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Finite element Stresses Analysis Of Disc Braking System

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Abstract—

For Better transportation there is need for cars manufacturers to provide good safety systems
The brake system has become important active safety systems. The disc brake is a device for deaccelerating or stopping the rotation of a wheel. This work presents the analysis of the contact pressure at the disc interfaces using a detailed 3-dimensional model of a brake in FEM. Finite element (FE) model of the brake-disc is created using solid modeling Software i.e. Pro-E and Analyzed in ANSYS which is based on the finite element method (FEM). It also investigates contact pressure distributions at varying load. Due to rise in temperature the change in angular velocity and the contact pressure is also studied. Wear reduces the life of friction material. Due High wear, the frictional material needs to be replaced Continuously. Problems such as Continuous wear of brake pads and thermal cracks in brake discs are due to high temperatures. Continuously controlling the temperature and thermal and mechanical stresses are critical to proper functioning of the braking system. Cooling of Brake System is further an important aspect to consider for brake disc durability and performance. Different materials for brake pads is tested as compared with the existing one. Finally comparison between analytical results and result obtained from Ansys is carried out and all the values obtained from the analysis are less than their Permissible values. Hence on the basis of thermal and contact stress analysis best suitable material is suggested.

Key words :- thermal stress , Finite element **,** Disc Brake, bad

1- introduction

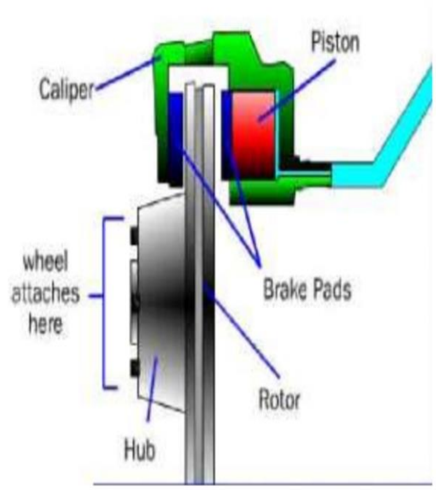
The disc brake is a device for deaccelerating or stopping the rotation of a wheel. A brake disc usually made of cast iron is mounted on the wheel or the axle. The brake disc revolves along with the wheel. The friction material i.e. brake pads are mounted on a device called a brake caliper is forced
mechanically, hydraulically, pneumatically or electromagnetically on both sides of the disc. Friction between the disc and wheel causes the wheel to retard or stop. Brakes (both disc and drum) converts friction to heat, but if the brakes get too hot, they will cease to work because they cannot dissipate enough heat.

Today, Most vehicles Consists of disc brake systems. A disc brake system basically consists of two pads, a caliper, a disc, a piston, a carrier bracket and two guide pins. One of the
major requirements of the caliper is to press pads against the disc and it should ideally achieve as uniform interface pressure as possible. Repetitive braking action causes rise in temperature due to friction and brake pad life gets reduced. This might lead to Problem to the customers who need to visit their garage more frequently in order to replace wear brake pads [1].

The frictional heat generated between two sliding bodies causes deformation which alters the contact pressure distribution [2]. The aim of the project is to show how to perform a crashworthiness simulation in the automobile industry using finite element method. Due to rise in temperature the change in angular velocity and the contact pressure is also studied. Finite element (FE) model of the brake-disc is created using solid modeling Software i.e. Pro-E and Analyzed in ANSYS which is based on the finite element method (FEM). Different material is to be tested so as to compare the existing brake lining material with the other brake lining materials and also suggest the new brake lining material for the present application.

2- Backgraond Working of Disc Brack

A disk brake works on the principle of Pascal's Law/Principle of transmission of fluid pressure. Pascal's law states that "pressure exerted at any point in a confined incompressible fluid is transmitted equally in all directions throughout the fluid."



Fig(1) ; workrmg of disk brack

When a brake lever or pedal is pressed, the braking effort is transmitted to the hydraulic caliper. Master cylinder piston pushes the master cylinder piston. This movement allows the
master cylinder piston to reciprocate and push the return spring inside the bore of master cylinder, which creates pressure in reservoir tank. At this moment, a primary seal allows the brake fluid of reservoir tank to inside the brake hose pipes. A secondary seal ensures that the brake fluid does not go other side.

