Comparative Study Of Thermal Analysis Of Solid And Ventilated Disc Brake

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ABSTRACT

Braking is a process which converts a vehicle's kinetic energy into mechanical energy which is to be dissipated in the form of heat. During the braking process, the frictional heat generated at the interface of the disc and pads can lead to high temperatures. In this paper, work is present in the form of result of transient thermal analysis of disc brake disc used in four-wheeler . The aim of this paper is realize the purpose of holes on the disc brake. the thermal analysis is done for two different models of disc. One is a simple disc without vents and holes and the other perforated (consists of holes). Researchers have tried to analyze the heat loss from a disc which is considered to be heated by disc brake friction when in use. Researchers analyze the heat loss taking into account convection and radiation. The results are compared for both the discs. The initial condition assumed here is that the vehicle has stopped completely by application of brakes. Both the disc are of same dimensions.
The geometry of disc brake rotor is made in Creo parametric 2.0 . The heat transfer analysis is done using ANSYS workbench 14.5. The analysis helps us to understand which of the two models is better in terms of performance, heat loss and hence extensively used in four wheeler in real world.

Keyword: *Thermal analysis; Disc brake rotor; Natural convection; Creo Parametic 2.0 ; ANSYS workbench 14.5; Heat loss.*

1. 1. INTRODUCTION

Brakes are the most important safety parts in the vehicles. Brakes function to slow and stop the rotation of the wheel. To stop the wheel, braking pads are forced mechanically against the rotor or disc on both surfaces. They are compulsory for the safe operation of all vehicles. In short, brakes transform the kinetic energy of the car into heat energy, thus slowing its speed. A friction brake generates frictional forces as two or more surfaces rub against each other, to reduce movement. Based on the design configurations, vehicle friction brakes can be grouped into drum and disc brakes. A brake disc usually made of cast iron or ceramic composites includes carbon, Kevlar and silica, is connected to the wheel and the axle, to stop the wheel [1-3] If brake disc are in solid body the heat transfer rate is low [4-6]. Time taken for cooling the disc is low. If brake disc are in solid body, the area of contact between disc and pads are more. In disc brake system a ventilated disc is widely used in automobile braking system for improved cooling during braking in which the area of contact between disc and pads remains same [7,8].Here in this analysis the disc is made up of Structural steel.

2. LITERATURE REVIEW

Gao and Lin [9] have presented an analytical model for the determination of the contact temperature distribution on the working surface of a brake. Dufre´noy[10] proposed a macro structural model of the thermo mechanical behaviour of the disk brake, taking into account the real three-dimensional geometry of the disk–pad couple. Contact surface variations, distortions and wear are taken into account. Formation of hot spots as well as non-uniform distribution of the contact pressure is an unwanted effect emerging in disk brakes in the course of braking or during engagement of a transmission clutch. If the sliding velocity is high enough, this effect can become unstable and can result in disk material damage, frictional vibration, wear, etc. [11].

3 DESIGN OF DISC WITH CREO PARAMETRIC

Both the disc were designed in Creo parametric 2.0 . It is a Designing software developed by PTC systems. Both the disc are of identical size. The Ventilated rotor having small holes or vents on it .

3.1 Design of Solid Disc Brake

Solid disc is disc without holes and vents on it surface. the solid disc is design in Creo parametric .the dimension for the solid disc are as follows.

Table -1: Parameters of Solid Disc Brake

Parameters	**Dimensions**
Outer disc diameter, mm	310
Inner disc diameter, mm	83
Disc Thickness, mm	19
Disc Height,mm	46

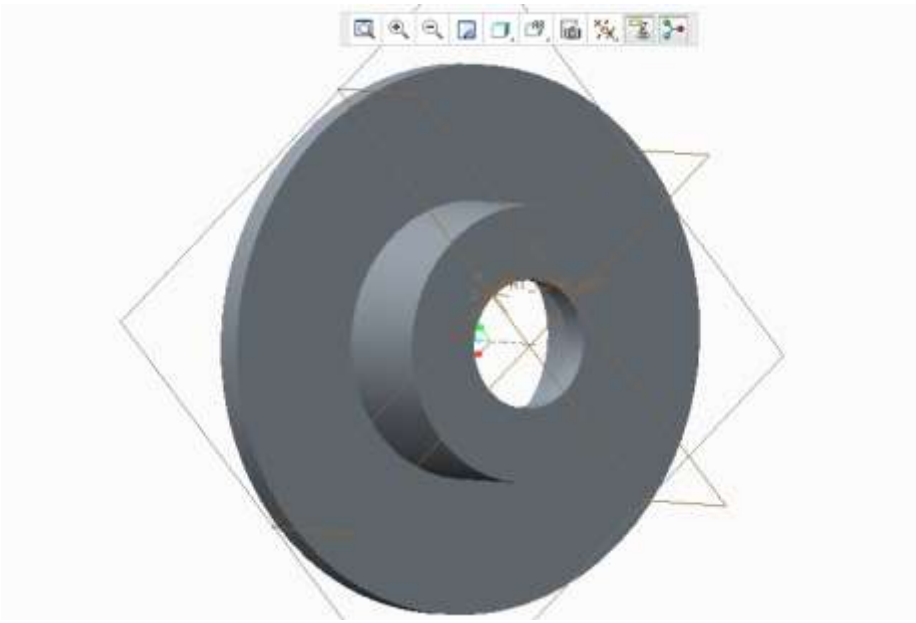

Fig -1: Solid Disc In Creo Parametric

3.2 Design of Ventilaed Disc Brake

Ventilated disc is made up of disc with holes and vents on it surface . the holes and are made by using Pattern feature in Creo parametric. following are the dimension for ventilated disc.

