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"DESIGN & ANALYSIS OF DISC BRAKE ROTOR BY USING ANSYS SOFTWARE"

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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 CATIAV5R20 and simulated using ANSYS 16.2 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 Finite Element Method approaches in the automotive industry the contact analysis and thermal analysis. 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 Alloy, Aluminium Alloy ALSI 398, Aluminium Alloy 1300, Titanium and Composite materials Carbon fibre. Finally comparison between these materials and carried out stresses and deformations level maximum and minimum then we have find out , Carbon fiber is best materials other than materials because its light weight and durable.

Keyword: *Gray Cast Iron , Aluminium Alloy, Titanium Alloy, Carbon fiber, Stresses , Deformation, CATIA, ANSYS, Disc brake caliper*

I. INTRODUCTION

The brakes designed for the purpose of racing need to have very high braking efficiency. The wear and tear of the pads or the cost is not of great concern to the manufacturer of the racing car brakes. Initially the automobiles employed drum brakes in the cars. The main focus of this thesis is not for the passenger car technology but it concentrates on the automotive racing industry, NASCAR, the Nation Association of Stock Car Racing. NASCAR is a racing league similar to other racing leagues like Formula 1. The words "Stock Car" are complete purpose built race cars whose only similarity to the production vehicles replicate in exterior side profile. Major vehicle systems are designed for their specific racing purposes . The chassis used by the racing car is full tube frame while that used on commercial vehicles is made of single body frame. Another difference is the drive train; race versions have eight cylinder engines with rear wheel drive whereas commercial vehicles are four or six cylinder engines with front wheel drive.

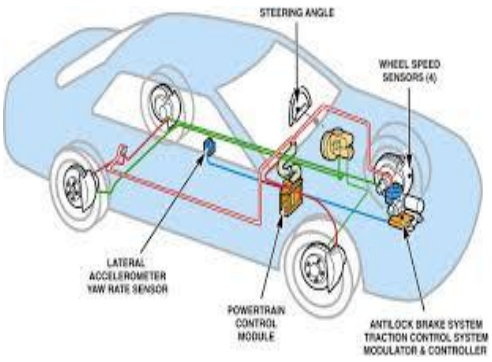

Figure 1.1 Car Mechanism

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1.1 How disc brakes workes

Disk brakes convert kinetic energy from the car into mechanical energy.

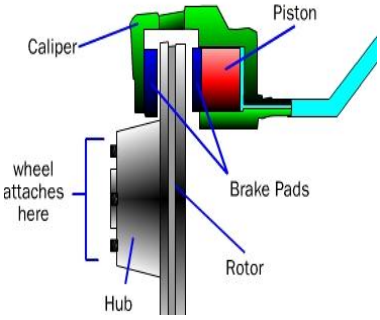

Figure 1.2 Disc brake systems

1.2 Brake Caliper

The brake fluid compresses the piston inside the brake caliper applying pressure to the brake pads.

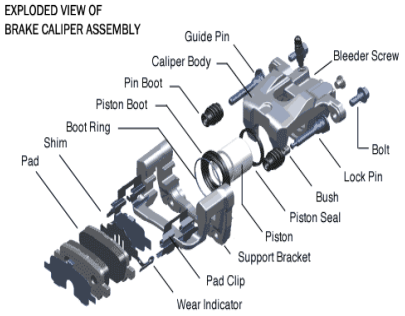

Figure 1.3 Brake Caliper Assembly Systems

1.2 Brake Rotors

- ✓ Connected to the axel – rotating at the same speed as the wheel
- ✓ Generally made out of steel
- ✓ Commonly slotted or drilled for extra heat dissipation

Figure 1.4 Brake Rotor

1.4 Brake Pads

- ✓ Fixed in the brake caliper
- ✓ Various compounds of materials are used
- ✓ Wear over time and must be replaced

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Figure 1.5 Brake Pads

1.5 Brake Pad Materials

- Asbestos
- Semi-Metallic
- Non-Asbestos Organics
- Low Steel
- Carbon
- Exact composition of each manufacturer's pads is a closely guarded secret

II. PROBLEM IN BRAKE ROTORS

On studying the background of brakes the main purpose of conducting this research work was finalized. The main objective was to propose a conceptual design for a disc brake rotor using exiting material Aluminium Alloy, Titanium Alloy, Gray Cast iron and new material Carbon Fiber, called a modular brake rotor. The efficient working of brake system depends on how the brake behaves at high temperatures. Thus the aim of the research work will be to reduce the thermal deformation in the modular brake rotor.

