

Design and Analysis of Disc Rotor in SolidWorks & Ansys

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ABSTRACT: The disc rotor is a mechanical component used in automobiles. It is used to reduce the speed of the rotating wheel and the rotor is squeezed between the brake pads. Continuous braking leads to heat generation in the disc rotor and it may also be subject to wear and thermal issues. The disc rotor was modelled in SolidWorks and analysis was done on Ansys Workbench 2019 R3. The objective of this paper is to design different models like drilled and ventilated type of disc rotor and analyze the temperatures produced in the disc rotor.

KEYWORDS: Disc Rotor, SolidWorks, Ansys Workbench, Thermal Analysis.

I. INTRODUCTION

In today's automobile industry, newer inventions are emerging into the world daily so the engineers believe that safety is the first priority to be given while designing the car. To reduce the speed of the moving car, brakes are applied so that the speed level decreases gradually. The automotive enthusiasts know the importance of the brakes and performance. For competitions like F1, MOTO GP, the cars move with greater speeds and during braking, the disc rotor achieves greater temperatures. The disc rotors LIKE ventilated and slotted typically possess high durability compared to others because the heat generated can be vented through the rotor [1-2]. The material selection will be based upon different properties like hardness, wear resistance, stiffness, thermal expansion, etc. The heat transfer rate varies from body to body so for a solid rotor the heat transfer rate is low compared to a ventilated and slotted rotor [3-4]. The different disc rotors used in automobile vehicles are shown in Fig 1.

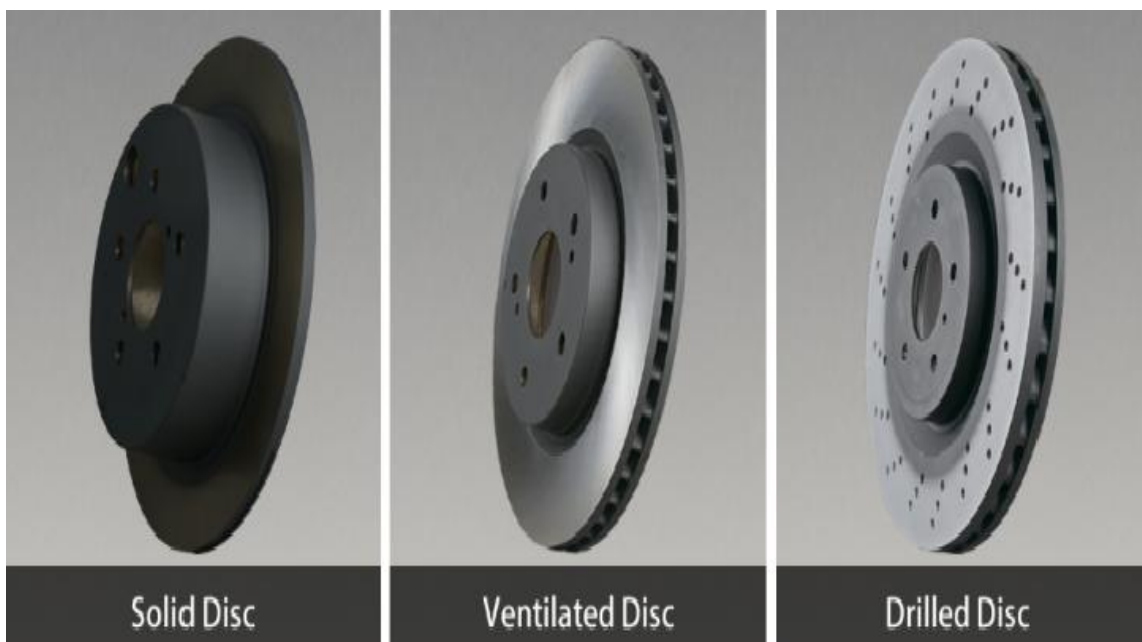


Fig 1: Different types of Disc rotors used in the automobile industry



II. CALCULATION OF DISC ROTOR

The heat flux and other performances are calculated with a velocity of 33.33 m/sec(120kmph).The standard dimensions were considered and the calculation follows:-

Input Data:

1. Initial velocity (u) = 33.33 m/s (120kmph)
2. Brake rotor diameter = 0.256m
3. Acceleration due to gravity g = 9.81 m/s²
4. Final velocity of the vehicle(end of braking) = 0 m/sec
5. Disc absorbed kinetic energy (k) = 0.9
6. Axle wheel distribution on each (γ)= 0.3
7. Coefficient of friction μ = 0.7
8. Mass of the vehicle = 1222 kg (kerb weight)

