

# Modelling and Analysis of Disc Brake Rotor under Various Loading Conditions

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**ABSTRACT:** Investigate the temperature fields and also structural fields of the solid disc brake throughout short and emergency braking with four totally different materials. The distribution of the temperature depends on the varied factors like friction, surface roughness and speed. The impact of the angular velocity and also the contact pressure induces the temperature rise of disc brake. The finite component simulation for two-dimensional model was preferred due to the heat flux ratio perpetually distributed in circumferential direction. we are going to take down the worth of temperature, friction contact power, nodal displacement and deformation for various pressure condition using analysis software system with four materials particularly forged iron, cast steel, deformation for various pressure condition using analysis software system with four materials particularly forged iron, cast steel, Al and carbon fiber reinforced plastic. Presently the Disc brakes are created from forged iron and cast steel. With the value at the hand we are able to confirm the simplest appropriate material for the drum with higher generation. The detailed drawings of all elements are to be volumes. The elaborate drawings of all elements are to be supplied with. IN this project we are changing the holes of the disc to observe the heat dispatch and the stress, strain, deformation values are obtained based on that the best Materials is suggested for making of disc breaks

**KEYWORDS:** disk brake, Structural analysis, Thermal analysis, ANSYS. Etc...

## I. INTRODUCTION

In today's growing automotive market the competition for higher performance vehicle is growing staggeringly. The Sport fans concerned will sure grasp the importance of a smart brake system not only for safety however also for staying competitive. The disc brake could be a device for speed or stopping the rotation of a wheel. A brake disc sometimes fabricated from cast iron or ceramic composites includes carbon, Kevlar and silica, is connected to the wheel And therefore the shaft, to prevent the wheel. A friction material within the variety of brake pads is forced automatically, hydraulically, pneumatically or electromagnetically against each side of the disc. This friction causes the disc and connected wheel to slow or stop. Generally, the methodologies like regenerative braking and friction braking system are utilized in a vehicle. A friction brake generates resistance forces as two or additional surfaces rub against every different, to cut back movement. Based on the style configurations, vehicle friction brakes will be classified into drum and disc brakes. If brake disc are in solid body the heat transfer rate is low. Time taken for cooling the disc is low. If brake disc are in solid body, {the area the world the realm} of contact between disc and pads are additional. In disc brake system a ventilated disc is wide Utilized in automobile braking system for improved cooling throughout braking during which the realm of contact between disc and pads remains same. Brake assembly that is often utilized in an automobile.

### 1.1 CAD/CAM/CAE:

The usage of CAD CAE & CAM have modified the overlook of the industries and developed healthy & customary competition , as might bring home the bacon target in lean time and ultimately the merchandise reaches market incalculable time with higher quality and consistency .Normally in general, it has lead to quick approach and inventive thinking. CATIA is a strong application that allows you to make wealthy and sophisticated styles. The goals of the CATIA course are to show you the way to create components and assemblies in CATIA, and the way to build

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easy drawings of those components and assemblies. This course focuses on the basic skills and ideas that alter you to make a solid foundation for your styles.

ANSYS stands for Analysis System Product. Dr. John Swanson was the founder of ANSYS Inc. in the year 1970. ANSYS was founded in order to establish a technology that facilitates several companies/industries to compute or simulate analysis issues. The screenshot of ANSYS user interface is shown in Figure 2. ANSYS is a general-purpose finite element analysis (FEA) software package that is extensively used in industries to resolve several mechanical problems. FEA is a method of fragmenting a composite system into small pieces called Elements. The ANSYS Software carries out equations that regulate the performance of these elements and solves them resulting in an overall description of how the system works integrally. The obtained results are displayed in a tabulated or graphical form. This type of system is used for optimization of systems.

## II. RELATED WORK

The main function of disc brake rotor is for transmission of mechanical force and dissipation of heat produced implies to be functioning at both medium and high temperature. The rotor provides braking surface or friction surface for brake pads to rub against it when brake is applied. A disc brake rotor is generally made from grey cast iron due to cast iron provides good wear resistance with high thermal conductivity and the production cost is low compared to other disc brake rotor materials such as Al-MMC, carbon composites and ceramic based composites (Jang et.al, 2003). Currently, there are two types of disc brake rotor used in passenger car which is solid disc and ventilated disc. A solid rotor is simply a solid piece of metal with friction surface on each side and this type of rotor is light, simple, cheap, and easy to manufacture. A ventilated disc meanwhile refers to the brake disc or rotor with various opening profiles (holes, grooves, etc.) which provide better cooling performance (additional heat transfer function) and weight savings as well as aesthetic appearance (Jacobsson, 2003). Therefore, it is widely used compared to solid disc. The thermal stability of the disc shape is influenced by the quantity of the material and the heat treatment before machining as well as the basic design for the disc rotor.

