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STEADY STATE THERMAL ANALYSIS OF DISC BRAKE ROTOR GRAY CAST IRON F12801

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ABSTRACT

Now a day in field of automotive very wide range of innovation happens regarding high speed vehicle, to better control of these high speed vehicles the most important factor is braking system. So in this research study we found the better option to improve the quality of the disk brakes for their characteristics of braking stability, and changing of torque in very high speed like formula one car racing events . In the disc brake rotor assembly, disc rotor is very important component so that we optimize the heat transfer rate in the rotor due to frictional heat generated on the interface of rotor, which leads to undesirable effects such as brake fade phenomena, local scoring, thermal cracking and thermo elastic instability. In the course of braking the parameters of the processes like load, temperature and conditions of contact vary with time so that we consider the effects of moving heat source with relative sliding speed variation. A steady-state thermal analysis is performed for four seconds of braking duration to characterize the temperature fields of the solid rotor with appropriate thermal boundary conditions. For the present analysis of solid rotor, CREO-PRAMETRIC 1.0 is used for the CAD modelling of the rotor and ANSYS14.0 is used as a FEA tool. Once the brake rotor temperature release in time duration than the distribution of temperature is obtained a transient structural analysis is performed to predict the failure of the disk rotor.

***Keywords**:* Disc brake; Steady-state; Frictional heat; Analysis; Rotor; Creo- parametric; FEM

INTRODUCTION

These days technology improved rapidly day to day which changes in vehicle sector surprisingly. On comparison of vehicle production before 20-25 years ago and later, we find abundant difference in aspect of comfort, economy and function and particularly in Safety. Very careful attention is given these days to passive and active safety system for vehicle. Active safety means helpful in avoiding traffic event and passive safety system protect passengers and drivers against injuries in traffic. In braking system one of most important is active safety of vehicle. Hence Braking system is necessary in an automobile for stopping the vehicle. Brakes are applied on the wheels to stop or to slow down the vehicle. Brakes should also be consistent with safety. While braking, most of the kinetic energy is converted into thermal energy which increases the disc temperature. This study deals in disc rotor design, disc rotor profile selection, disc rotor material selection and thermal stress analysis on Honda CB Unicorn, 150cc brake disc rotor. The heat dissipated along the brake disc surface during the periodic braking via conduction, convection and radiation. The findings of this research study provide a useful design tool to improve the brake performance of disc brake system.

The steady-state theory is a view that the universe is always expanding but maintaining a constant average density, matter being continuously created to form new stars and galaxies at the same rate that old ones become unobservable as a consequence of their increasing distance and velocity of recession. A steady-state universe has no beginning or end in time; and from any point within it the view on the grand scale, the average density and arrangement of galaxies--is the same. Galaxies of all possible ages are intermingled. The theory was first put forward by Sir Gold. It was further developed by Sir Fred Hoyle to deal with problems that had arisen in connection with the alternative big-bang hypothesis. Observations since the 1950s have produced much evidence contradictory to the steady-state picture and supportive of the big-bang model. The ANSYS /Multiphysics, ANSYS/Mechanical, ANSYS /FLOTRAN, and ANSYS/Thermal products support steady-state thermal analysis. A steady-state thermal analysis calculates the effects of steady thermal loads on a system or component. Engineer/analysts often perform a steady-state analysis before doing a transient thermal analysis, to help establish initial conditions. A steady-state analysis also can be the last step of a transient thermal analysis; performed after all transient effects have diminished.

We can use steady-state thermal analysis to determine temperatures, thermal gradients, heat flow rates, and heat fluxes in an object that are caused by thermal loads that do not vary over time. Such loads include the following:

Convections
Radiation
Heat flow rates
Heat fluxes (heat flow per unit area)
Heat generation rates (heat flow per unit volume)
Constant temperature boundaries.

DESIGN OF ROTOR

CAD model of disc brake rotor was done in CREO-Parametric dimensions of rotor mentioned in Table 1. Material used is Gray Cast Iron (F12801) because it is relatively hard and resist wear, cheaper than steel, it absorbs and dissipates heat as well.