Then the hydraulic fluid enters in to the cylinder of caliper assembly via brake hose pipes and pushes the caliper piston or pistons. At this time the piston ring moves in roller like shape with piston. Then the caliper piston pushes brake pad. This action causes brake pads to stick or remain in contact with brake disc which creates friction and stops the brake disc/rotor to rotate. This way disk brake system stops or retards the vehicle.

When the brake lever or pedal is released the piston ring pushes the caliper piston back to cylinder of caliper till both, caliper piston and piston ring come into their original shape. At the same time retraction spring pushes the brake pads to their original position. The retracting spring in master cylinder pushes the master cylinder piston back to its earlier original position and allows the fluid to flow back to reservoir via hose pipe and master cylinder bore.

In this study, the researcher gives the guideline about the performance of disc brake friction material. The selection of material is based on always experience or the trial and error experimental method. In this paper the researcher used inertia brake dynamometer to conduct the experiment. The coefficient of friction variation is determined at different speed and pressure. The coefficient of friction increased with increase in speed from 20 kmph to 80 kmph and then coefficient of friction continuously decreased from 80 kmph to 140 kmph. The maximum coefficient of friction was observed at 80 kmph [3].

overturned in federal court but it resulted in a major shift away from asbestos by friction material suppliers and vehicle manufacturers. Because it is an economical fiber for low temperature brake applications. The selection of the ingredients and composition in the formulation has been largely depends on experience [4].

3 Analytical Results

- **Properties of materials**

Table (1) Materail properties of brack bads

Properties	Ceramic	Cast iron (DISC)	S2 Glass Fiber
Density (g/cm3)	3.21	7.4	2.4
Young's Modulus (GPa)	390	130	86.9
Poisson's Ratio	0.24	0.27	0.28
Thermal Conductivity (W/mk)	40	55	1.45
Sp. Heat (J/Kg)	800	447	737
Coeff. Thermal Expansion (/K)	8.4e-06	10e-6	0.9e-06

Table(2) material properties of rotor and brack bad

Properties	Cast Iron (DISC)	Existing Pad
Density (g/cm^3)	7.4 g/cm^3	2.58 g/cm^3
Young's modulus (GPa)	130 GPa	72.9GPa
Poisson's ratio	0.27	0.22
Thermal conductivity (W/mK)	55 W/mK	1.3 W/mK
Sp. Heat (J/KgK)	447 J/KgK	810 J/KgK
Coeff. Thermal expansion (/K)	10e-6 /K	5.4e-6 /K

