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"DESIGN & ANALYSIS ON BRAKE CALIPER BY USING DIFFERENT MATERIALS THROUGH ANSYS"

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ABSTRACT

The disc brake caliper 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 finite element model of a real car disc brake . Finite element (FE) models of the brake-disc are created using CATIAV5R20 and simulated using ANSYS 17.0 which is based on the finite element method (FEM). It is also investigates different levels in modelling a disc brake 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 is investigated. In our project we take different materials like Steel Alloy, Aluminium Alloy, 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*: Steel Alloy, 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 [2]. 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

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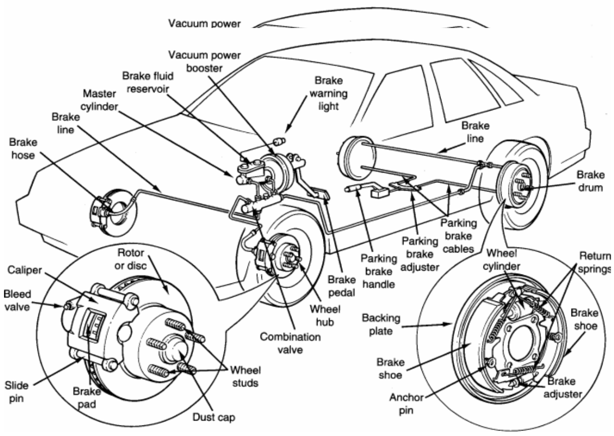

Figure 1.1 Vehicle Brake System

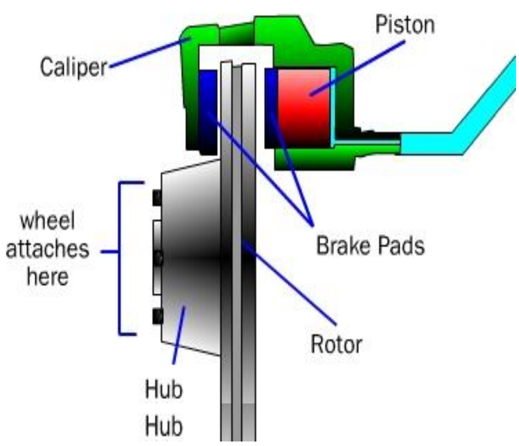

Figure 1.2 Disc brake systems

1.1 How do disk brakes work?

- Disk brakes convert kinetic energy from the car into thermal energy by friction.

1.2 Brake Caliper

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

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

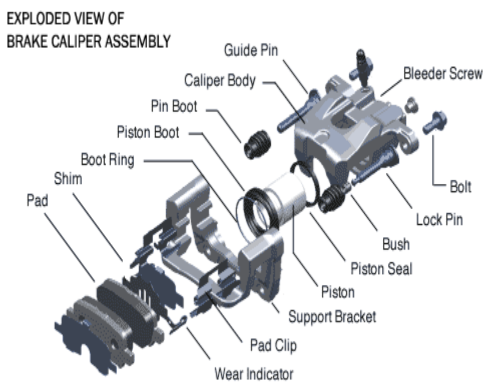

Figure 1.3 Brake Caliper Assembly Systems

Figure 1.4 Brake Rotors

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

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II. PROBLEM IN BRAKE CALIPERS

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 caliper using exiting material Aluminium Alloy, Titanium, Steel Alloy and New materials Carbon fiber, called a modular brake caliper. 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 caliper. Since Structural Steel is hard to machine, modular caliper will be developed as an assembly instead of single block design.

III. OBJECTIVES

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 metals are considered for the analysis of scissor lift is epoxy e glass fiber structural steel and stainless steel.

Table- 1 Structure Steel Mechanical properties

Material Field Variable	Value	Units
Density	7850	Kg/m³
Young's modulus	2E+05	Mpa
Poisson Ratio	0.30	-
Shear modulus	76923	Mpa
Bulk Modulus	1.6667E+05	Mpa
Tensile Yield Strength	250	Mpa
Compressive Yield Strength	250	Mpa
Tensile Ultimate Strength	460	Mpa
Compressive Ultimate Strength	0	Mpa

Table- 2 Aluminum Alloy materials 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

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Table- 3 Carbon Fiber materials Mechanical

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 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