Table1: Material properties (F12801)

Properties	Disc
Mass density(kg/m^3)	7500
Specific heat (J/k^{o}c)	490
Thermal conductivity (w/m^{o}c)	46
Inner radius (mm)	150
Outer radius (mm)	320
Disc thickness (mm) (Total)	21 (7+7+7)

Table 2 : Alloy composition

Iron(Fe)	92.1-93.9
Carbon(C)	3.1-3.4
Silicon (Si)	2.5-2.8
Manganese (Mn)	0.05-0.07
Phosphorus (P)	0-0.9
Sulfur (S)	0-0.15

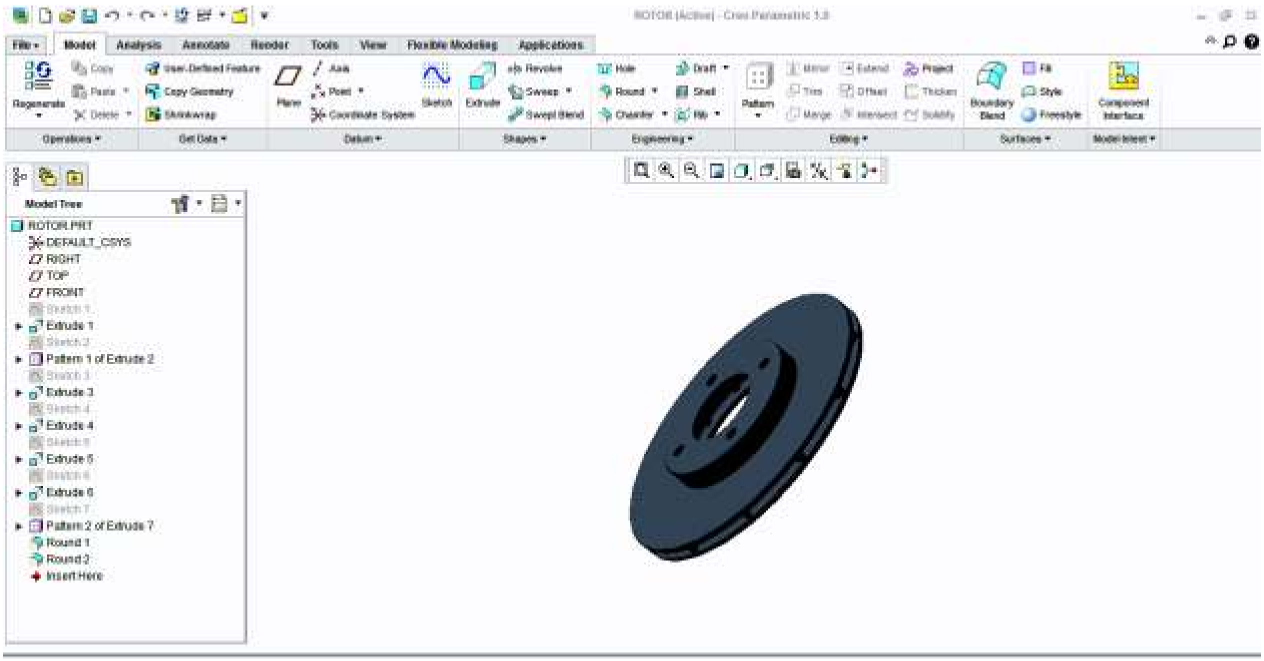

Fig. 1 : CAD model of Rotor in Creo-Parametric

After the part modelling of disc rotor we save this part as a copy in .igs file format for the further analysis of the disc brake roto in Ansys 14.0.