Some of the thermally most important properties of disc brake rotor are as follows (Jacobsson, 2003):-  
I) Thermal capacitance (density and specific heat) is the ability to store the heat. Initially on braking process, a significant amount of frictional heat is stored and during short braking, this thermal capacitance is dominates.

II) Heat dissipation becomes important consideration at long braking times (above 2-3 minutes). The convection is occurring for more than 90% of the total heat dissipation in most of the braking condition, whereby radiation is almost negligible.

There have also been many attempts to model both the transient and steady state temperatures of brake rotors with varying degrees of success. Many examples are found in the literature including Noyes and Vickers (1969), Sisson (1978), Day and Newcomb (1984) and Sheridan et al. (1988), and the accuracy of these models is usually determined by the heat transfer coefficient. The level of complexity of the models generally reflected the technology available at the time, with the complexity increasing with advancing computer technology. In recent years advances in computer technology has enabled CFD solutions of the fundamental thermo-fluid equations. This approach has allowed models to move away from bulk temperature analysis to determine both the temperature profiles and the air velocity contours on the surface of the brake rotor. Research conducted by Jones et al. (1995) found excellent correlation between experimental and CFD results

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**Material properties (source: nation master)**

	Cast Iron	Aluminum	Al Composite
Thermal Conductivity W/m.K	54	250	181.65
Specific Heat J/Kg.K	586	910	836
Density Kg/m <sup>3</sup>	7100	2712	2765.2
Young's Modulus N/m <sup>2</sup>	125 * 10 <sup>9</sup>	69 * 10 <sup>9</sup>	98.5 * 10 <sup>9</sup>
Poisson's Ratio	0.25	0.33	0.33
Coefficient of Linear Expansion /K	9.9 * 10 <sup>-6</sup>	23 * 10 <sup>-6</sup>	17.5 * 10 <sup>-6</sup>

**MODELING OF DISC BRAKE:**

It is terribly difficult to specifically model the brake disk, in that there are still there always needs of some assumptions to model any complicated pure mathematics. These assumptions are created, keeping in mind the difficulties concerned in the theoretical calculation and the importance of the parameters that are taken and those that are ignored. In modeling we tend to always ignore the things that are of less importance and have very little impact on the analysis. The assumptions are always created depending upon the main points and accuracy needed in modeling.

**III. EXPERIMENTAL RESULTS**

From the below figures shows analysis of ANSYS software to find out different materials with different types of loads are applied and find out deformation strain ,stress of each material at each load, and also observed heat flux at different loading conditions and it gives which materials is having high heat dissipation of different materials. and also find out weight comparison of materials.

Figures shows modelling of disc brake rotor. **Fig -1:** Drafted sheet of disc showing dim in mm, **Fig 2 -:** Drafted sheet showing thickness, **Fig -3:** Drafted sheet of disc showing isometric view, **Fig -4:** Sketch used for making disc in CATIA, **FIG:5 :**Sketch used for making holes for bolts in CATIA **Fig -6:** making of hexagonal holes in CATIA, **Fig -7:** Modeled fig in CATIA, **Fig -8:** Gray cast iron deformation at 2000N of Load, **Fig -9:** Gray cast iron strain at 2000N of Load, **Fig -10:** Gray cast iron stress at 2000N of Load, **Fig -11** Gray cast iron heat flux at 20000 c of Temperature, **Fig -12:** aluminum deformation at 2000N of Load, **Fig -13:** aluminum strain at 2000N of Load, **Fig -14:** aluminum stress at 2000N of Load, **Fig -15:**aluminum heat flux at 20000 c of Temperature, **Fig -16:** Nickel chrome steel deformation at 2000N of Load, **Fig -17:** Nickel chrome steel heat flux at 2000<sup>o</sup>c of Temperature, **Fig -18:** carbon reinforced material deformation at 2000N, **Fig -19:** carbon reinforced material strain at 2000N of Load, **Fig -20** carbon reinforced material stress at 2000N of Load, **Fig -21:**carbon reinforced material heat flux at 20000 c of Temperature.

