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DESIGN & ANALYSIS OF DISC BRAKE ROTOR USING CATIA AND ANSYS SOFTWARE

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Abstract— **The compact disk are a tool that slows down or stops the wheel rotation. Friction causes the disc and the attached tire to slow down or stop. Brakes turn heat into heat, but if the brakes are too hot, they will stop working because they cannot absorb enough heat. This state of failure is known as brake fade. Disk brakes are exposed to extreme heat stress during normal braking as well as normal heat pressures during heavy braking. The actual disc brake has no holes; the design is adjusted by providing holes in the disk break to release more heat. In this project work an attempt was made to model and break the first disc break model and assemble using catia V5R20 and direct and modal analysis was performed with ANSYS 14.0 software using four different materials such as mild steel, Aluminum, Castiron and composite material (e-glass).**

Keywords* - *Structure and Transient analysis, ANSYS, FEA, Ventilated disc brake

I. INTRODUCTION

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.

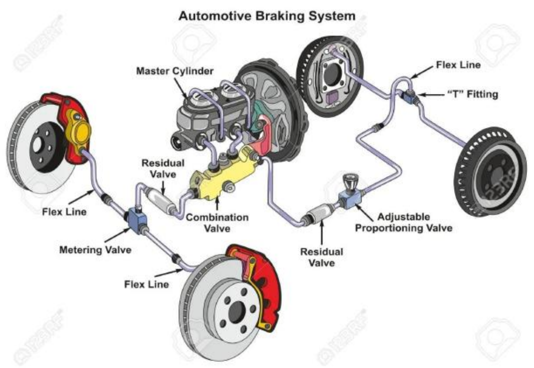

Figure 1.1 Vehicle Brake System

1.1 How do disk brakes work?

The brake rotor (disc) around the wheel, fastened with brakes (friction material) mounted on a caliper from both sides by the pressure of the piston (s) (pressure mechanism) and reduces the rotation of the disc, thereby reducing and stopping. the car.

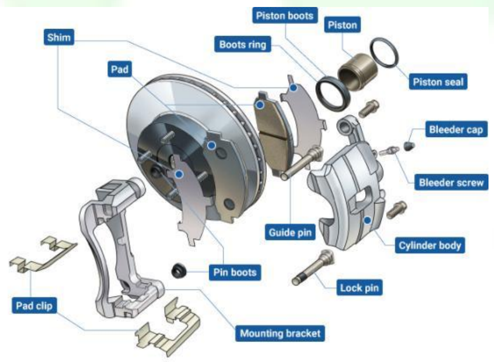

Figure 1.2 Disc brake systems

1.2 Brake Caliper

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

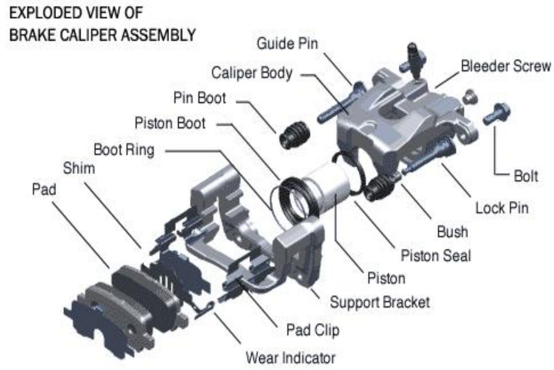

Figure 1.3 Brake Caliper Assembly Systems

1.3 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

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. LITERATURE SURVEY

Pravin Mohan and Patel Sudheendra S [2017] Post-work activity thinks of a smart system of plate brake plate. The circular brakes provide superior braking, more precise design, light weight, and preferred protection from water traps over drum brakes. The point of this used structure was to increase the quality of the caliper, without increasing the caliper mass by a large amount and reducing the negative heat formation at high operating temperatures. Since titanium is difficult to make in a machine the formation of a single square of a common machine of machinery was not used in this work but rather an attempt was made to build a brake caliper with various parts and assembled together to form one unit. In addition the used titanium parts are made of non-stick plates to save money on future machine costs. As titanium has a high thickness care was taken while designing a new brake frame to keep the weight off. The current brake caliper is broken due to loading conditions with new recommended features. The results were intended for removal and concern associated with warm effects. The new caliper was measured by weight and unrelated load sand effects were considered for shift / reversal and concern for temperature impact. [1]