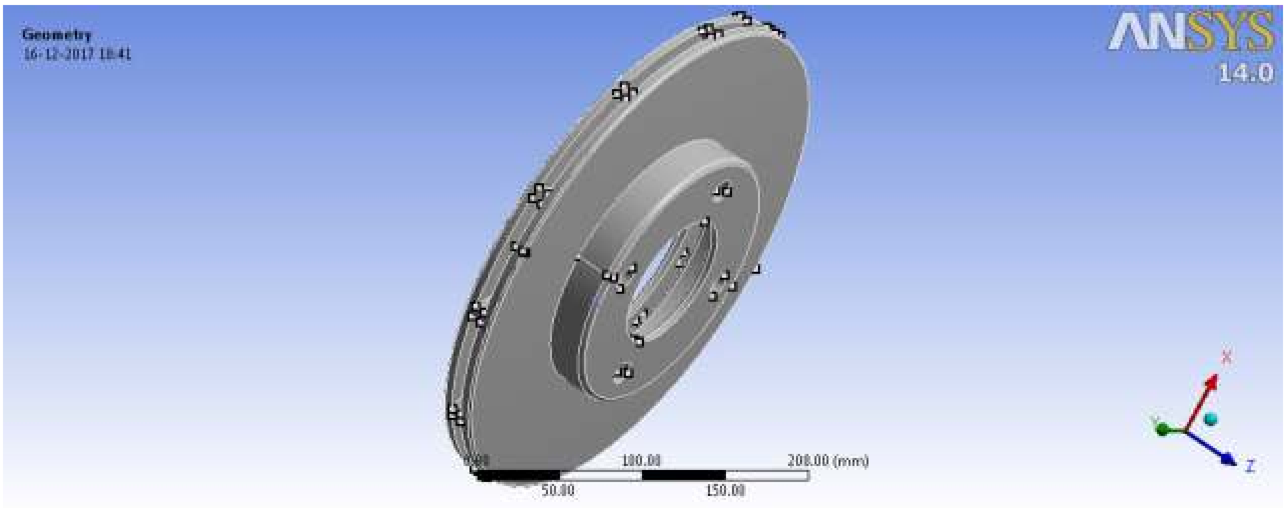

Fig. 2 : Imported model of rotor in Ansys workbench

BOUNDARY CONDITION FOR THE STEADY STATE ANALYSIS

After importing the cad model in Ansys workbench have meshed the rotor in suitable elements to good result of the analysis.

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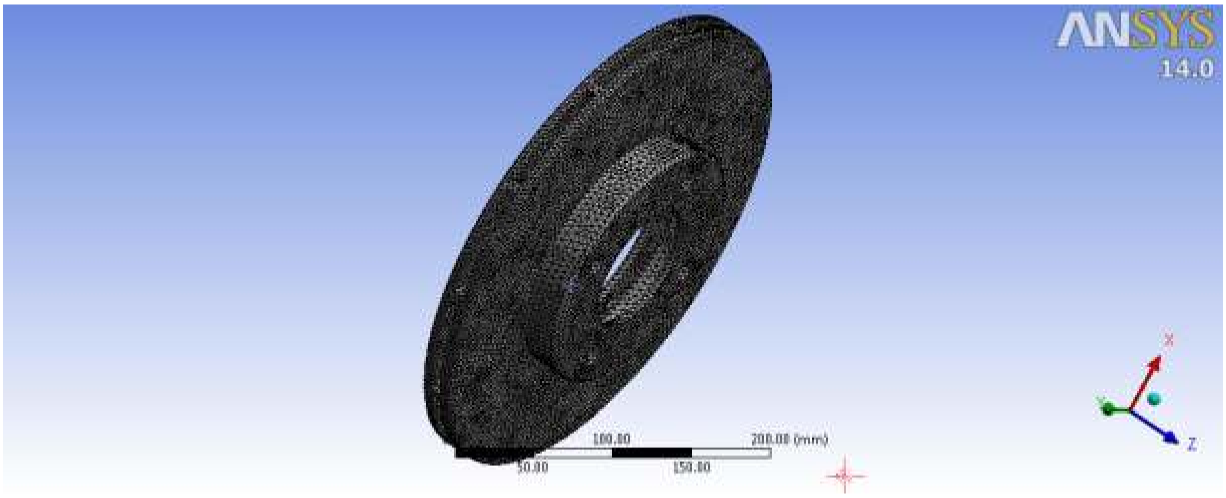