Table -2: Parameters of Ventilated Disc Brake

Parameters	Dimensions
Outer disc diameter, mm	310
Inner disc diameter, mm	83
Disc Thickness, mm	19
Disc Height,mm	46
Holes Diameter,mm	12
Number of holes	30
Number of Slots	10

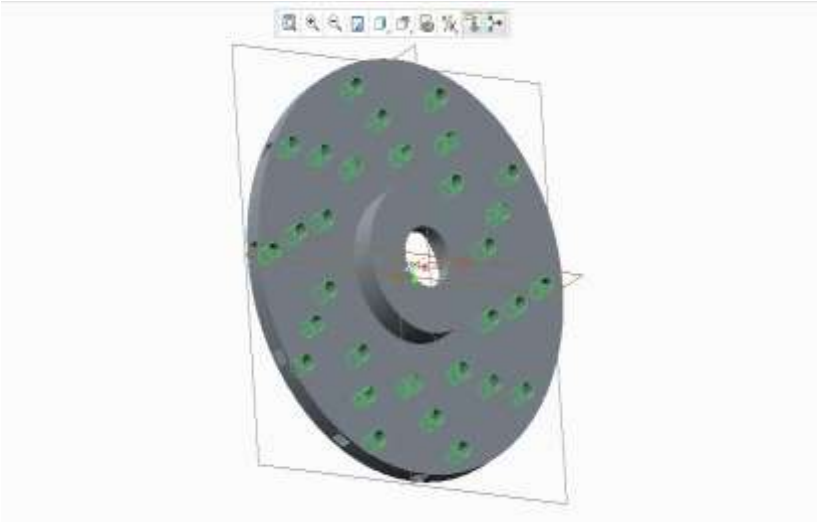

Fig -2: Ventilated Disc In Creo Parametric

4. IMPORTING MODEL TO ANSYS 14.5

4.1 Importing Model

The Above fig. are then imported in Ansys. For importing file format must be in STEP. file format which can be eassily imported in ansys . the following are the imported model in ansys.

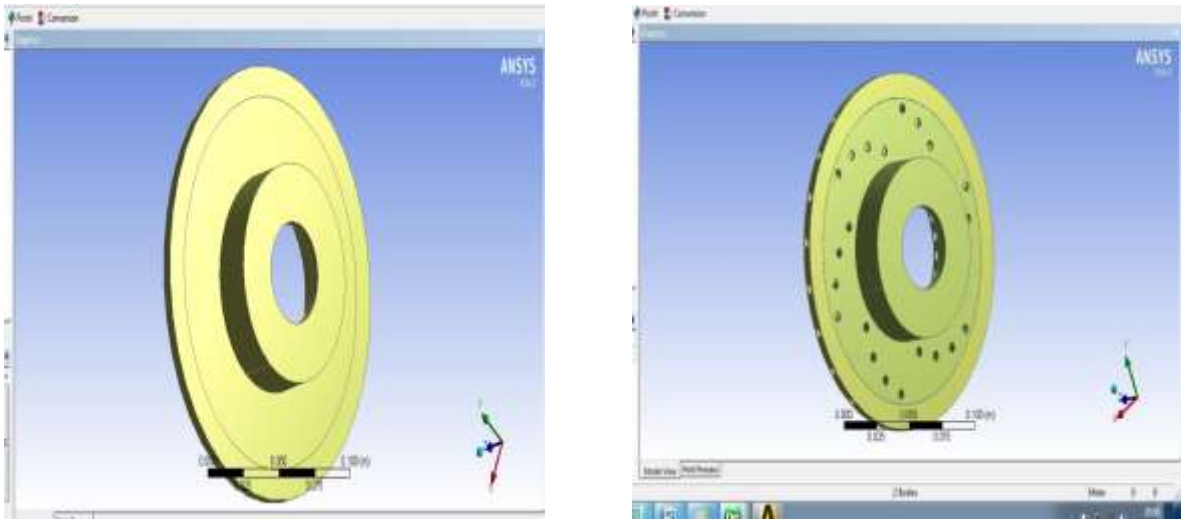

Fig -3: Imported STEPS Models in ANSYS

4.2 Material definitions

The material selected for the Solid and ventilated disc brake is Structural steel . The properties of material is shown in table .