III. OBJECTIVE

Disc brake noise and vibration generation during braking has been one of the most important issues and definitely worrying problem to automotive manufacturers. Despite brake noise is not a safety issue and has little impact on braking performance, it gives customers the impression of underlying quality problems of the vehicle. In addition, the customers view that the noise emitted from the brake system is indicator of malfunctioning condition and consequently lose confidence on the quality of the vehicles.

IV. MATERIALS

4.1 Material Selection

Material selection plays a very important role in machine design. Three materials are considered for the analysis of disc brake rotor Gray Cast Iron, Aluminium Alloy, Titanium Alloy and Carbon Fiber.

Table- 1 Gray Cast Iron Mechanical properties

Material Field Variable	Value	Units
Density	7200	Kg/m^3
Young's modulus	1.1E+11	Mpa
Poisson Ratio	0.28	
Shear modulus	4.2969E+10	Mpa
Bulk Modulus	8.3333E+10	Mpa
Tensile Strength	240	Mpa
Compressive Strength	820	Mpa
Material Field Variable	Value	Units
Density	7200	Kg/m^3

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Table- 2 Aluminium Alloy Mechanical properties

Material Field Variable	Value	Units
Density	7750	Kg/m³
Young's modulus	1.93E+05	Mpa
Poisson Ratio	0.31	
Shear modulus	76664	Mpa
Bulk Modulus	1.6937E+05	Mpa
Tensile Yield Strength	207	Mpa
Compressive Yield Strength	207	Mpa
Tensile Ultimate Strength	310	Mpa
Compressive Ultimate Strength	0	Mpa

Table- 3 Carbon Fiber Mechanical properties

Material Field Variable	Value	Units
Density	1950	Kg/m³
Young's Modulus	300000	MPa
Poisson Ratio	0.30	
Tensile Strength	5090	MPa
Compressive strength	1793	MPa

Table 4 Titanium Alloy Mechanical properties

Material Field Variable	Value	Units
Density	4620	Kg/m^3
Young's modulus	9.6E+10	Pa
Poisson Ratio	0.36	
Shear modulus	3.528E+11	Pa
Bulk Modulus	1.1429E+11	Pa
Tensile Yield Strength	930	Mpa
Compressive Yield Strength	930	Mpa
Tensile Ultimate Strength	310	Mpa
Compressive Ultimate Strength	1070	Mpa

V. THEORETICAL STRESS CALCULATION

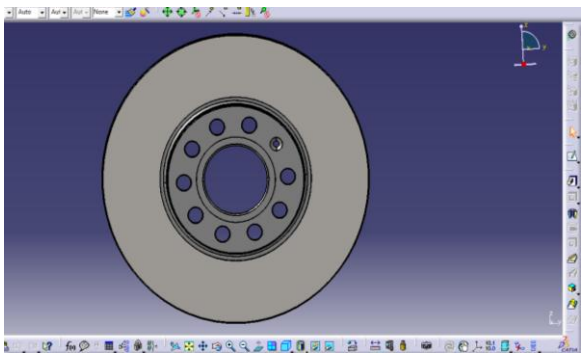

Figure 5.1 CAD Model generated in CATIA

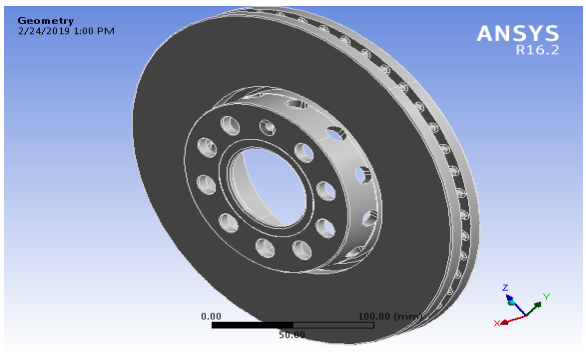

Figure 5.2 CAD Model imported in ANSYS and generate meshing

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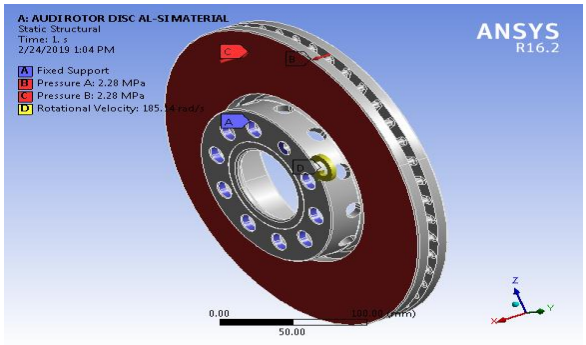