Fig.3 : Meshed model of the rotor

GEOMETRICAL PROPERTIES OF THE MODEL

The geometrical properties of the model for the meshing are shown in the table 3

Table 3 : Geometrical Properties of rotor

Definition	
Type	Design Modeller
Length Unit	Millimetres
Element Control	Program Controlled
Display Style	Body Colour
Bounding Box	
Length X	320. mm
Length Y	320. mm
Length Z	46. mm
Properties	
Volume	1.1251e+006 mm³
Mass	6. kg
Scale Factor Value	1.
Statistics	
Bodies	1
Active Bodies	1
Nodes	183818
Elements	109734

Boundary condition for the analysis: - For the boundary condition the initial temperature set 22 oC shown if fig-4 at A and the convection set at 22 0 C with the convection coefficient 1.24 10^-06. The detailed of boundary condition is shown in fig-4.

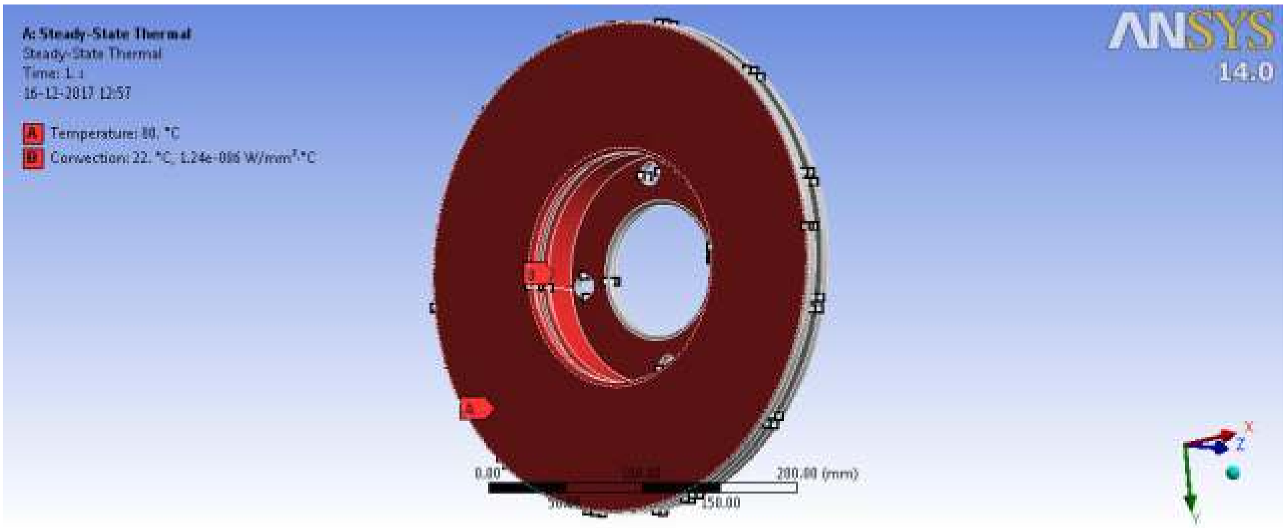

Fig. 4 : Boundary condition for the analysis

ANALYSIS OF ROTOR

Steady State thermal analysis- After application of appropriate thermal boundary conditions the initial temperature analysis is shown in the fig-5. From this analysis this clarifies that the outer area of the rotor produces maximum 80 0 C temperature and inner area of the rotor produces minimum 78.542 0C temperature which are low from the melting temperature of the material F12801 (1180 o C). So the material is safe for this analysis of initial temperature.