- **Stress generated on disc due to pressure**

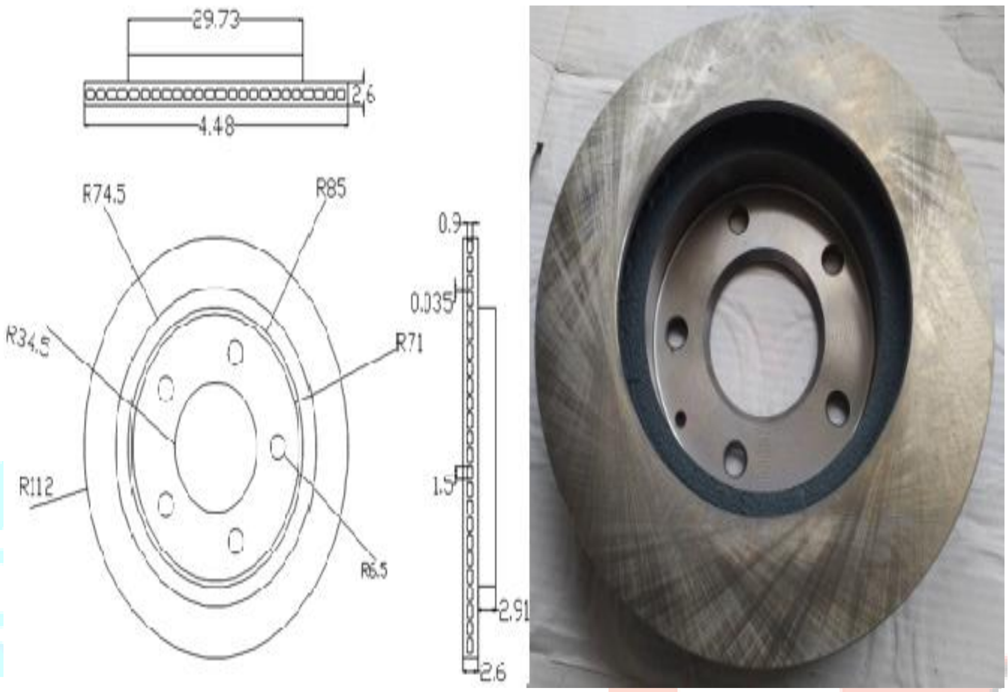


Fig (2)Disk or rotor of disk brac:

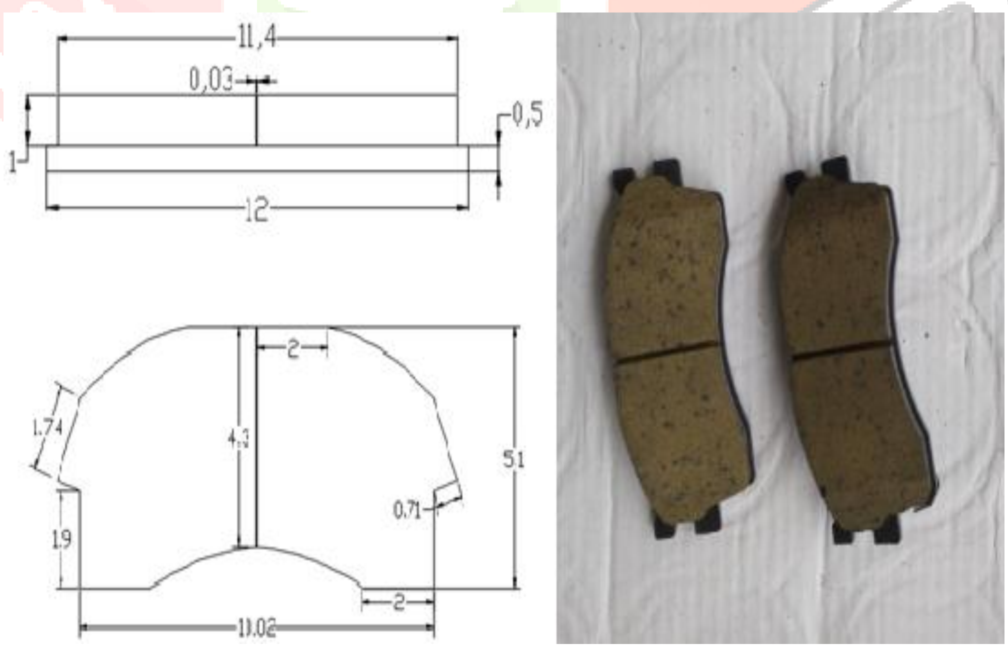


Fig (3) Brack bad

$\sigma = p_a/A$ ……………. (1)

Wher:

σ Stress

€ Strain

E Mouduies of elasticity [5]

$$\sigma = \frac{1.0132 * 10^5}{\frac{\pi}{4}(0.112 - 0.85)^2} = 23.68 * 10^7 \ N/m^2$$

$\varepsilon = \sigma/E$ …………….. (2)

$$\varepsilon = \frac{23.68 * 10^7}{130 * 10^9} = 0.00182$$

$\sigma_{thermal} = \frac{E}{1-\gamma} * \alpha * \Delta T$ ……………. (3)

Wher:

$\sigma_{Thermal}$ Thermal stress

$$\sigma_{thermal} = \frac{130 * 10^9}{1 - 0.27} * 10 * 10^{-6} * \left((450 - 27) + 273\right) = 1239 \, N/mm^2$$