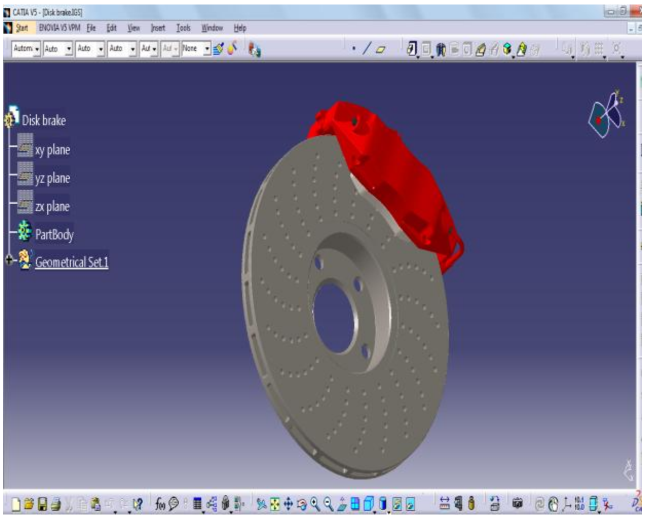

Figure 5.1 CAD Model generate in CATIA

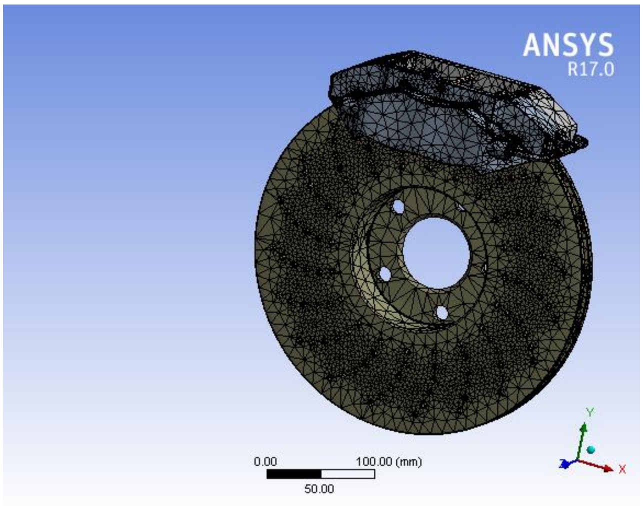

Figure 5.2 CAD Model import in ANSYS and generate meshing

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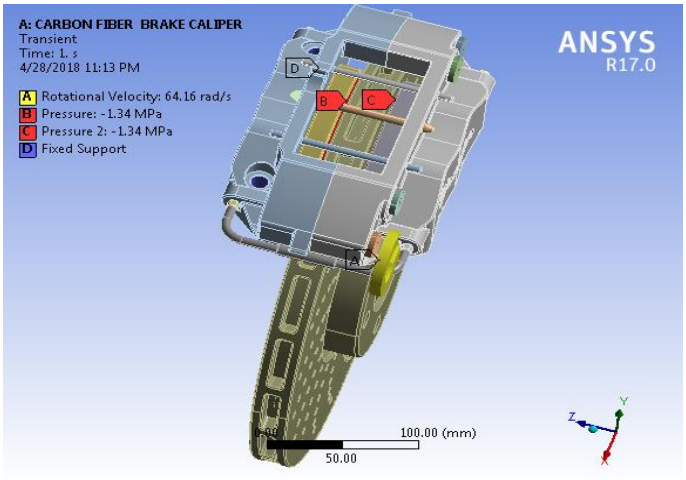