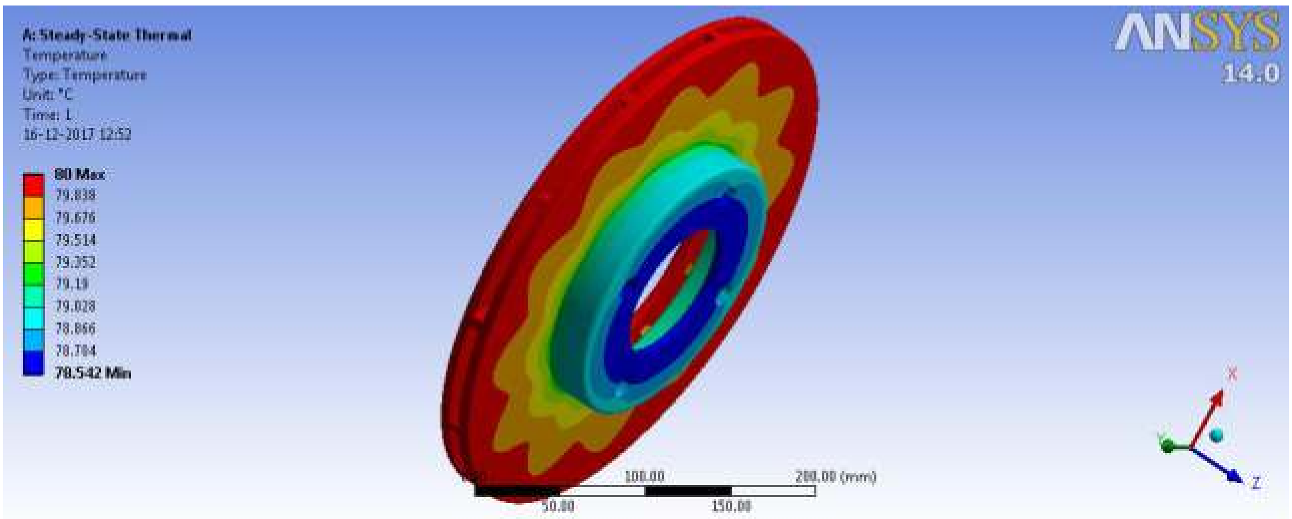

Fig.5 : Initial temperature analysis

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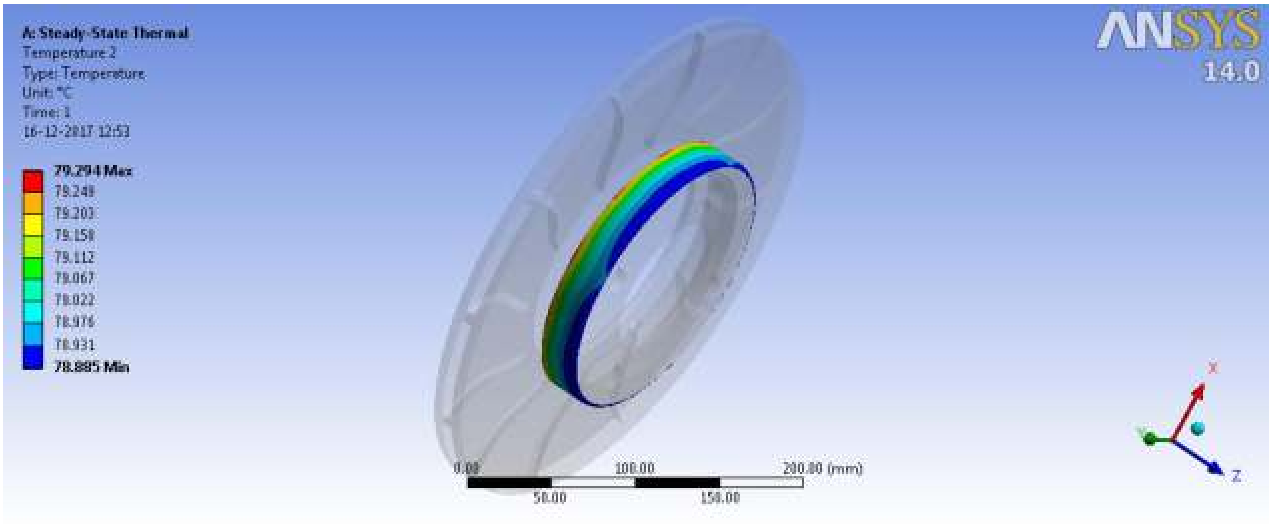

Fig. 6 : Final temperature analysis

The result of this analysis indicates that the temperature flows from the inner side of the rotor hub to the outer side. It means high temperature is in the inner side of the rotor hub and the low temperature at the outer side of the rotor hub as shown in fig.6