Figure 5.3 Applied boundary conditions for ALSI Material

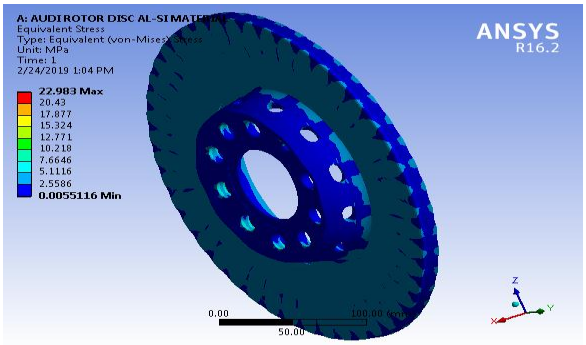

Figure 5.4 Von misses stresses in ALSI material Brake Rotor

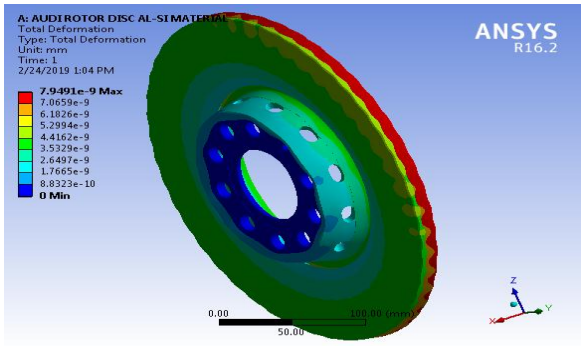

Figure 5.5 Deformation in ALSI material Brake Rotor

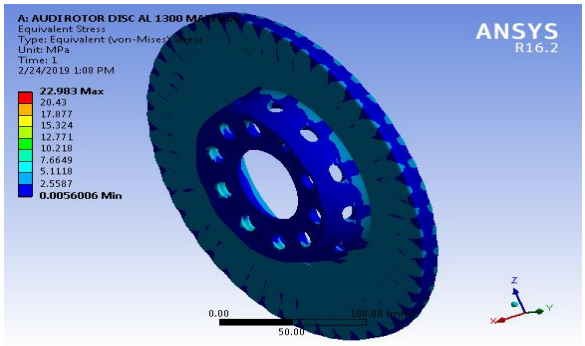

Figure 5.6 Von misses stresses in ALG-HS 1300 Alloy Brake Rotor

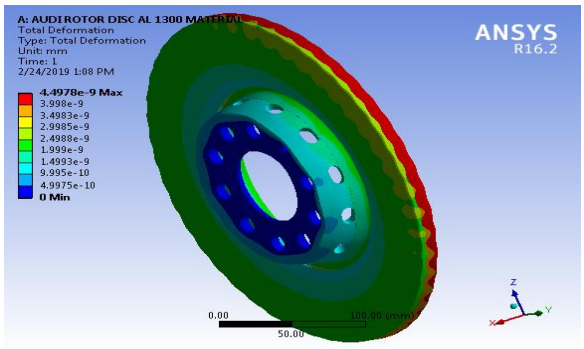

Figure 5.7 Deformation in ALG-HS 1300 Alloy Brake Rotor

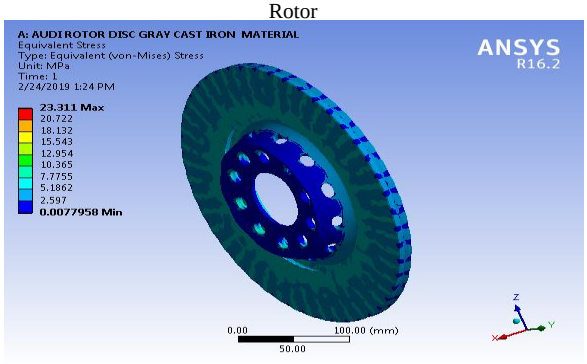

Figure 5.8 Von misses stresses in Gray Cast Iron Brake Rotor

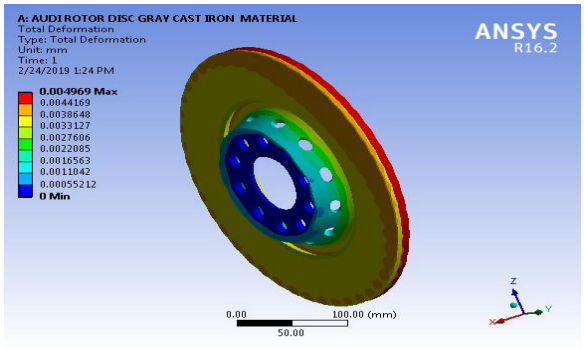

Figure 5.9 Von misses stresses in Gray Cast Iron Deformation Brake Rotor

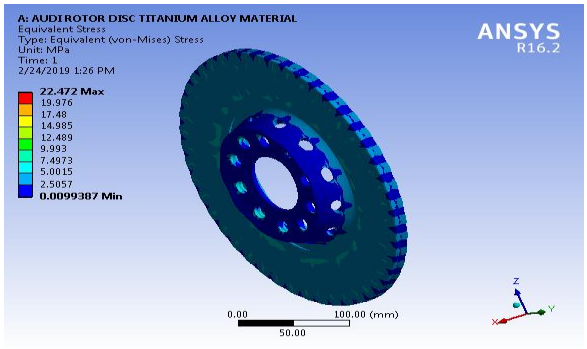