Figure 5.3 Applied boundary conditions

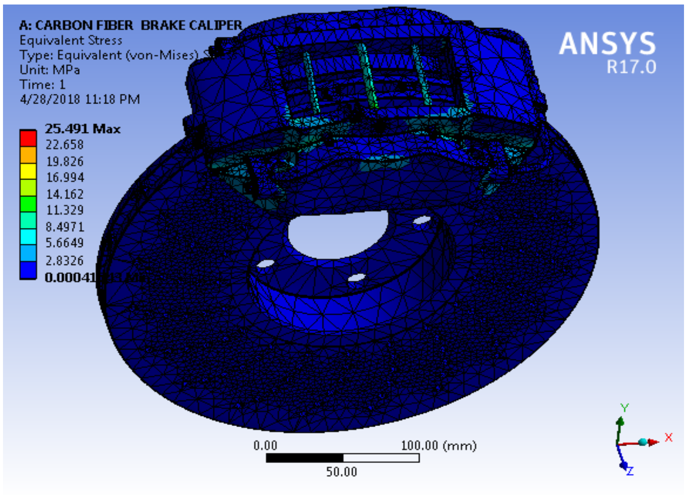

Figure 5.4 Von misses stresses in Carbon fiber Brake caliper

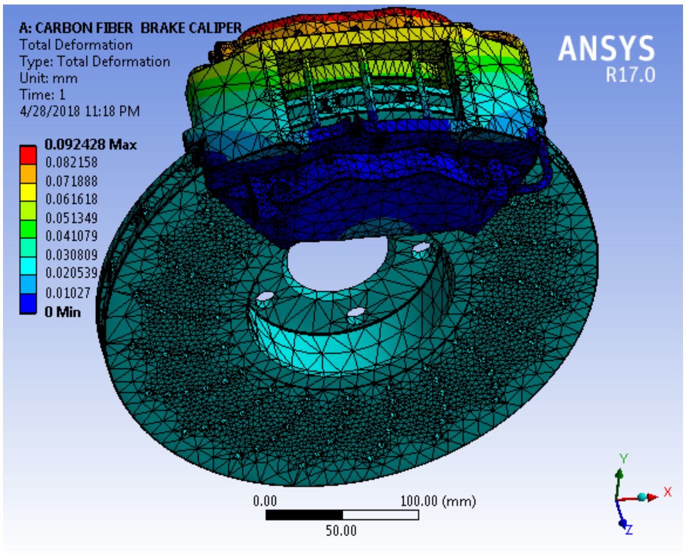

Figure 5.5 Deformation in Carbon fiber Brake caliper

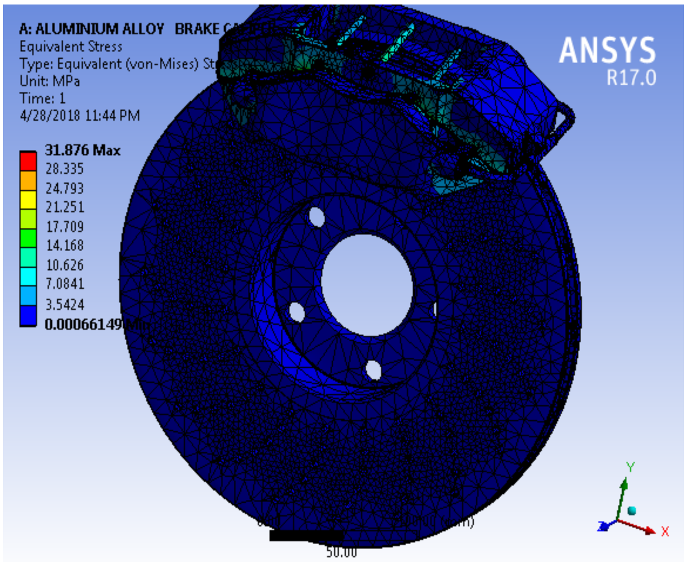

Figure 5.6 Von misses stresses in Aluminium Alloy Brake caliper

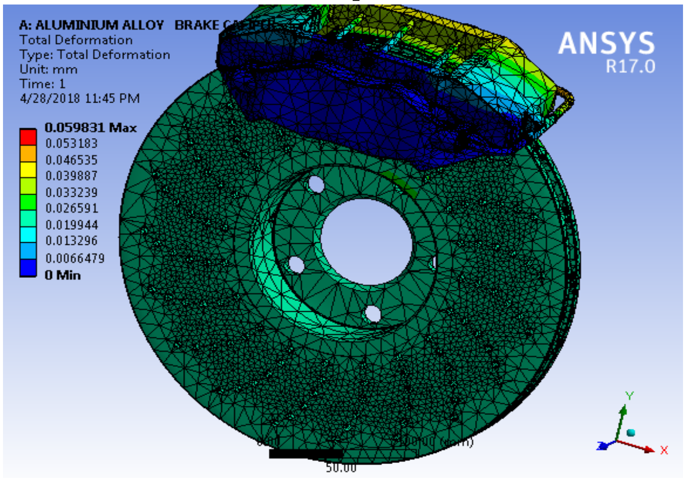

Figure 5.7 Deformation in Aluminium Alloy Brake caliper

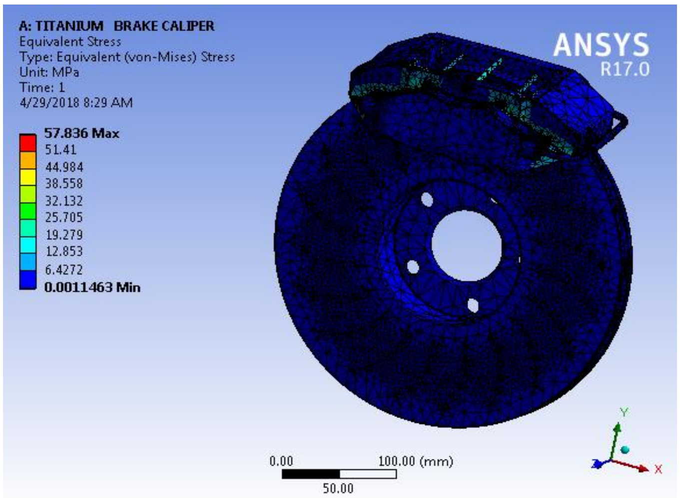

Figure 5.8 Von misses stresses in Titanium Brake caliper

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Impact Factor : 2.015

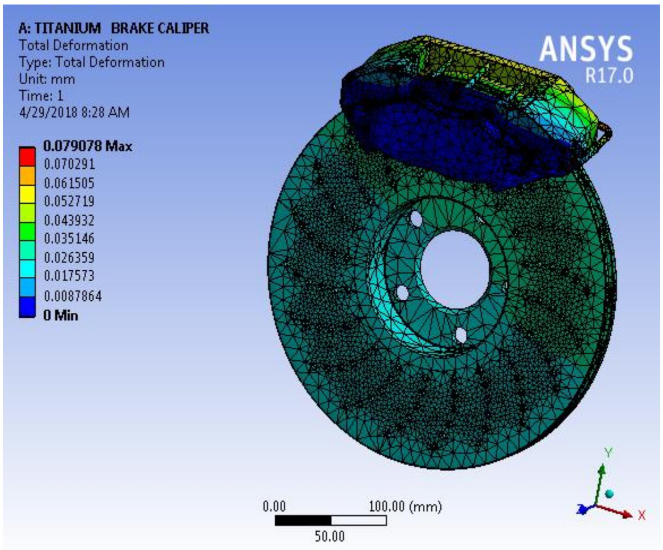

Figure 5.9 Deformation in Titanium Brake caliper

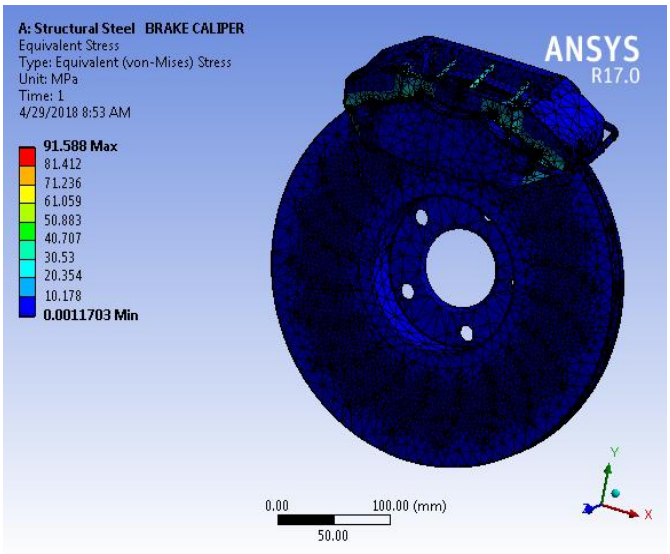

Figure 5.10 Von misses stresses in Structural Steel Alloy Brake caliper