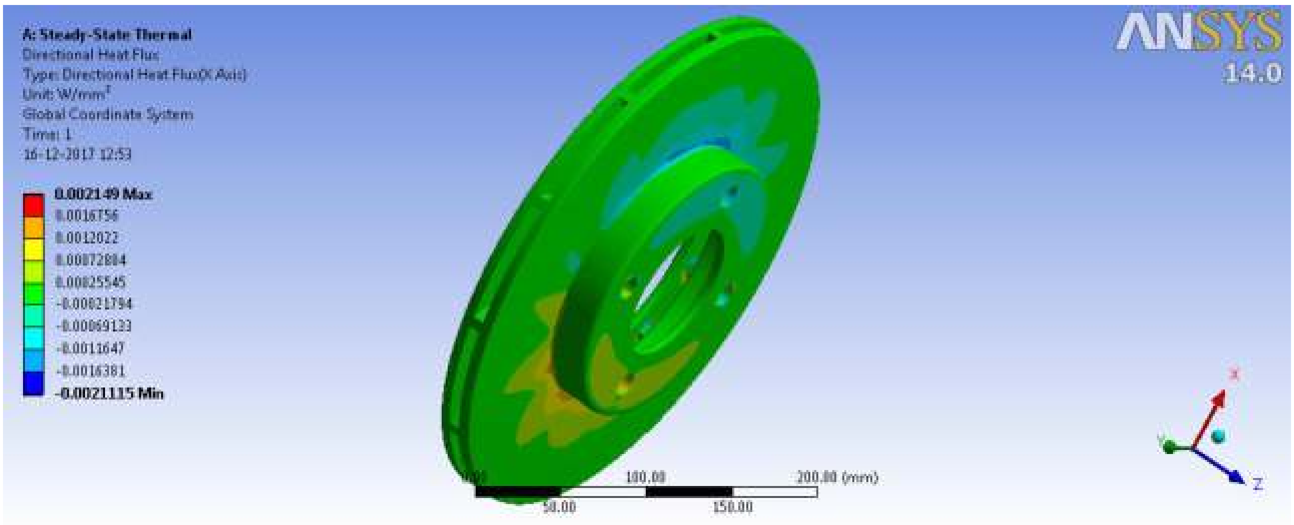

Fig.7: Analysis for the directional heat flux

From the direction heat flux analysis we found the information regarding the heat flux intensity on the rotor and the rotor hub to avoid plastic deformation of the rotor during the braking as shown in fig.7.

The total heat flux analysis shows the information for the combine effect heat flux in rotor area shown in fig.8

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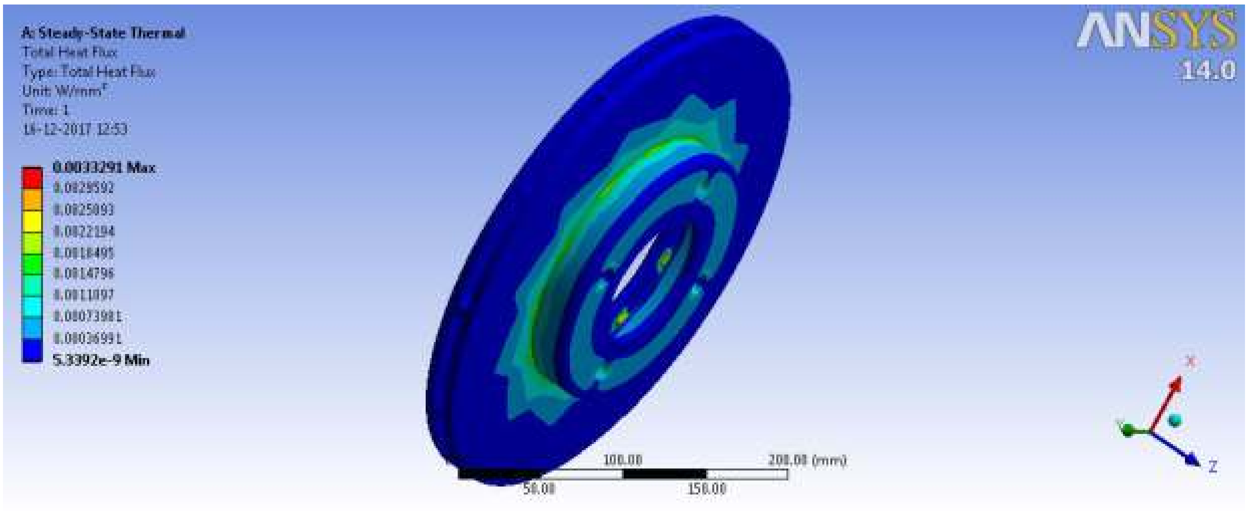