Figure 5.10 Von misses stresses in Titanium Alloy Brake Rotor

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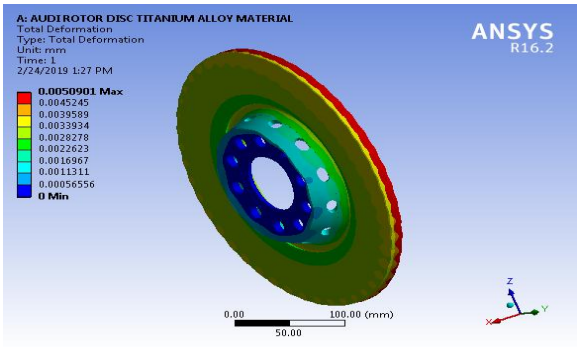

Figure 5.11 Deformation in Titanium Alloy Brake Rotor

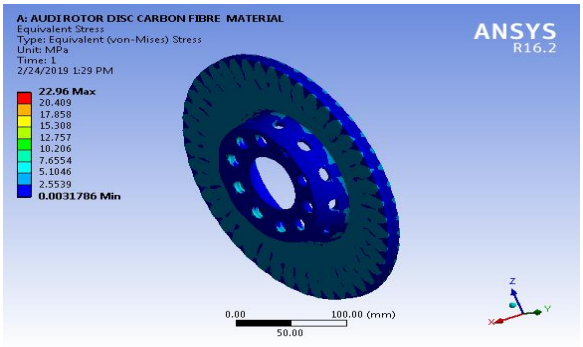

Figure 5.12 Deformation in Carbon Fiber Brake Rotor

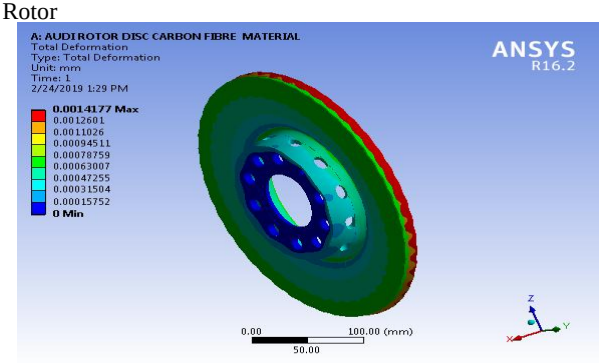

Figure 5.13 Deformation in Carbon Fiber Brake Rotor

VI. ANALYTICAL CALCULATION

Audi A3 Car

Car Kerb weight = 1340 kg

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

KE =1/2 mv^2 = 1/2 x 1250 $(27.77)^2$ = 5.1 $x10^5$ Joules

Braking force (F_B) = work/ Displacement = W/s = 5.1 $x10^5$/55.2 = 9360.25 N

Now we take 60% and 40% ratio

So 60% (5616.15 N on front Two wheels) and (3744 N on rear two wheels)