→Kinetic energy generated

$$K.E = k \frac{1}{2} \gamma \frac{m(u-v)^2}{2}$$

$$= 0.9 \times \frac{1}{2} * 0.3 * \frac{1222(33.33-0)^2}{2}$$

K.E =91466.79 J

→Stopping distance

$$d = \frac{u^2}{2\mu g} = \frac{33.3^2}{2 * 0.7 * 9.81}$$

d= 80.74 m

→Deceleration time

Braking time t = 4sec

→Braking Power :

$P_b = K.E / t = 22866.69 \text{ W}$

→Heat flux: It is defined as the heat transferred per unit area

$Q = P_b / A = 654434.66 \text{ W/m}^2$

III.MODELLING IN SOLIDWORKS

SolidWorks is a designing application commonly used in the automobile industry and the modeling was done with exact dimensions where the object appears as a real entity. This software will be the common language for the engineers where they can understand every aspect of the design[5]. In SolidWorks we can design a part or assembly it will be having inbuilt SketchUp tools. While designing disc rotor the suitable plane is to be selected and outline to be drawn to get the exact view.

a) Transformation of Model :

The model which was earlier designed in SolidWorks to be converted into IGES or STEP format so that it can be easy to access in any type of analysis software. Now, we can analyze like structural, thermal...etc. geometry imported view of original design disc rotor in Ansys Workbench

FLOWCHART PROCESS OF DESIGNING THE DISC ROTOR

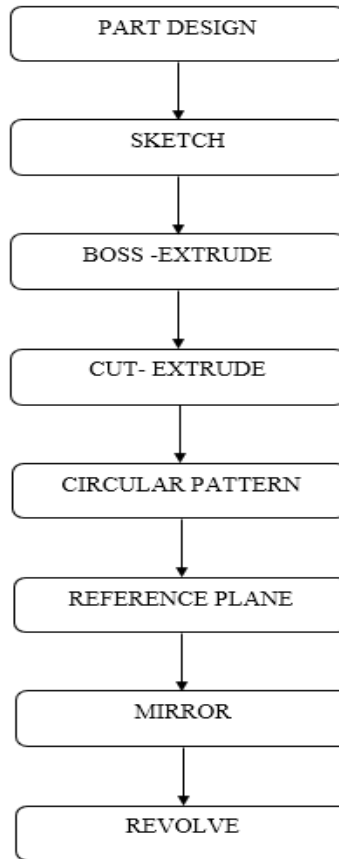


Fig 2:Process of modelling in SolidWorks

b) Disc brake rotor modelling using SolidWorks

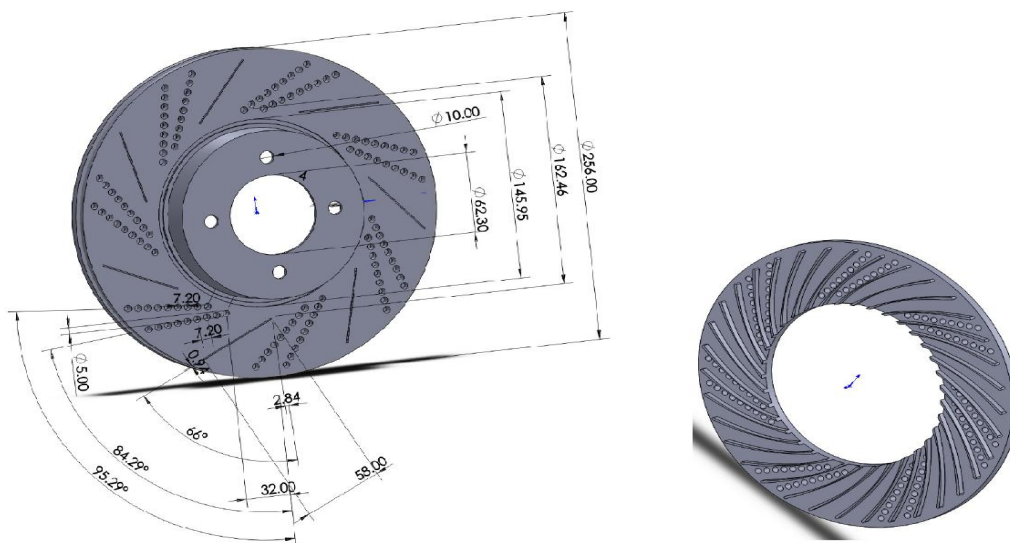


Fig 3:Drawing of Disc rotor in SolidWorks (Model - 1)