Fig. 8 : Analysis for total heat flux

Graph between temrature and covection cefficient:- This graph shows the relationship of the increment of the temprature and the effect of the covection coefficient of the material indicating that if the temprature increases the coefficient also increases but in the parabolic form.

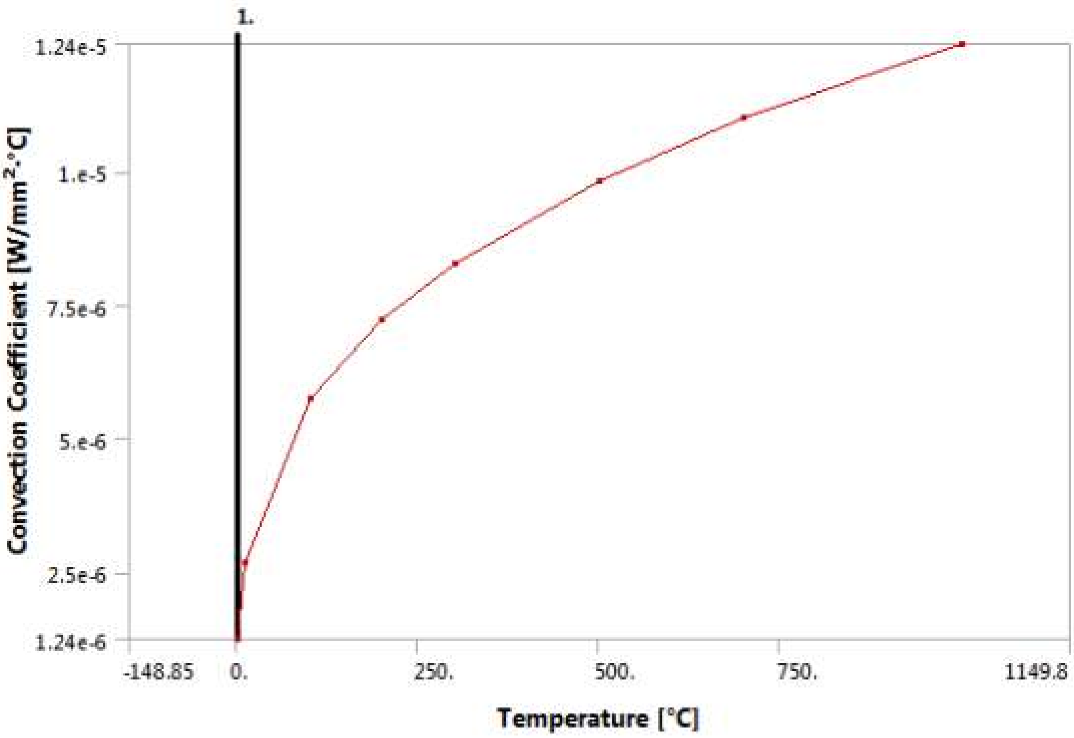

Fig. 9 : Graph between temrature and covection cefficient

Graph of increating temprature in radial direction- This graph shows the increament of the temperatures in ratial direction. From the graph, it is shown that the thемprature flows inner to outer direction with low to high.