Table -3: Material Properties for Structural Steel

Material Properties	**Structural Steel**
Thermal conductivity(w/m k)	60.5
Density, ρ(kg/m3)	7580
Specific heat , c (J/Kg)	434
Thermal expansion ,(10^{-6} / *k*)	0.12
Elastic modulus, *E* (GPa)	210
Coefficient of friction, μ	0.5
heat transfer coefficient h(w/km^2)	150

4.3 Mesh generation

The elements used for the meshing of the Solid and ventilated disc are tetrahedral three-dimensional elements with nodes (iso-parametric). In this simulation, the meshing was refined in the contact zone (disc-pad). This is important because in this zone, the temperature varies significantly

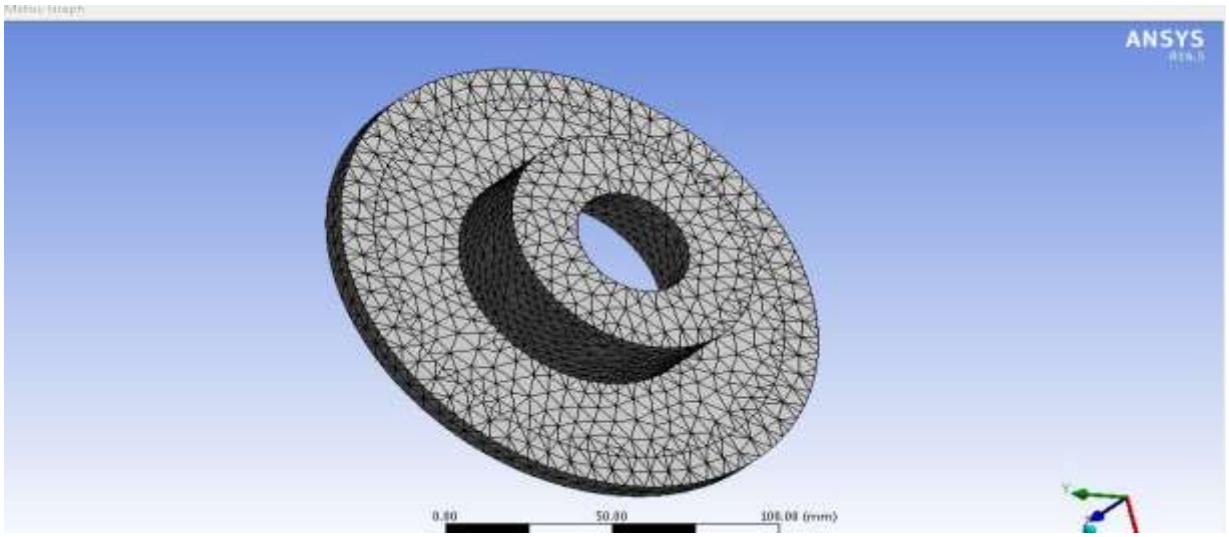

Fig -4: Meshing Of Solid Disc

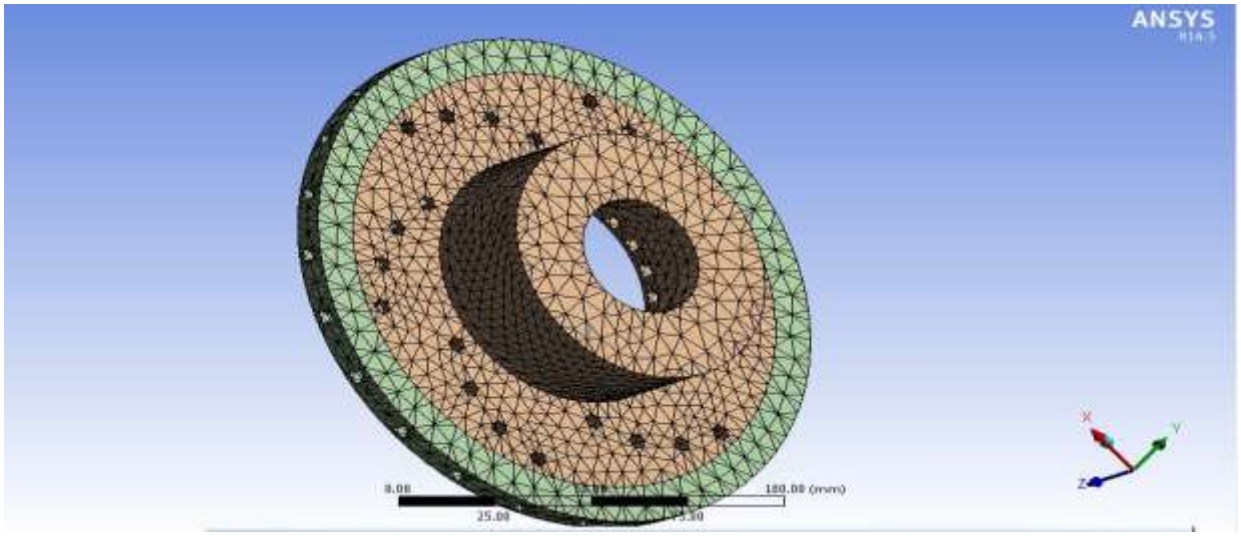

Fig -5: Meshing Of Ventilated Disc

4.4: Boundary conditions and loading

The boundary conditions are introduced into within the module ANSYS Workbench by choosing the mode of the first simulation, and by defining the physical properties of the materials.
These conditions constitute the initial conditions of our simulation. After having fixed these parameters, we introduce appropriate boundary conditions associated with each surface and specify the following computational parameters:

- Total time of simulation = 10 s.
- Increment of initial time = 0.25 s.
- Initial temperature of the disc = 22 ˚C.
- Materials: Structural Steel.
- Convection: we provided the simplified case of convection