$\varepsilon_{thermal} = \alpha * \Delta T$……………… (4)

$$\varepsilon_{thermal} = 10 * 10^{-6}\left((450 - 27) + 273\right) = 0.0069$$

- **Stresses on bad**

$\sigma = p_a/A$

$$\sigma = \frac{1.0132 * 10^5}{0.524} = 19.33 * 10^7 \ N/m^2$$

$$\varepsilon = \sigma/E$$

$$\varepsilon = \frac{19.33 * 10^7}{86.9 * 10^9} = 0.00222$$

$$\sigma_{thermal} = \frac{E}{1-\gamma} * \alpha * \Delta T$$

$$\sigma_{thermal} = \frac{86.9 * 10^9}{1-0.28} * 0.9 * 10^{-6} * \left((740-27)+273\right) = 1071\, N/mm^2$$

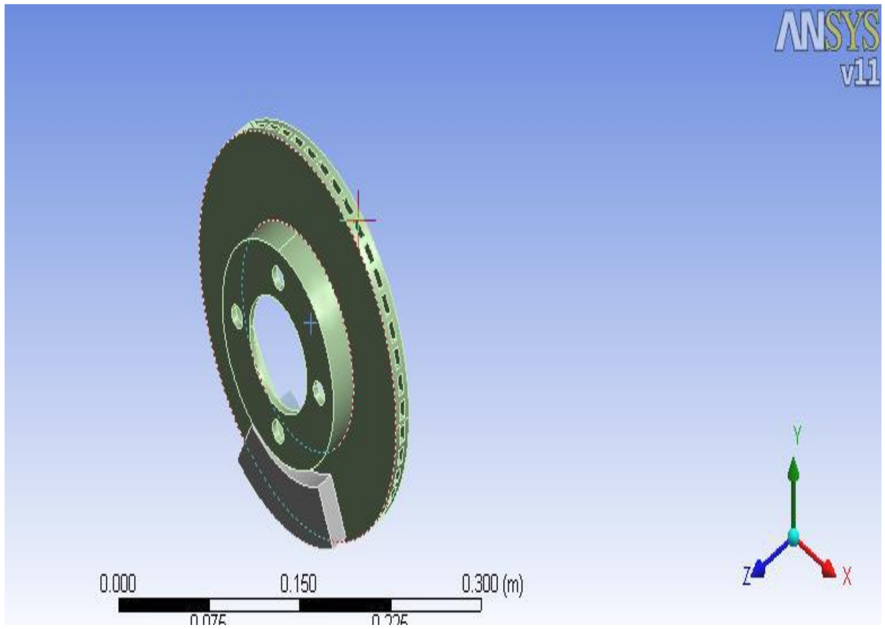
$$\varepsilon_{thermal} = \alpha * \Delta T$$

$$\varepsilon_{thermal} = 0.9 * 10^{-6}\left((740-27)+273\right) = 8.87 * 10^{-4}$$

4 Finite element analysis

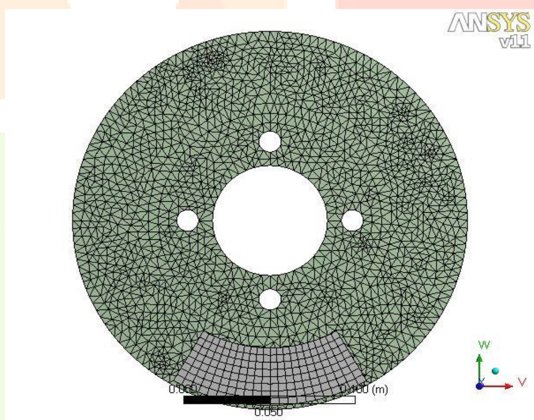
The finite element method is a tool to get the numerical solution of wide range of engineering problem. The method is capable to handle any complex shape or geometry, for any material under different boundary and loading conditions. The analysis requirement of engineering problems is overcome with help of finite element method

1 3D Geometry is already done in Pro-E software it’s IGS file is transfer to the Ansys software.



Fig(4): Finite element geometry of disk brackeshing

The elements used for the mesh of the model are tetrahedral three-dimensional elements with 8 nodes. The number of nodes is 53390 and the element is 24404.