For Single wheel (Front) Force = 5616.15/2 = 2808.05 N

Force by one piston = 1674/4 = 418 N

Velocity (v) = Π DN / 60 = 27.77 = Π X 0.300 X/60

N = 1767.89 say = 1768 RPM

w= 2ΠN/60 = 2 X 3.14X 1768 / 60 = 185.144 rad/sec

Piston Pressure = Force / Area

P = F /A

Area = Π / 4 x d^2= Π / 4 x $(28)^2$ = 615.75 mm^2

P_1= 702.018/615.75 = 1.14 MPa

P = P1 + P2 = 1.14 + 1.14 = 2.28 MPa

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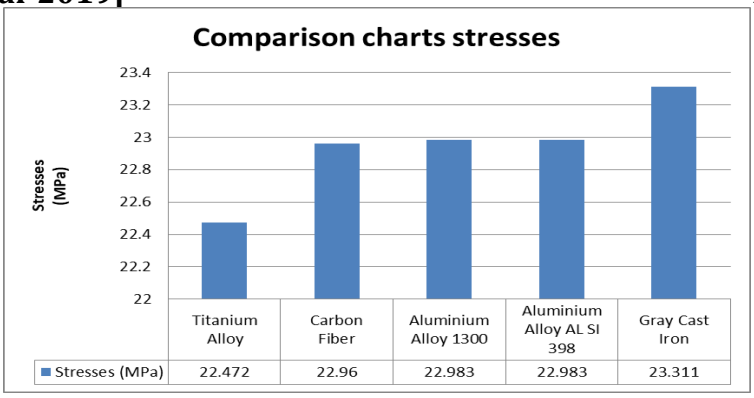

Figure 6.1 Stresses comparison Charts

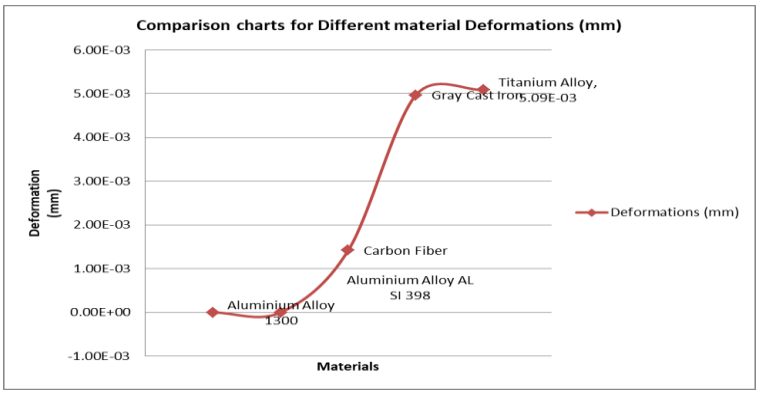

Figure 6.2 Deformations comparison charts

VII. RESULT AND DISCUSSIONS

In above table its cleared that we take different four materials and seen that the maximum von misses stress value for All material like Gray Cast Iron , Titanium Alloy, Aluminium Alloy 1300 , Aluminium Alloy ALSI 398 and Carbon Fiber respectively are 23.311 MPa, 22.472 MPa, 22.983 MPa, 22.983 and 22.96 MPa .

We get maximum deformation value for all material like Gray Cast Iron , Titanium Alloy, Aluminium Alloy 1300 , Aluminium Alloy ALSI 398 and Carbon Fiber respectively are 0.004969 mm, 0.0050901 mm, $4.4978e^{-9}$ mm and $7.9491e^{-9}$mm . Here we can clearly observed that Carbon Fiber materials has very less value of deformation compare to other materials. 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. So we can suggested Carbon Fiber materials for brake rotor in future. Because it is light weight and durable materials.

VIII. CONCLUSION & FUTURE SCOPE

7.1 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 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 o 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

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five different materials Grey Cast Iron, ALSI 398, Titanium Alloy , ALG -HS 1300 and Carbon Fiber in our research. Analysis is done on these materials and conclude that Carbon Fiber shows the minimum stress and deformation values in boundary conditions. So Carbon Fiber is suggested for future manufacturing of Disc Brake Rotor.

7.2 FUTURE SCOPE

- In future this work can be extended by using different composite materials and we can do thermal CFD analysis and Vibrational analysis in dick brake calliper with different boundary condition like fluid pressure temperature etc.

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