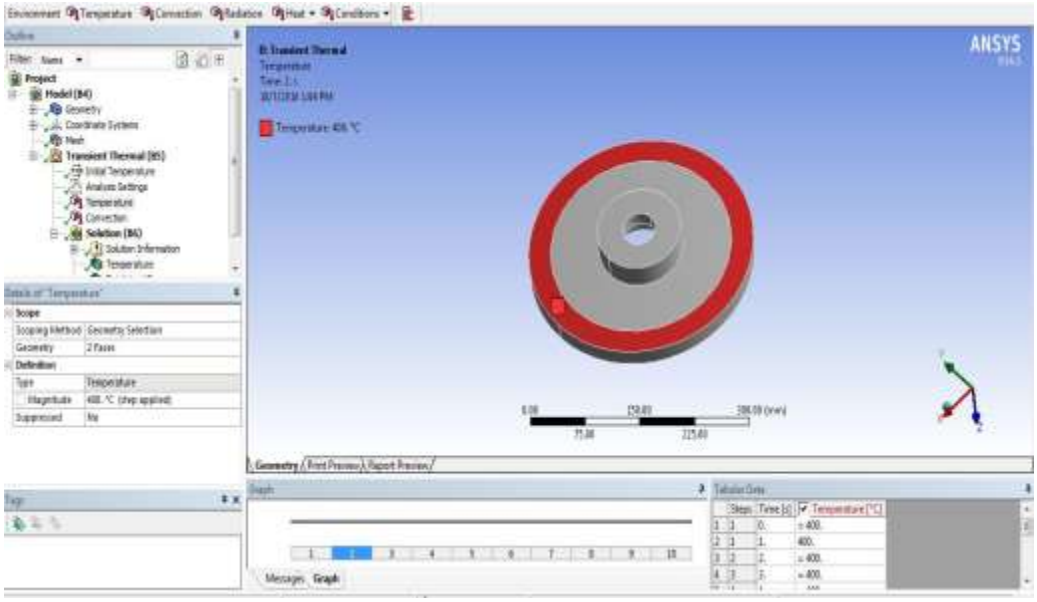

Fig -6: Temperature Boundary condition

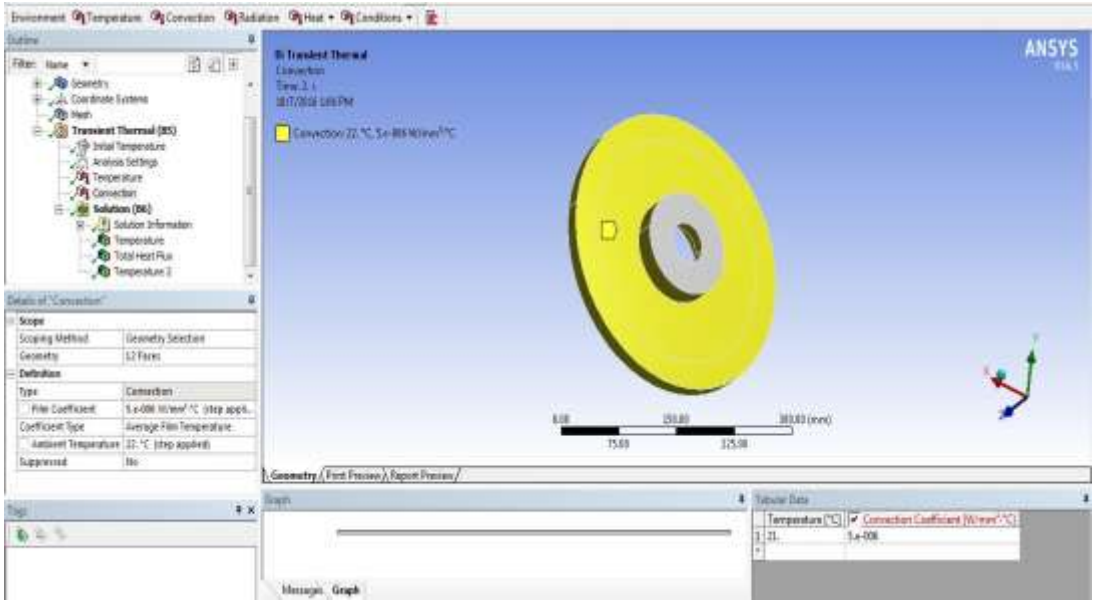

Fig -7: Convection Boundary condition

5 SOLUTION RESULT

ANSYS software was used for the analysis of both types of Disc Brake. ANSYS has been the pioneer in the application of computational methods to solve the engineering design over 40 years. The main module used in this work is transient thermal analysis. In the Transient thermal analysis, the Temperature distribution at different time intervals is determined. The temperature and Convection boundary conditions were simultaneously applied on both the rotor models. The temperature range is in between 400 to 800 degree C in working condition. For this problem we consider the temperature of 400 ^{0} C as input .

5.1 Solid Disc

Following fig. shows results of temperature distribution of Solid disc without vents after analysis in Ansys 14.5.