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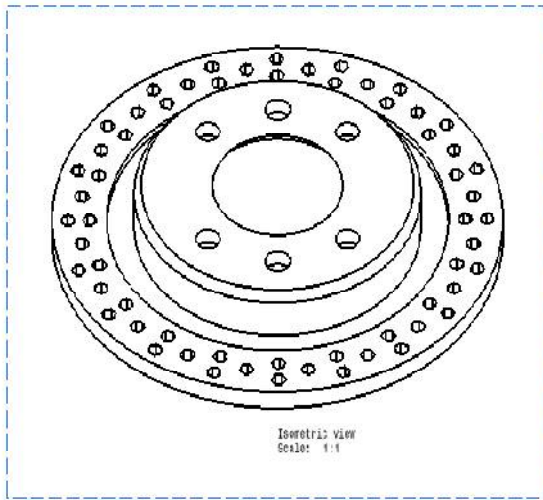


Fig -1: Drafted sheet of disc showing dim in mm

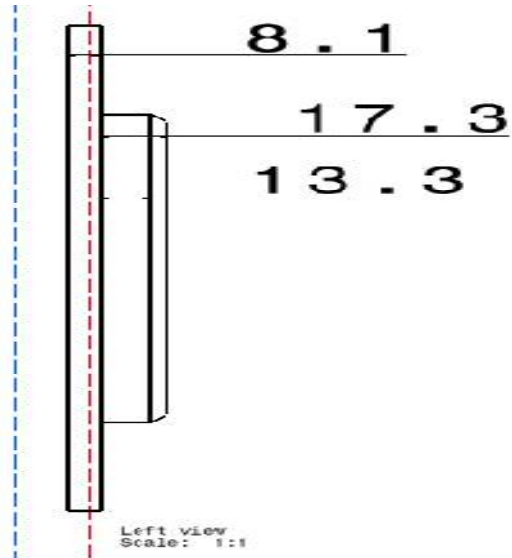


FIG:2: Drafted sheet showing thickness

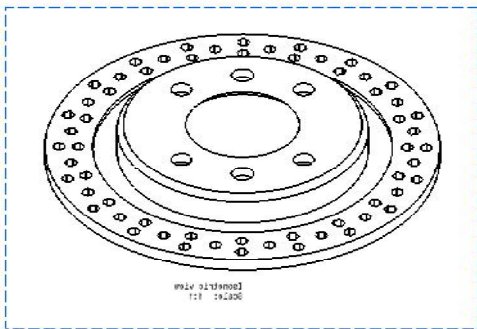


FIG:3 Drafted sheet of disc showing isometric view

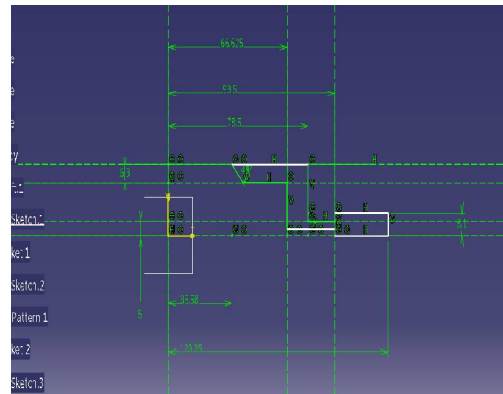


Fig -4: Sketch used for making disc in CATIA,

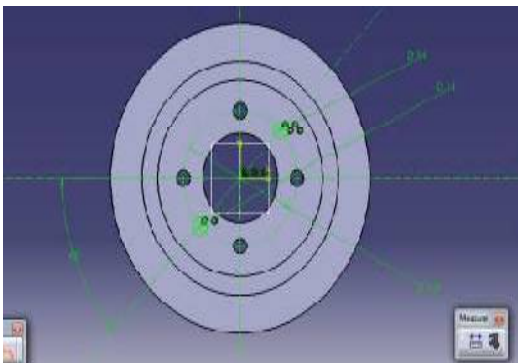


FIG: 5: Sketch used for making holes for bolts in CATIA