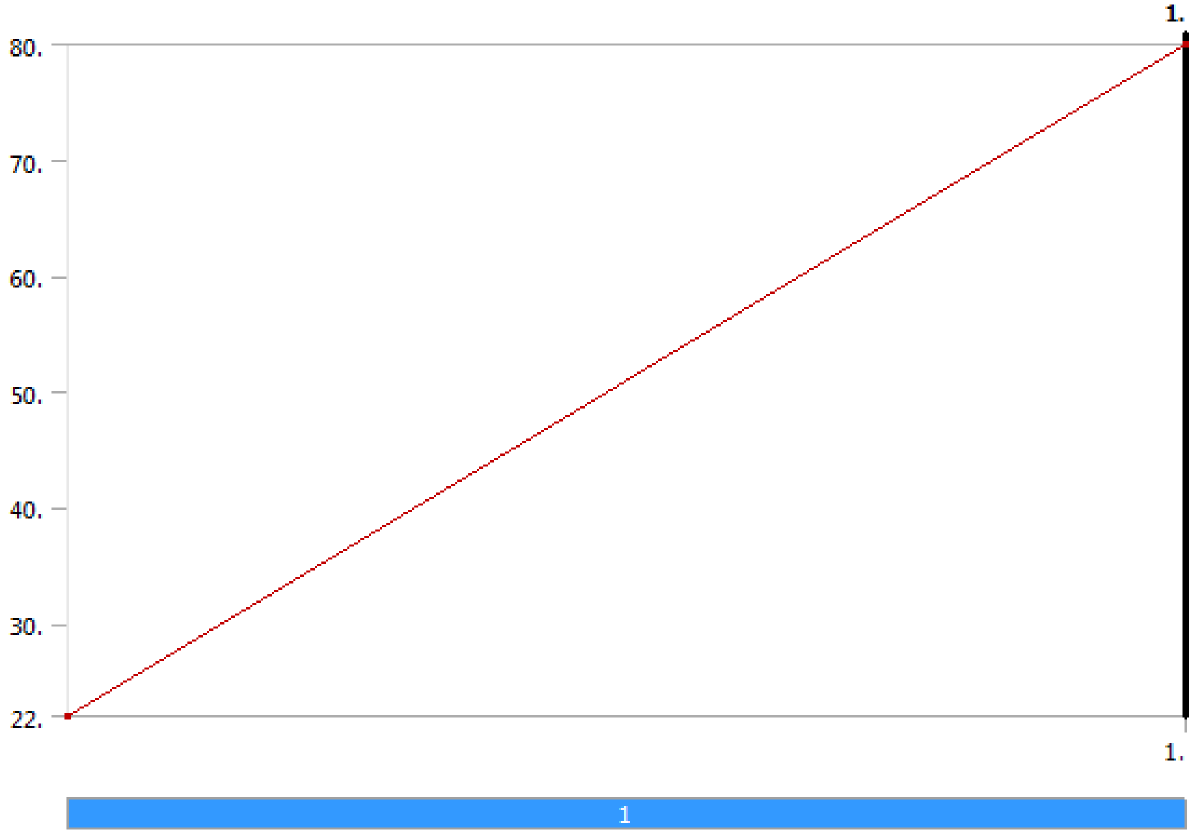

Fig. 10 : Graph of increating temprature in radial direction

RESULTS AND DISCUSSION

From the steady state analysis of the disc rotor it was found that the material F12801 gives the better result from the convection cast iron in the initial result and the non-reality effect is also safe for this material. The results of the steady state analysis are shown in bellow table 4.

Table 4 : Results of Steady State thermal analysis of the disc rotor

Analysis Method	Temperature (°C)	Total Heat Flux(W/mm^2)	Directional Heat Flux(W/mm^2)	Temperature 2 (°C)
FEM (Ansys)	22	3.3 * 10^-3 to 5.33 *10^-9	**2.14*10^-3 to 2.11*10^-3**	**80**

CONCLUSION

This analysis can provide the useful information regarding the further analysis of the disc rotor to use the rotor to more and more complex condition for the braking condition and the nonlinearity of the rotor to provide the more stability in the field of the braking system. The future scope for this study may be in transient thermal analysis, modal analysis transient structural analysis of the disc to collect the more information and feasibility of the rotor in various condition of the braking system.

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