S. Arvin Rao, Muhamad Anuwar Jusoh, Abd Rahim Abu Bakar*,(2017) Brakes screech has always been one of the most important challenges of Sound, Vibration and Strength (NSH) in the construction and development of the brake frame. For ten years it has plagued the automotive industry. Brake scientists have proposed a number of ways to reduce brake screech and counter-operation techniques in order to survive and reduce the ridicule that comes with the brake plate frame. In this paper, the effectiveness of obliged layer dampers (CLD) in reducing the noise of brake screech clamor has been evaluated. The CLD distinguishes the sound of brake screech by the shear damage of viscoelastic materials. Two brake test settings were geared using a brake test dynamometer using the CLD. Two different types of CLD were used, namely a three-dimensional bound damper and a mandatory four-layer damper. The Screech test was performed using a brake clamor test modification based on the SAE J2521 standard methodology. From the experiments, the four-layer CLD set is more effective than the three-layer CLD structure. The CLD made of nitrile butadiene elastic, silicone elastic and soft metal has already become the best water separator for a water range of 5 bar to 30 bar and a temperature of 50oC to 200oC with a significant reduction in shrinkage which is 11.3 dBA. In line with these lines, the CLD process eventually became a powerful way to reduce the noise of brake screech. [2].

Yugesh Anil Kharche and Prof. Dheeraj Verma [2014] The brake plate is a gadget that slows down or stops the wheel rotation. Braking is a process that changes over the stiffness of a motor vehicle into a mechanical force that must be disassembled as a heat exchanger. This paper shows the investigation of contact mass in the area of the plate interface using a 3-dimensional point model of a limited part of a real circular motor brake. Models of the limited (FE) part of the brake-circle are made using Pro-E and replicate using ANSYS based on limited phase (FEM) strategy. It also checks the various sizes in displaying the brake plate frame and mimics the distribution of the contact weight with a different load. It incorporates the Finite Element Method methods in the automotive business for communication testing and warm inquiry. The effect of rakish speed and the relative mass of contact on the rise in temperature of the circular brake has been studied. Rubbing wear means a shortening of its lifespan. The more aging you are, the more conflicting things should be replaced. Diverse Brake cushion material has been tried as compared to the present. Eventually the correlation between the systematic results and the result obtained from Ansys became so strong, and all the attributes found in the investigation were not their own valid merits. So based on warmth and contact and pressure research the right things are suggested. [3].

III 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.

IV OBJECTIVE

The sound of disc brakes and vibration production during braking has been one of the most important and troubling issues for car manufacturers. Although the sound of the brakes is not a safety issue and has little effect on the performance of the brakes, it gives customers a glimpse of the current problems with car quality. In addition, customers find that the noise emanating from the brakes system is an indication of poor performance and as a result they lose confidence in the quality of the vehicles.