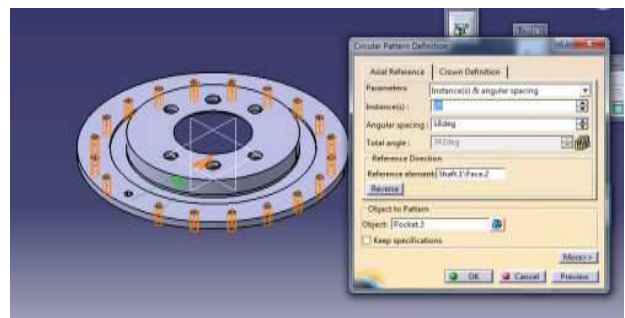
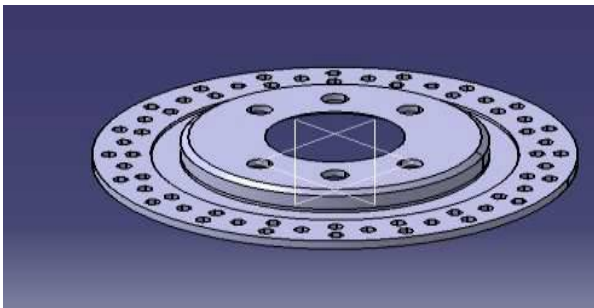
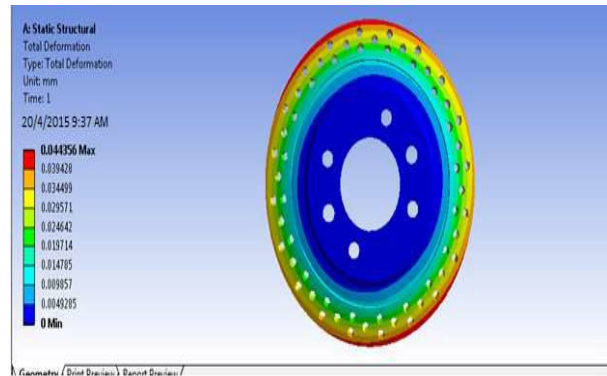


FIG:6 :Making of hexagonal holes in a CATIA

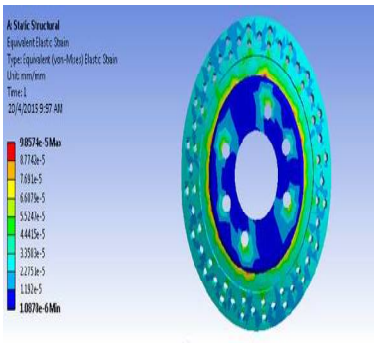




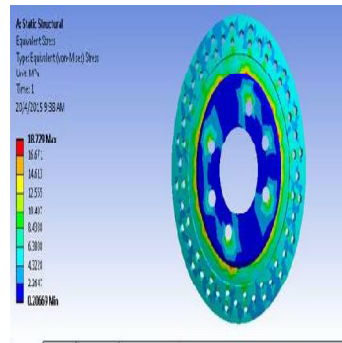
**Fig -7:** Modeled fig in CATIA



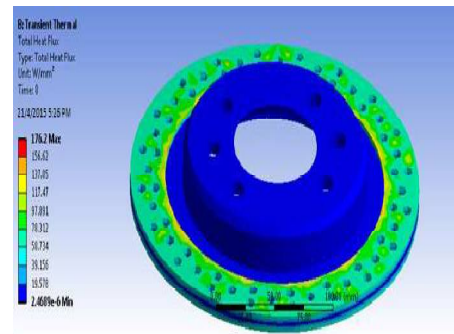
**Fig -8:** Gray cast iron deformation at 2000N of Load



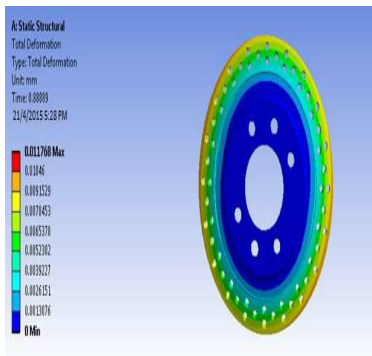
**FIG -9:** GRAY CAST IRON STRAIN AT 2000N OF LOAD