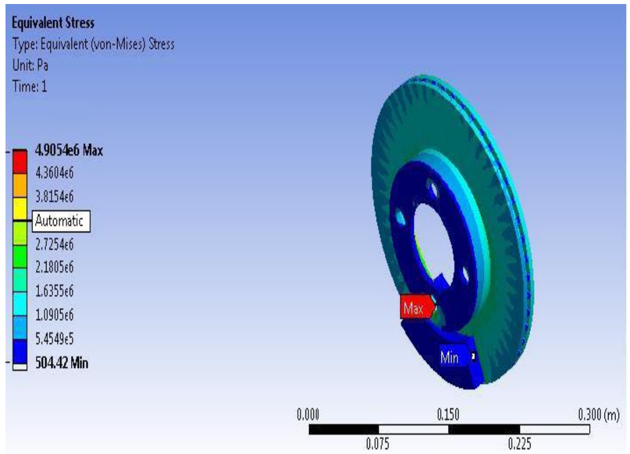


Fig((5): finte element meshing

2 Finite element results

1 . FEM Analysis with existing brake pad material

2



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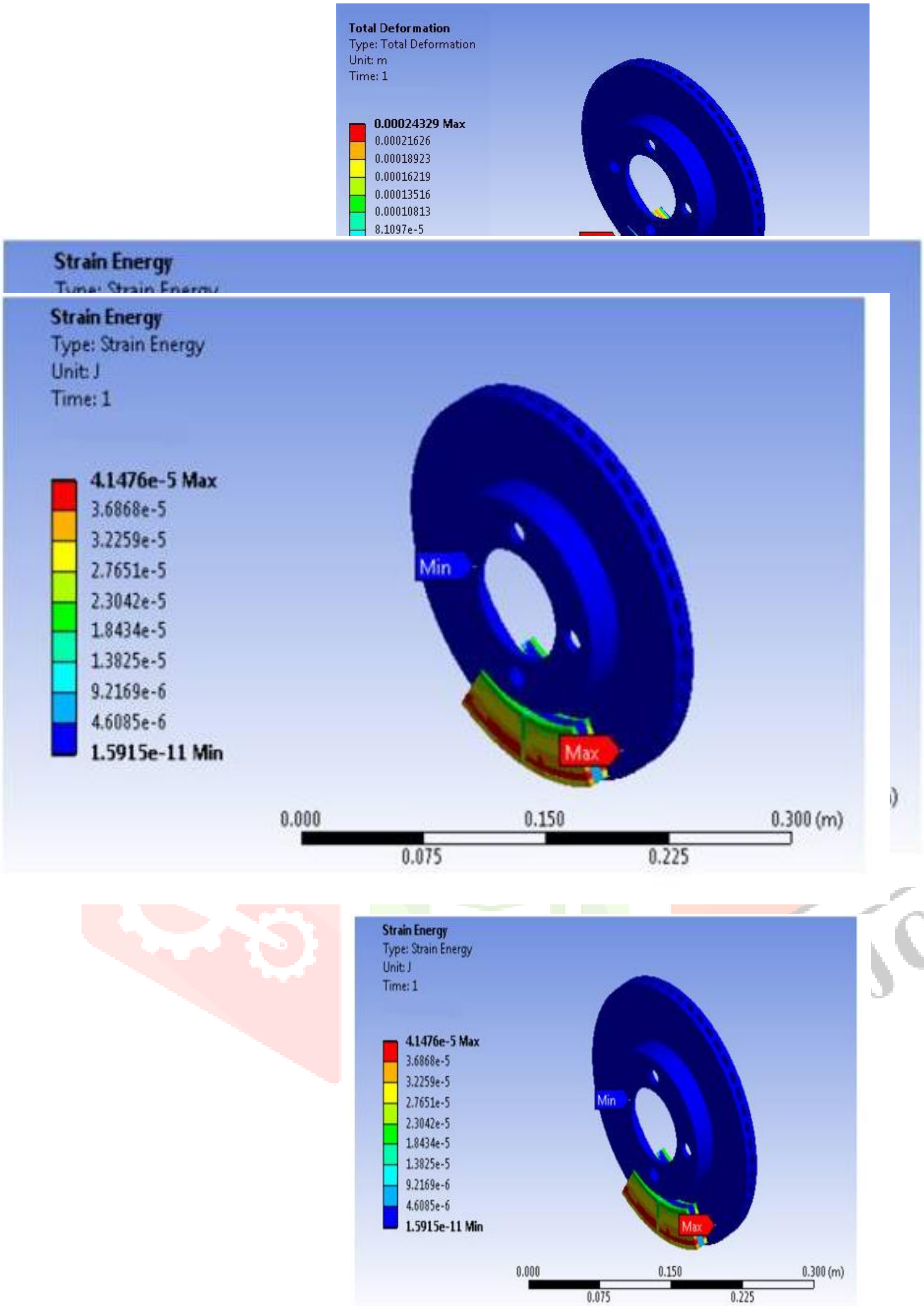
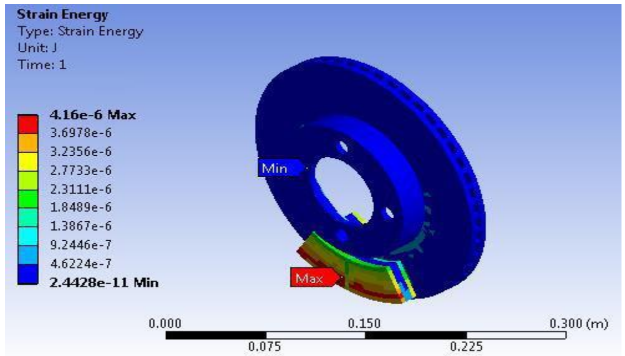
Fig(7): max and min deformation in exsting brack bad material