V MATERIALS

5.1 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

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. MODELING & SIMULATION

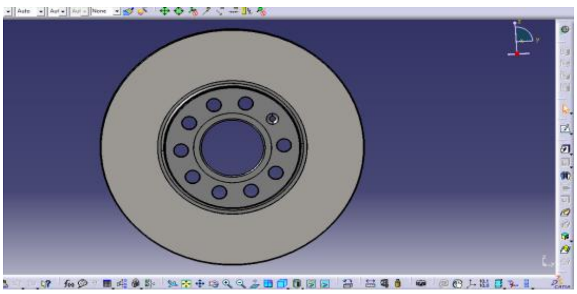

Figure 5.1 CAD Model generated in CATIA

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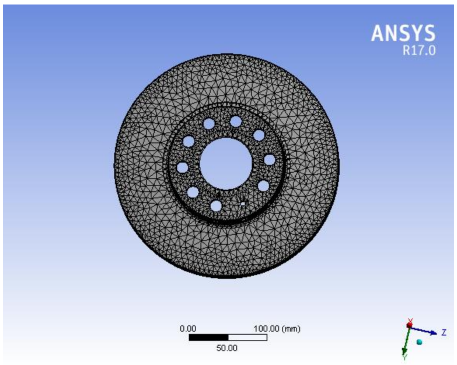

