 3-dimensional model of a real car disc brake. Determination of the braking force is the most crucial aspect to be considered while designing any braking system. The generated braking force should always be greater than the required braking force. The calculation of required clamping force helps us to decide the parameters of the disc brake rotor. Modeling and analysis of disc brake rotor is done to select the best material which is more durable. Space and assembly constraints are also an important factor while designing the rotor body. Find out the value of deformations and stresses due to cause of pressure. We take four different materials Grey Cast Iron, Aluminium Alloy, Titanium Alloy and Carbon Fiber in our research. Analysis is done on these materials and conclude that Carbon Fiber shows the high heat dissipation, heat flux, minimum stress and deformation values in boundary conditions. So Carbon Fiber is subjected for future manufacturing of Disc Brake Rotor.

The cost of the carbon fiber vented disc brake is more than compare to other materials but the life spam of a carbon fiber disc brake is more than ordinary vented disc brakes. So Carbon Fiber is subjected for future manufacturing of Disc Brake Rotor.

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