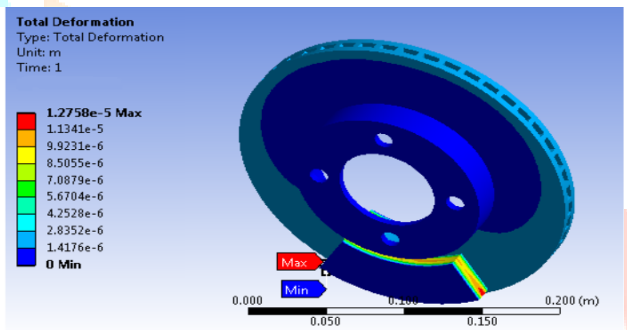


Fig(9): max and min ENERGY exsting brack bad

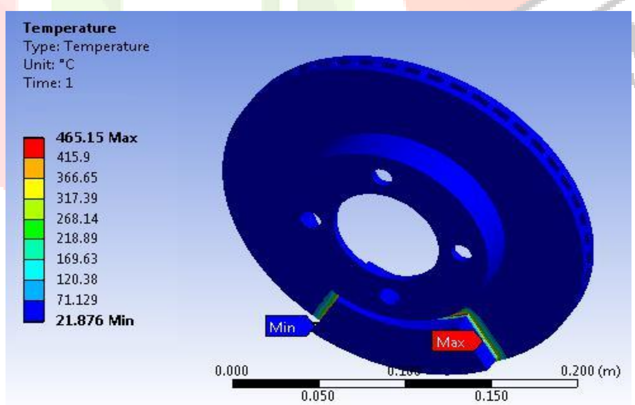
2 FEM Analysis With Ceramic Brake Pad Material



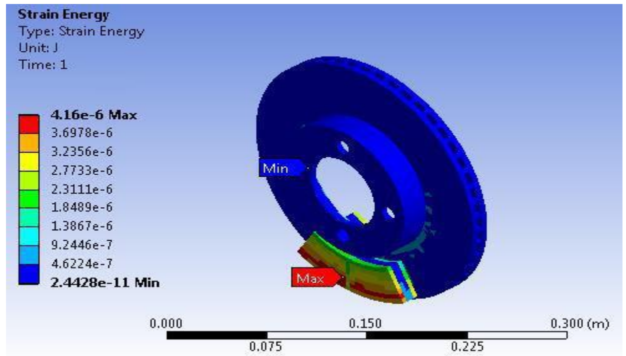
Fig(10)max and min equivalent stress of ceramic brack bad mateail