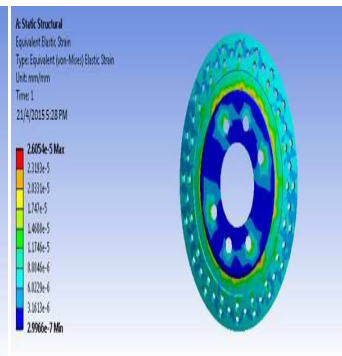
**FIG -10:** GRAY CAST IRON STRESS AT 2000N OF LOAD



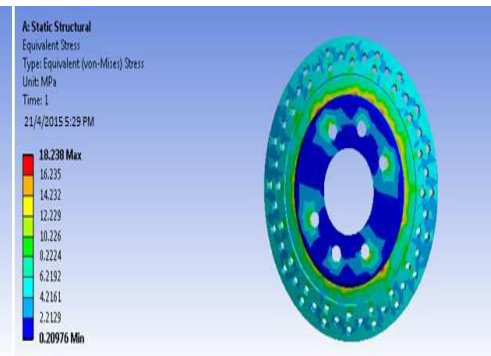
**FIG -11:** GRAY CAST IRON HEAT FLUX AT, 2000<sup>0</sup> C OF TEMPERATURE



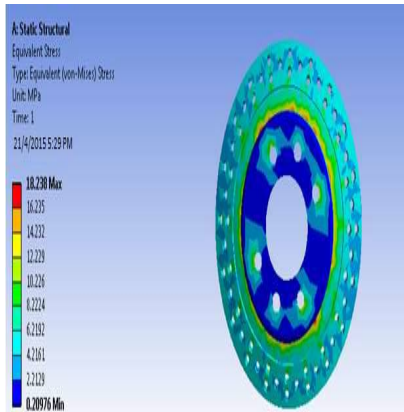
**FIG:12 :** aluminum deformation At 2000N of Load



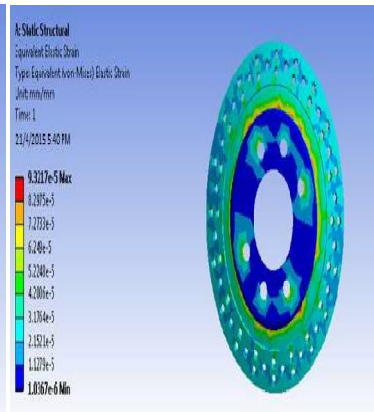
**FIG:13:** aluminum strain at 2000N of Load



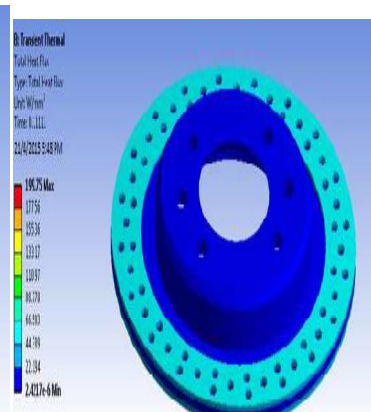
**Fig -14:** aluminum stress at 2000N of Load



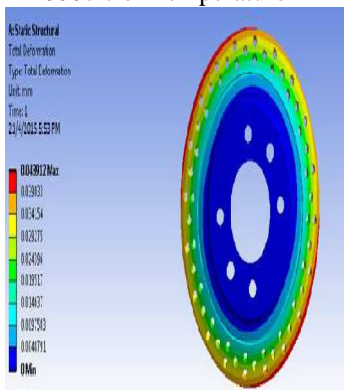
**FIG:15** : aluminum heat flux at 2000o c of Temperature



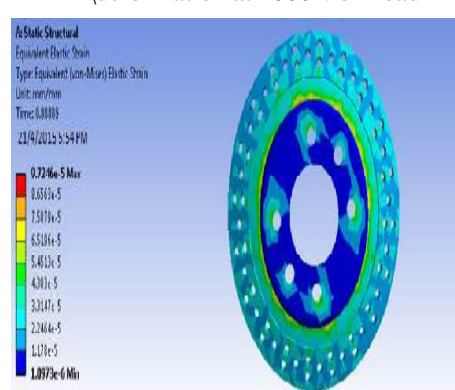
**FIG:16:** Nickel chrome steel \ deformation at 2000N of Load