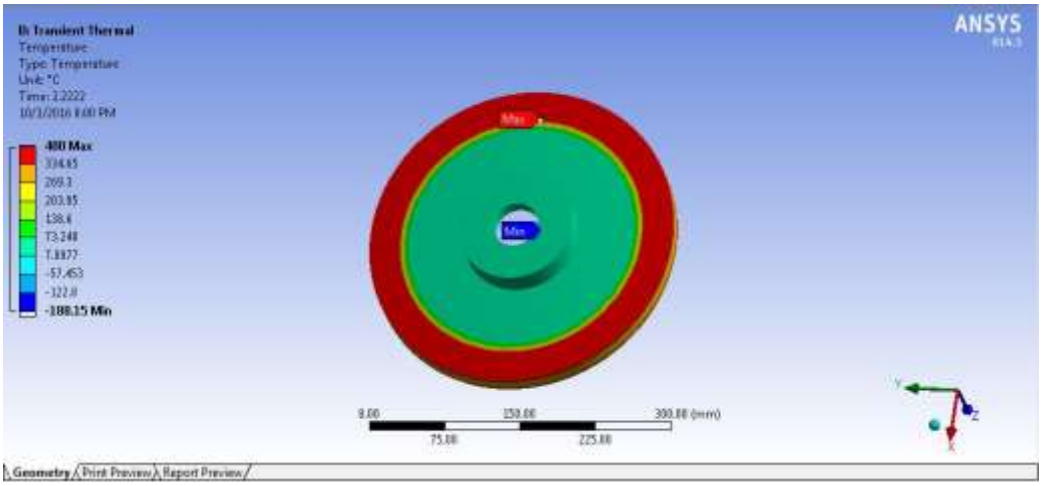

Fig -8: Temperature on Whole Solid Body

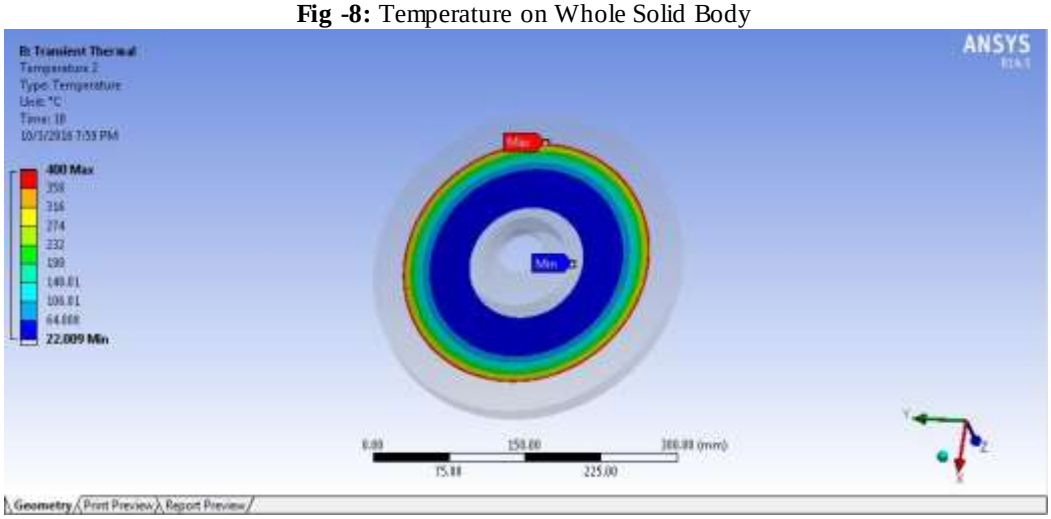

Fig -9: Temperature on Particular region

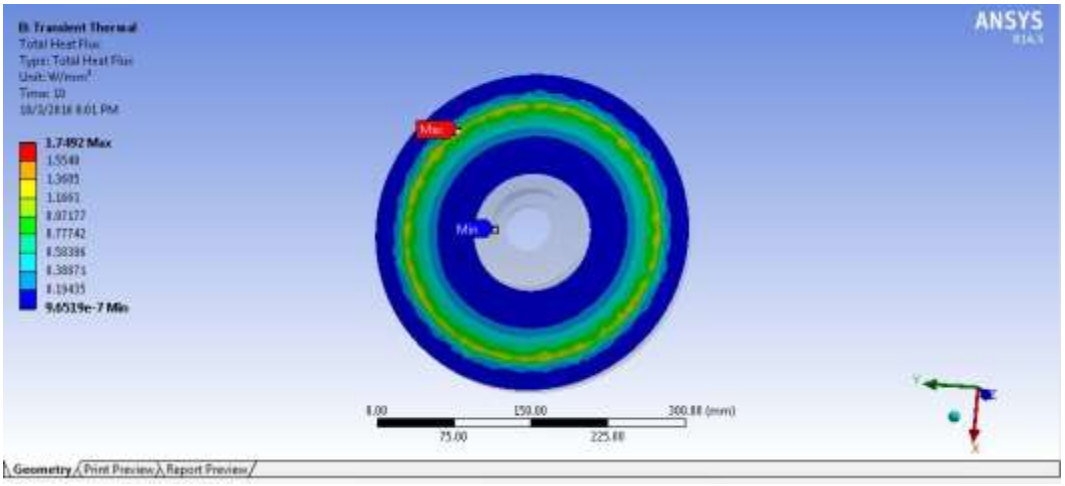

Fig -10: Heat Flux on Whole Body

5.2 Ventilated Disc

Following fig. shows results of temperature distribution of Ventilated rotor after analysis in Ansys 14.5.