Fig(11)max and min deformation of ceramic brack bad mateail

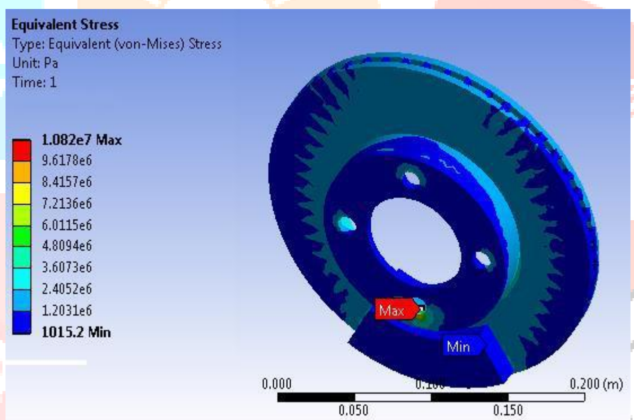


Fig(12)max and min temerture of ceramic brack bad mateail

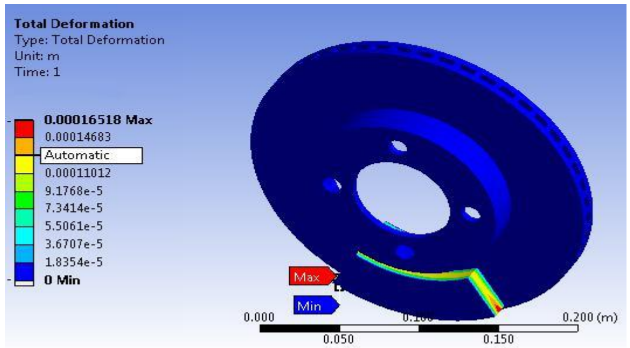


Fig(13)max and min enerjy of ceramic brack bad mateail

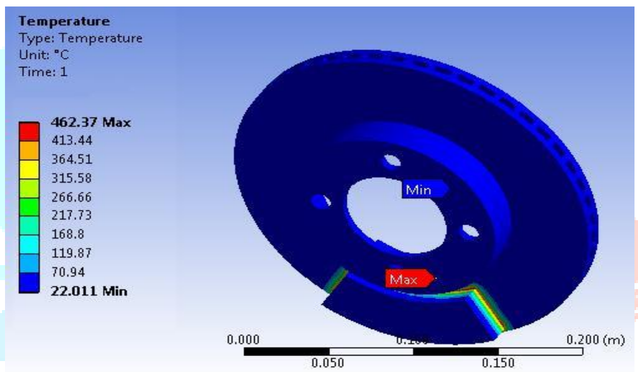
3 . FEM Analysis with carbon reinforced fibre brake pad .
Material



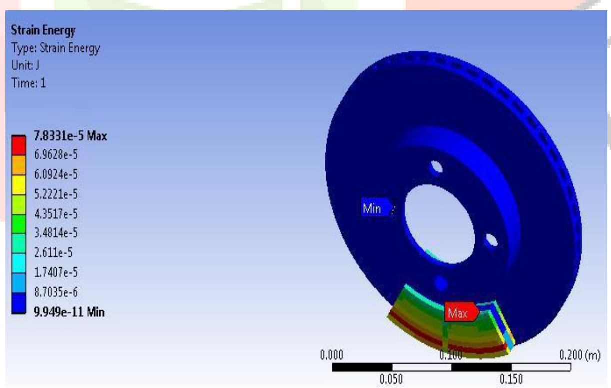
Fig(14) max and min equivalent stress of carbon rainforced fiber bad material