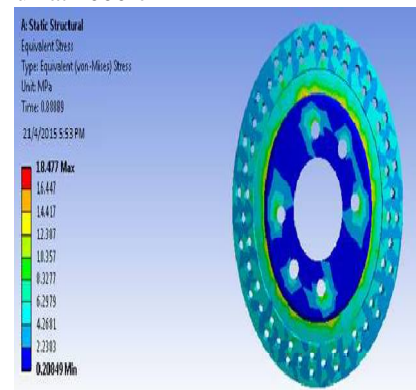
**FIG:17** : Nickel chrome steel heat flux at 2000<sup>o</sup>c



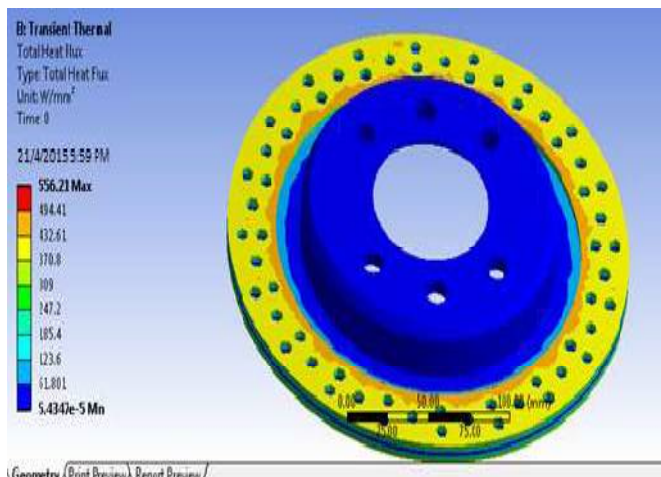
**FIG:18:** carbon reinforced material Deformation at 2000N



**Fig -19:** carbon reinforced material, strain at 2000N of Load



**Fig -20** carbon reinforced material stress at 2000N of Load



**FIG:21:** carbon reinforced material heat flux at 2000<sup>o</sup> c of Temperature

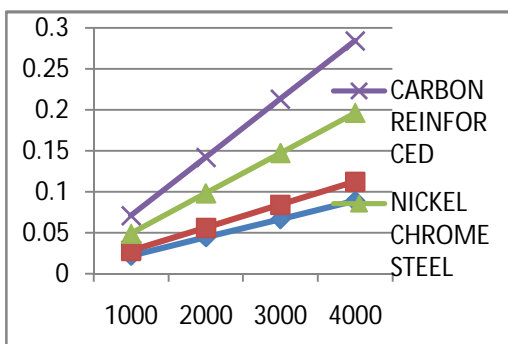
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## IV.RESULTS

### DEFORMATION

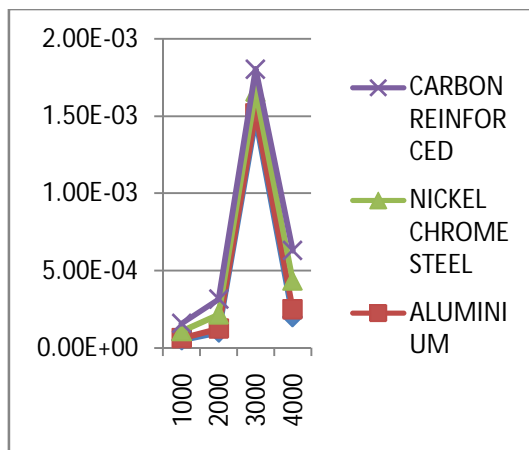


LOAD in N	CAST IRON	ALUMINIUM	NICKEL CHROME STEEL	CARBON REINFORCED
1000	0.022178	0.00588	0.021003	0.021956
2000	0.044356	0.011768	0.042003	0.043912
3000	0.066534	0.017652	0.063008	0.065868
4000	0.088713	0.023536	0.084011	0.087824

**Table 1** and graph showing the values of deformation vs. Load.

Here we had considered load vs. deformations have been considered by varying load we had find deformations by using ansys software and the results have been tabulated by observing above results we can say that carbon reinforced (ceramic) material is having less deformation when compared to other materials by this we can say that ceramic can with stand to more amount of force.