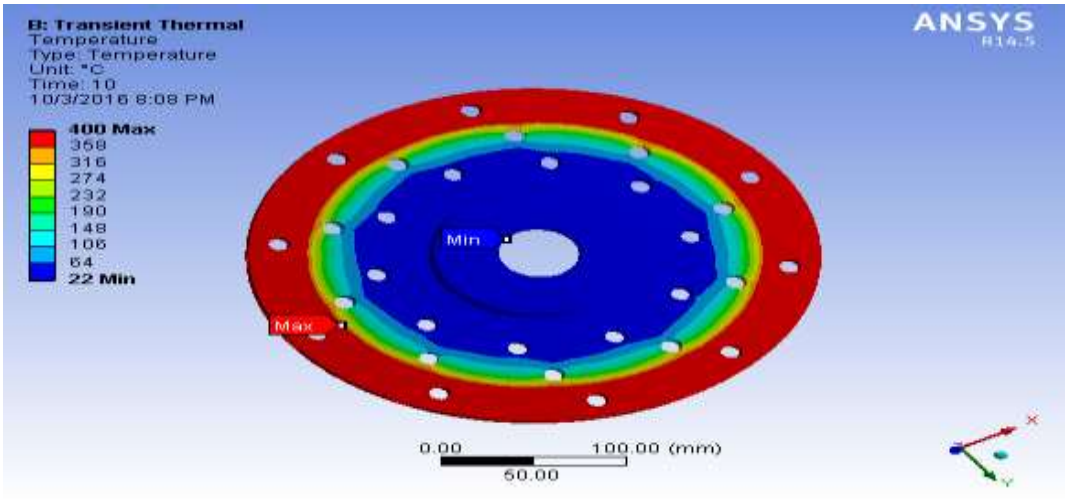

Fig -11: Temperature on Whole Ventilated Body

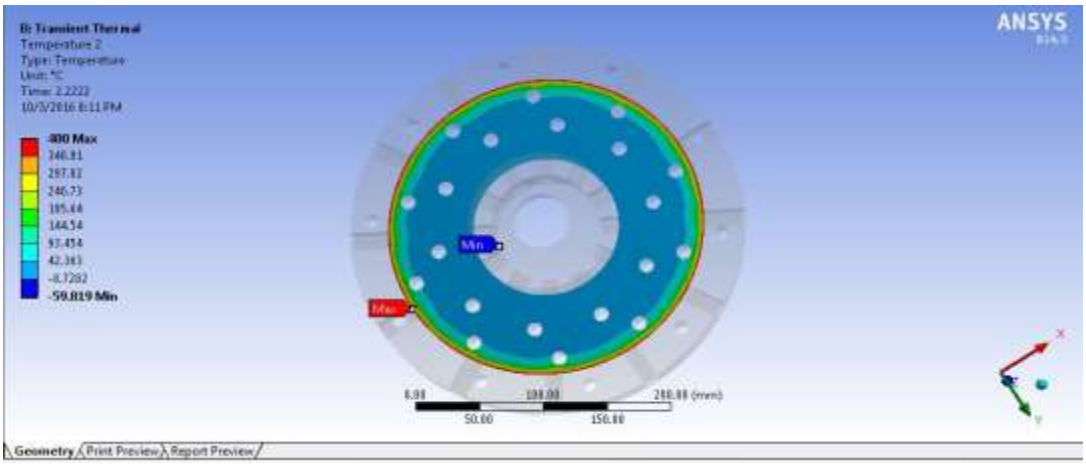

Fig -12: Temperature on Particular region

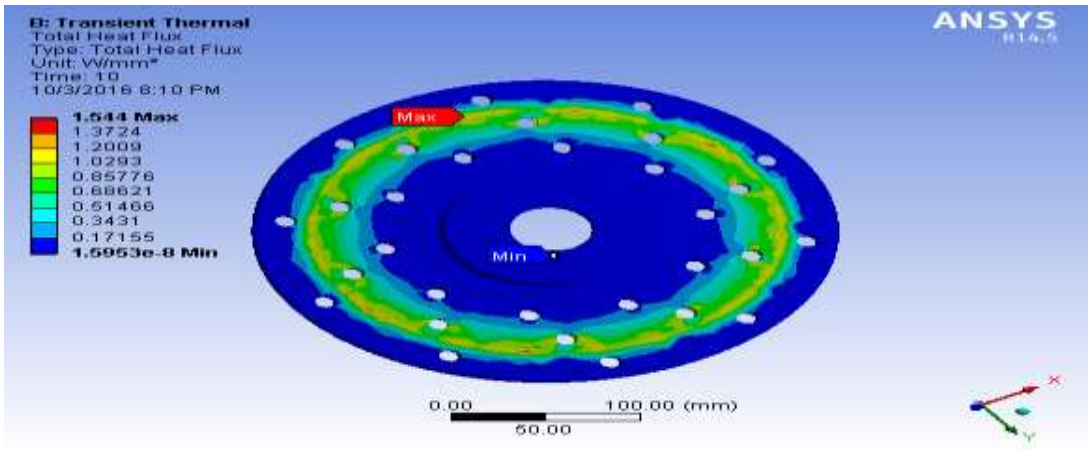

Figure-13: Heat Flux on Whole Body

6 SOLUTION AND RESULT COMPARISON

6.1 Result Comparison

It is assume that high temperature attained by a disc brake is 400°C. So initial temperature to be 400°C.The analysis of both the models was done and results are as shown in following table .