Fig(15) max and min deformation of carbon rainforced fiber bad material

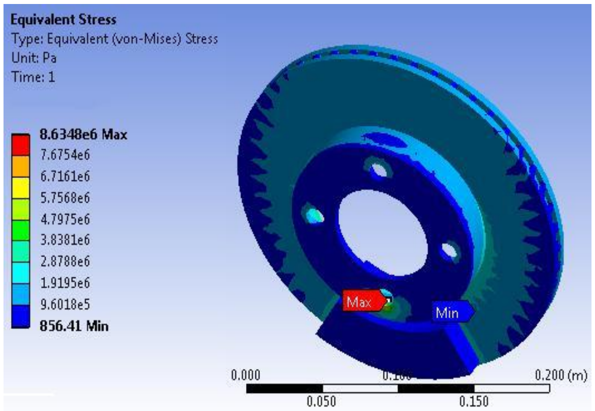


Fig(16) max and min tempertcur of carbon rainforced fiber bad material

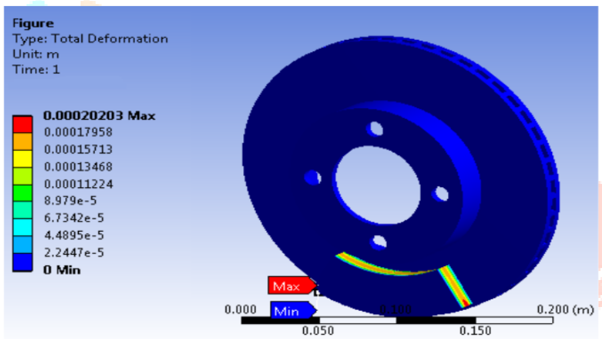


Fig(17) max and min enerjy of carbon rainforced fiber bad material

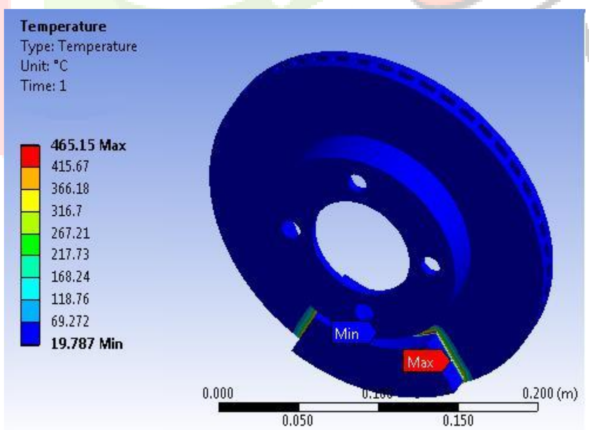
3 FAE Analysis glass fibre brake pad4



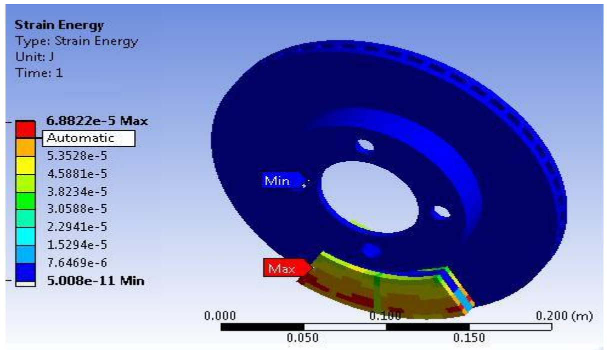
Fig(18): max and min equivalent stress of glass fibre brack bad material



Fig(19): max and min deformation of glass fibre brack bad material



Fig(20): ma and min temprtur of glass fibre brack bad material



Fig(21): max and min enerjy of glass fibre brack bad material

5 Discussion

From this analysis, the followings points are observed and pointed out

1. : On the basis of total deformation, equivalent stress, strain energy lost, total energy loss and thermal error the ceramic material is safe.
2. On the basis of temperature distribution and total heat flux the S2- glass fibre is safe.

4 Conculsion

1 In this study, the Pressure analysis and the thermal analysis for different brake pad material is examine. Different brake pad material is tested as compared with the existing brake pad material.

2It was observed that ceramic material is safe as compared to the other materials.

3Also, the result was validated by comparison with the analytical values and the software values. Hence, the ceramic material is best for the present application

5 References

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