### STRAIN



LOAD in N	CAST IRON	ALUMINIUM	NICKEL CHROME STEEL	CARBON REINFORCED
1000	4.9287E-5	1.3027E-5	4.6609E-5	4.8623E-5
2000	9.8574E-5	2.6054E-5	9.3217E-5	9.7246E-5
3000	0.0014786	3.9082E-5	0.00013983	0.00014587
4000	0.00019715	5.2109E-5	0.00018643	0.00019449

**Table 2** and graph showing the values of Strain

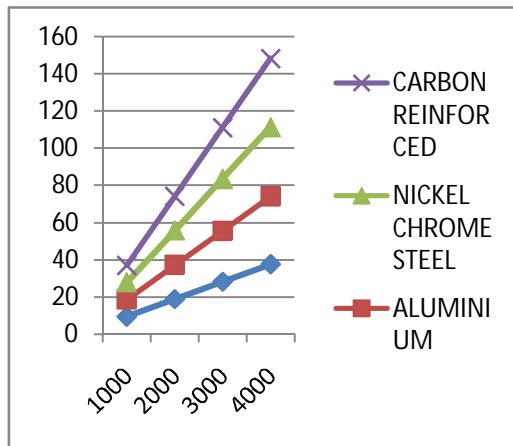
By observing strain values we can say that carbon reinforced material is having near values as gray cast iron and cfrp can be suggested for making of ceramic disc brake rotors.

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## STRESS

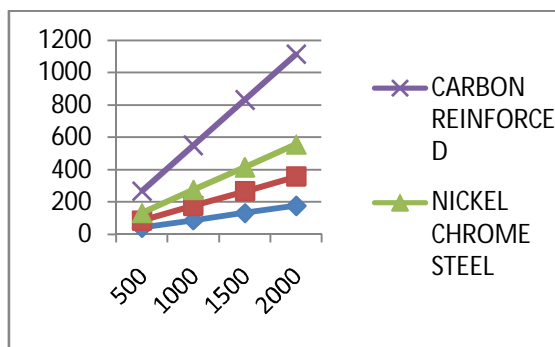


LOAD in N	CAST IRON	ALUMINIUM	NICKEL CHROME STEEL	CARBON REINFORCED
1000	9.3645	9.1191	9.3217	9.2383
2000	18.729	18.238	18.643	18.477
3000	28.094	27.354	27.965	27.715
4000	37.458	36.476	37.287	36.953

Table 3 and graph showing the values of Stress

By observing strain values we can say that carbon reinforced material is having approximated near values when compared to other metals. Here the stress factor is normal when compared.

## HEAT FLUX



TEMPERATURE IN C	CAST IRON	ALUMINIUM	NICKEL CHROME STEEL	CARBON REINFORCED
500	42.581	43.527	48.271	134.41
1000	87.122	89.057	98.764	275.01
1500	131.66	134.59	149.26	415.61
2000	176.2	180.12	199.75	556.21

Table 4 and graph showing the values of heat flux vs. temp

By observing above table values of ceramic and other materials ceramic (cfpr) has having highest amount of heat flux by this we can say that ceramic will be having good heat dispatch. By this we can suggest ceramic disc brake rotors where the high amount of heat will be generated.



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## WEIGHT

NAME OF MATERIAL	WEIGHT IN KG
CAST IRON	2.4729KG
ALUMINIUM	0.88074KG
NICKEL CHROME STEEL	2.6422KG
CARBON REINFORCED	0.60975KG

Table 5 showing the values of weight

By observing the weights of materials we can say that carbon fiber will be having less weight when compared with other materials.

## V.CONCLUSION & FUTURE SCOPE

By observing the Structural analysis and Thermal analysis results victimization Al alloy and Carbon reinforced polymer the stress values are at intervals the permissible stress value. Thus victimization Al Alloy and Carbon reinforced polymer is safe for disk brake. By observing the structural analysis, the vibrations are less for Al Alloy than different two materials since its natural frequency is a smaller amount. And additionally weight of the Al alloy reduces virtually three times when compared with alloy steel and cast-iron since its density is incredibly less. There by mechanical efficiency are going to be raised. However the strength of Carbon reinforced material is quite Al Alloy. Since the Thermal Analysis additionally Carbon reinforced is additionally permissible. By observing analysis results, Carbon reinforced polymer is best material for disk brake and it are often used for sports vehicles.

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