It is observe that in solid disc the minimum temperature reached was 64.008 while for Ventilated it is 42.363. its proves that vents on the disc helps the disc to get cooled better. Hence, the disc with holes is better regarding heat dissipation as compared to solid Disc model.

Table -4: Results of Structural steel Materials

Results	**Solid**		**Ventilated**	
	MAX	MIN	MAX	MIN
Temperature	400	64.008	400	42.363
Heat Flux	22.684	2.52	1.544	0.17

6.2 Graphical Result Comparison

For the solid and ventilated disc ,we have drawn the individual graphs .this graph are line graph. In this graph X axis is taken as Time while the Y axis is taken as Temperature . The maximum value of temperature is 400 degree C.

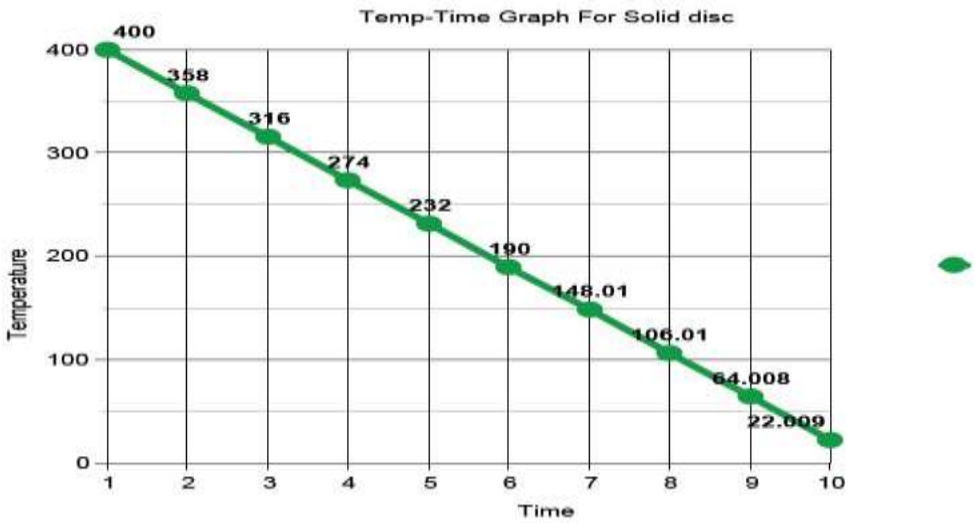

Chart -1: Graph For Solid Disc

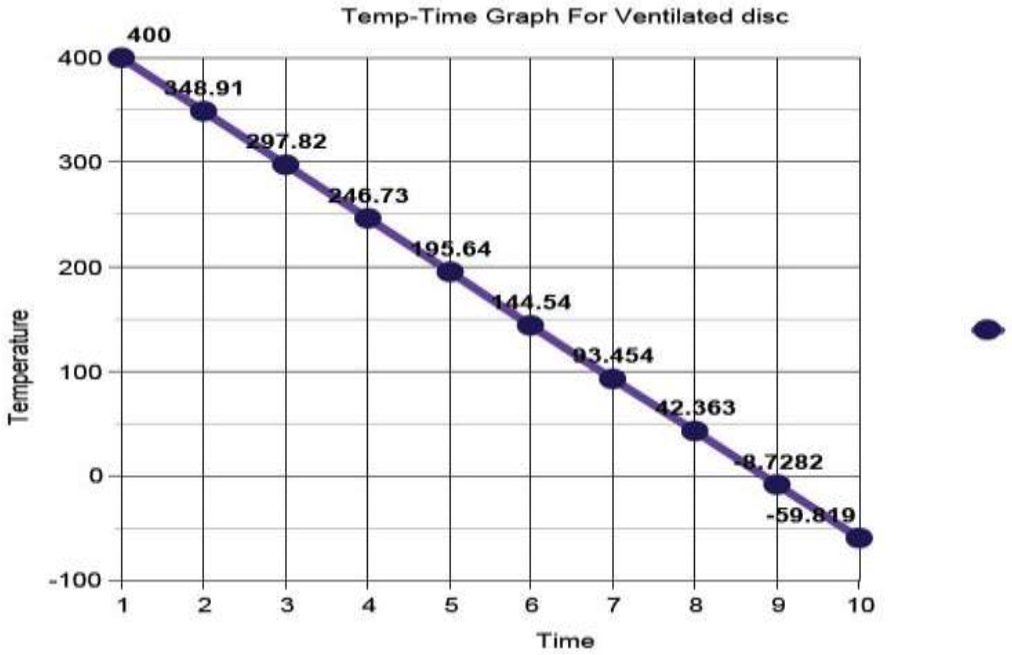

Chart -2: Graph For Ventilated Disc

After plotting individual graph for each disc, we plotted the comparative graph for both, solid and ventilated disc . This graph shows that, the Ventilated disc reading falls down comparatively as solid disc.