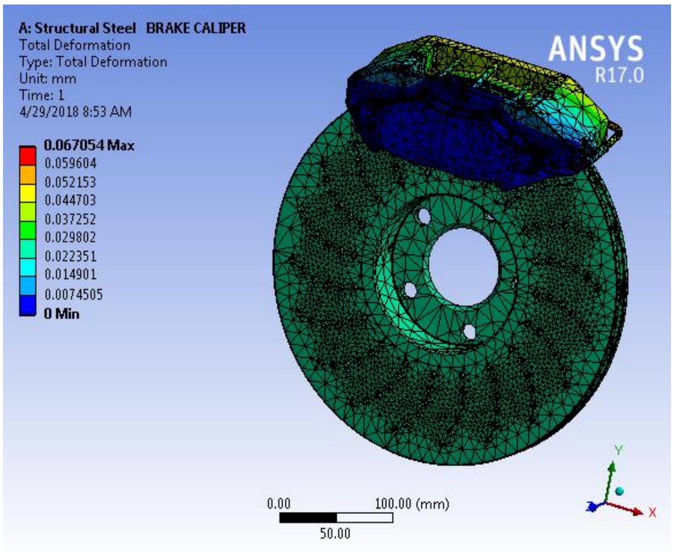

Figure 5.11 Von misses stresses in Structural Steel Alloy Brake caliper

VI. ANALYTICAL CALCULATION

Maruti Wagnor Car

- Car Gross Weight = 1250 kg and Velocity v = 80 km/hr = 22.2 m/sec
- K.E. =1/2 mv^2 = 1/2 x 1250 $(22.2)^2$ = 3.08 $x10^5$ Joules
- Braking Force (F_B) = Work/ Displacement = W/s = 3.08 $x10^5$/55.2 = 5580 N
- Now we take 60% and 40% ratio
- So 60% (3348 N On front Two wheels) , 40% (2232 N on Rear Two wheels)
- Our Calculation is based on Front Wheels
- For Single wheel (Front) Force = 3348/2 = 1674 N
- Pressure by one piston = 1674/4 = 418 N

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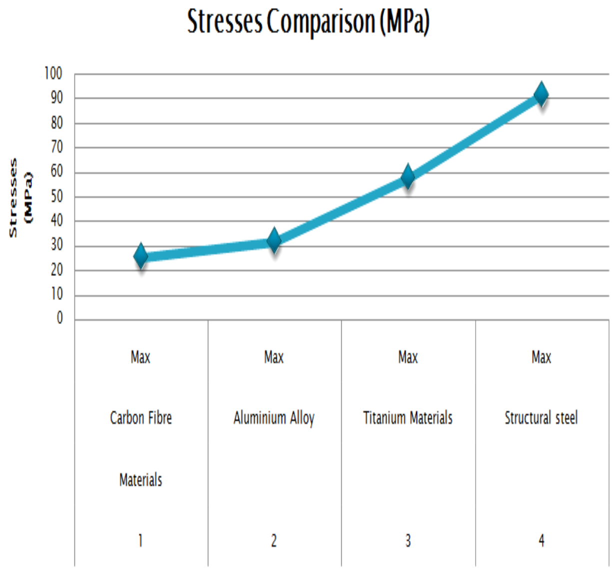

Figure 6.1 Stresses comparison Charts

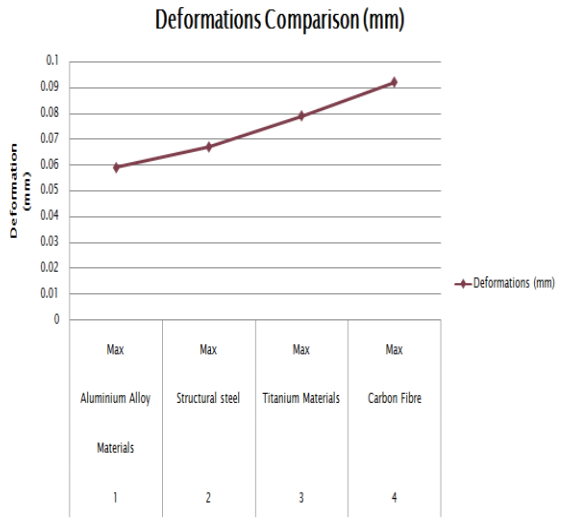

Figure 6.2 Deformations comparison charts

VII. RESULT & DISCUSSION

Carbon fiber needs to be layered in multiple directions to be useful (somewhat like plywood). 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 (a so-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.

VIII. CONCLUSION & FUTURE SCOPE

7.1 CONCLUSION

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 diameter and the number of pistons to be used. Space and assembly constraints are also an important factor while designing the caliper body.

The seal groove geometry is pivotal to the operation of the caliper as it allows the piston to retract after the required clamping force has been applied.

7.2 FUTURE SCOPE

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

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