Figure 5.2 CAD Model imported in ANSYS and generate meshing

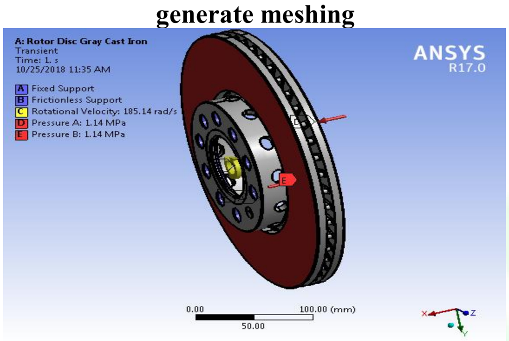

Figure 5.3 Applied boundary conditions

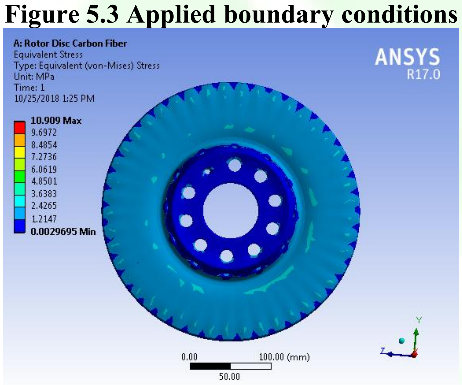

Figure 5.4 Von misses stresses in Carbon Fiber Brake Rotor

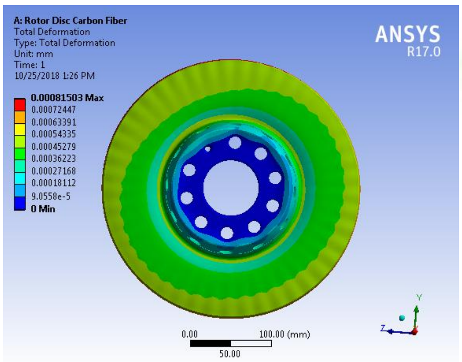

Figure 5.5 Deformation in Carbon Fiber Brake Rotor

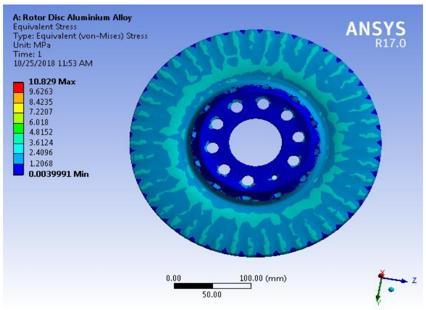

Figure 5.6 Von misses stresses in Aluminium Alloy Brake Rotor

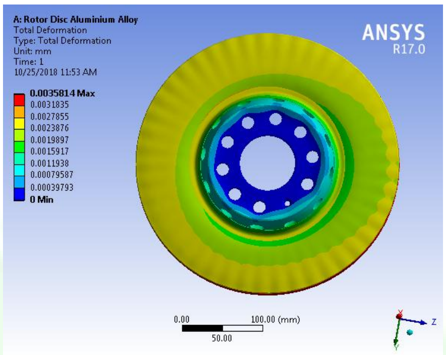

Figure 5.7 Deformation in Aluminium Alloy Brake Rotor

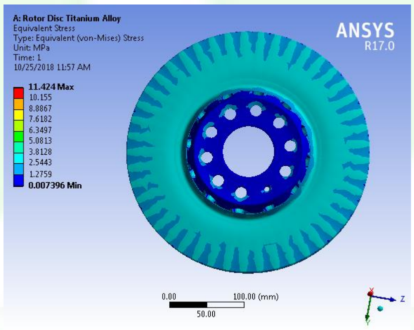

Figure 5.8 Von misses stresses in Titanium Brake Rotor

VI. ANALYTICAL CALCULATION

Audi A3 Car

Car Kerb weight = 1340 kg

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

KE =1/2 mv2 = 1/2 x 1250 (27.77)2 = 5.1 x105 Joules

Braking force (FB) = work/ Displacement = W/s = 5.1 x105/55.2 = 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 d2= Π / 4 x (28)2 = 615.75 mm2

P 1= 702.018/615.75 = 1.14 MPa

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

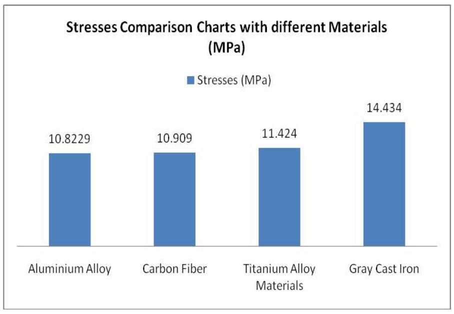

Figure 6.1 Stresses comparison Charts

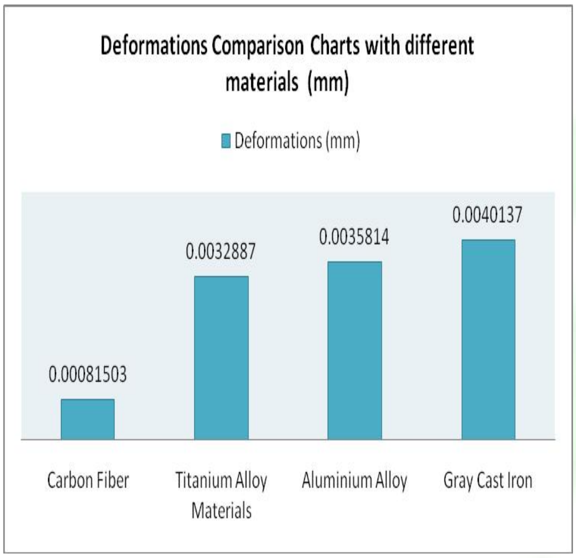

Figure 6.2 Deformations comparison charts

VI CONCLUSIONS

A disc brake is a way to reduce or stop the wheel rotation. Braking is the process of converting a car's kinetic energy into mechanical energy that must be dissipated by temperature. Determination of braking power is the most important factor to consider when designing any braking system. The braking force produced should always be greater than the required braking force. Calculation of the required strength strength helps us determine the boundaries of the disc brake rotor. Modeling and analysis of the disc brake rotor is done to select the best durable material. We found four different materials Grey Cast Iron, Aluminum Alloy, Titanium Alloy and Carbon Fiber in our study. Analysis is performed on these factors and it concludes that Carbon Fiber shows minimum pressure and aging values in boundary conditions. Carbon Fiber is therefore proposed for future Disc Brake Rotor. The final design of the machine and the shape and size of their parts allow it to get enough repetition of power to stop the car completely. Consideration of design features to facilitate machine design. This is important to understand the force of action and the force of a collision on a new disc brake device, using an effective disc brake, which can help reduce the risk that can occur on a daily basis.

VI FUTURE SCOPE

In the future this function can be extended by Using different composite materials. We can perform thermal CFD analysis on dick brake rotor with different boundary conditions such as liquid pressure, temperature etc. The modular design will be analyzed without considering the effects of thermal expansion.Vibration analysis can be performed. Alternative analysis can be performed using UTM machine and other strength tests.

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