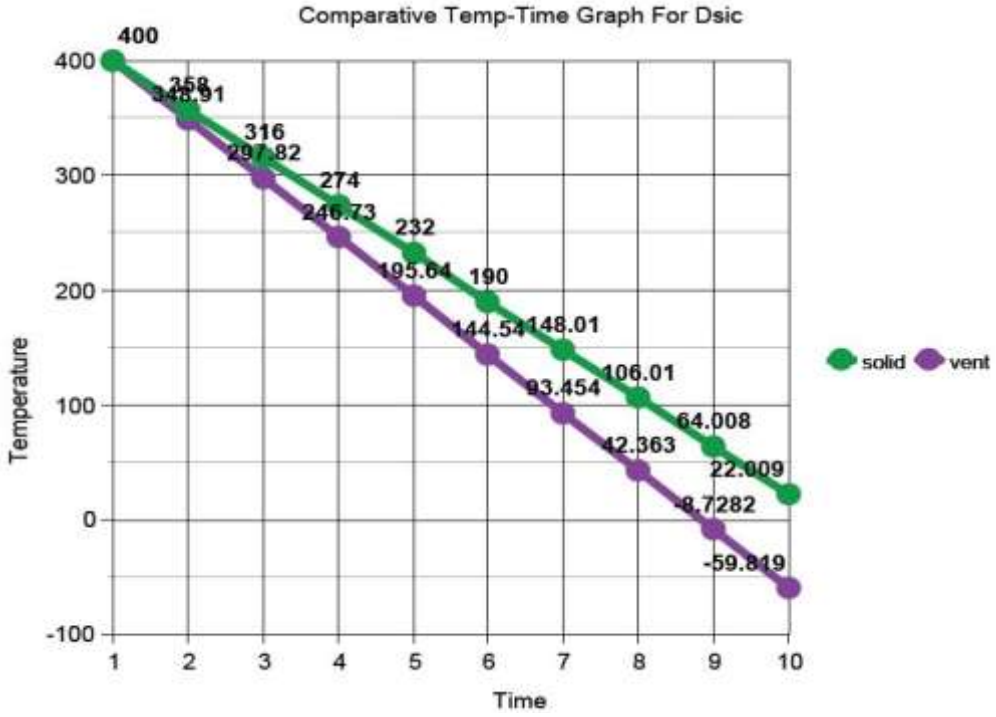

Chart -3: Comparative Graph For Both Disc

7. CONCLUSIONS

In this Dissertation , We have compared two types of Disc , one disc without holes and the other Ventilated on the basis of heat dissipation. Objective of this project is to determine whether the holes in the ventilated disc helps to aid the heat dissipation .Both the disc are of same dimensions and same material and subjected to same operating conditions and then analyzed with same boundary conditions. Transient thermal analysis was done on ANSYS 14.5 workbench to find out the best amongst the two. It is find out that for Ventilated model the minimum temperature is attained to 42.363 while as for solid disc it is 64.008.This proves that Ventilated disc design is more efficient than the Solid disc in heat dissipation .

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9. REFERENCES

[1] **Ameer Fareed Basha Shaik, Ch.Lakshmi Srinivas, "Structural and Thermal Analysis of Disc Brake With and Without Cross drilled Rotor of Race Car", International Journal of Advanced Engineering Research and Studies, Vol.1, PP 39**-43, 2012.

[2] **S. Sarip, "Design Development of Lightweight Disc Brake for Regenerative Braking and Finite Element Analysis"**, International Journal of Applied Physics and Mathematics, Vol. 3, PP 52-58, 2013.

[3] **Guru Murthy Nathil, T N Charyulu, "Coupled Structural/ Thermal Analysis of Disc Brake" IJRET, Vol.2, PP 539**-553, 2012.

[4] **V. Chengal Reddy, M. Gunasekhar Reddy, "**Modeling and Analysis of FSAE Car Disc Brake Using FEM**"** International Journal of Emerging Technology and Advanced Engineering, Vol.3, PP 383-389, 2013.

[5] **Michal Kuciej, Piotr Grzes, "**The Comparable Analysis of Temperature Distributions Assessment in Disc Brake Obtained Using Analytical Method and FE Model**"**, Journal of KONES Powertrain and Transport, Vol.18, PP 236-250, 2011.

[6] **Antti Papinniemi, Joseph C.S. Lai, "**Disc Brake Squeal, Progress And Challenges **"** ICSV14, Australia, PP 1-8, 2007.

[7] **F.Talati, S.Jalalifar, "Investigation of heat transfer phenomenon in a ventilated disk brake rotor with straight radial vanes" journal of applied science** Vol.8 PP 3583-3592, 2008.

[8] **Ali Belhocine, Mostefa bouchetara, "**Thermal behavior of dry contacts in the brake discs **"** international journal of automotive engineering, Vol.3, PP 9-17, 2011.

[9] **Gao CH, Lin XZ (2002),‖ Transient temperature field analysis of a brake in a non-axisymmetric three- dimensional model‖, J Mat Proc Tech** 129, pp 513–517.

[10] **Dufre´noy P (2004),—Two-/three-dimensional hybrid model of the thermomechanical behaviour of disc brakes‖**, J Rail Rapid Transit Part F 218, pp 17–30.

[11] **Voldr˘ich J (2006) Frictionally excited thermoelastic instability indisc brakes**—Transient problem in the full contact regime. Int J MechSci, Vol 49 No. 2, pp 129–137.

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