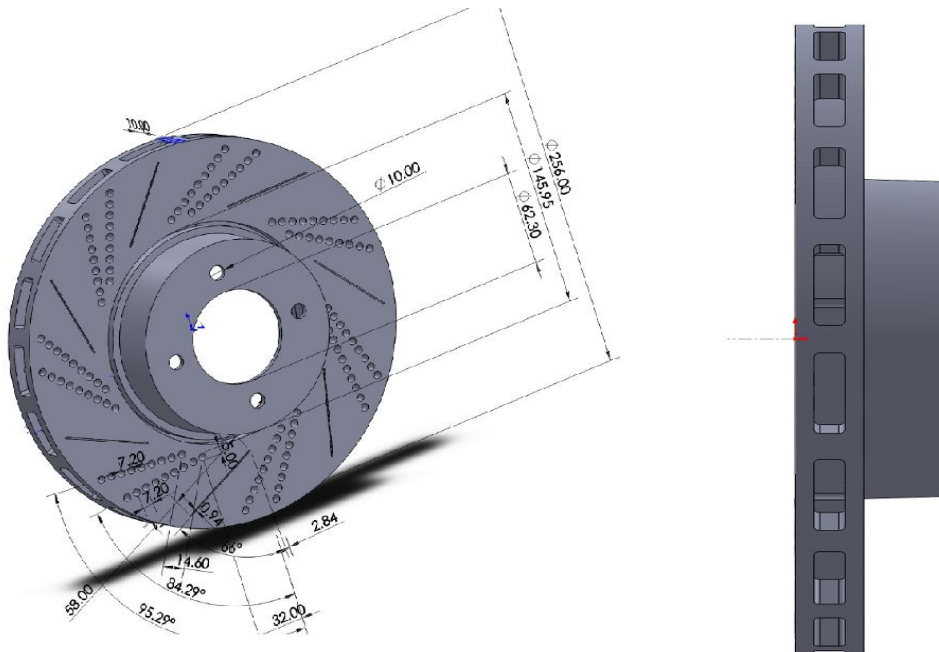


Fig 4: Drawing of Disc rotor in SolidWorks (Model - 2)

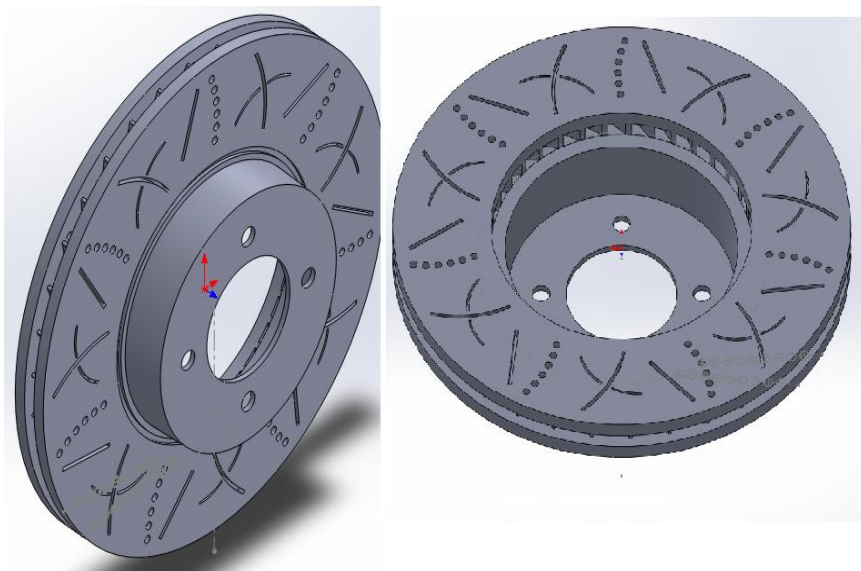


Fig 5: Drawing of Disc rotor in SolidWorks (Model - 3)

The above-mentioned fig:3, Fig:4,fig:5 are the different models designed as per the specified dimensions of the automobile manufacturer Hyundai i20.

The dimensions of the disc rotors are as follows:

- 1) Diameter = 256 mm
- 2) Thickness = 22 mm

- 3) Height = 46.5 mm
- 4) Centre hole = 62.3 mm
- 5) No. of stud holes = 4

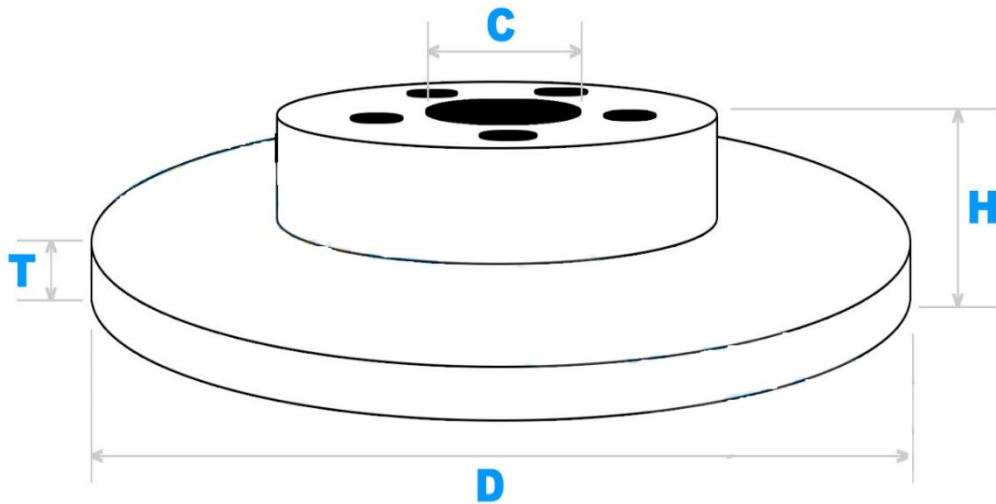


Fig 6:Nomenclature of disc rotor

IV. MATERIAL PROPERTIES

The selection of material will be based upon a variety of factors such as cost, wear resistance, corrosion, etc. The disc rotors attain maximum temperatures while braking so we have to consider the materials which are having high thermal conductivity i.e for grey cast iron. It contains 1.5-4.3% of carbon and 0.5-0.5% of silicon, manganese, sulphur

Material Properties	Grey Cast Iron
Thermal conductivity (w/m K)	52 w/m K
Density, ρ (kg/m ³)	7200kg/m ³
Specific heat, c (J/Kg K)	447
Elastic modulus, E (GPa)	110
Coefficient of friction, μ	0.5
Operating Conditions	
Braking Time Sec	4

V. FINITE ELEMENT ANALYSIS

Ansys is a modeling and analysis software that is widely used by mechanical engineers. The Ansys works on the principle of finite element method in which the process is divided into

- Pre-processor
- Solution
- Post-processor

a) Procedure for Transient Thermal Analysis

- Open ANSYS WORKBENCH

- Create a new file. Click Transient Thermal analysis.
- Click geometry →Import new file
- Select model in WORKBENCH window
- Click Model →Edit→mesh→sizing→relevance center→medium.
- Select model→Generate Mesh
- Select transient thermal →Analysis setting→End time as 4 sec
- Right-click on transient thermal→Insert convection→Select the desired geometry→Film coefficient→500 W/m²
- click Heat –click Heat flux –select the hole wizard –apply –Heat flux magnitude–654434.66w/m²
- Solution→Insert→Thermal→ temperature→Geometry→All bodies→OK.
- Solve→Evaluate all results

b) Meshing Details

The meshing tool is used to divide the model into a number of small pieces known as finite elements. Since the model is divided into several discrete parts, in simple terms known as “mesh” is required to carry out a finite element analysis.[6] The mesh results are as shown in Table No 1.

Model	Material Type	No. of Elements	No. of Nodes
1	Grey Cast Iron	24023	47458
2		24485	46120
3		27545	49869

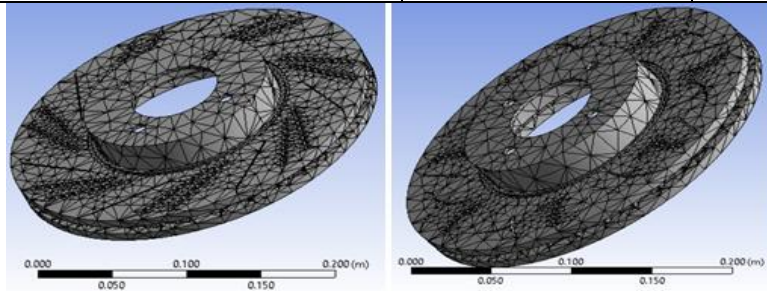


Fig : Model -1

Fig: Model -2

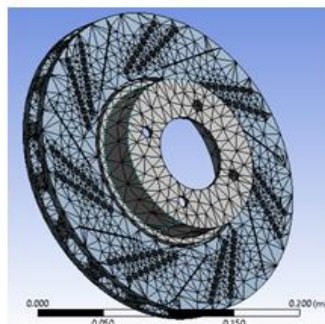


Fig: Model-3

Fig 7:Meshing of disc rotor in Ansys Workbench (Model-1-2-3)

VI.RESULTS

To validate the present models, a transient thermal analysis behavior of a disc brake was performed for the operating condition. The time step $\Delta t = 0.001$ sec was used in the computations. In each process, the heat flux distribution time $t=4$ sec occur and then the steady-state is reached. So, the disc rotor was thermally observed for 4 sec.

The results obtained from analytical and FEM solutions are compared for both transient thermal behavior of the model.

Finally, the best model is suggested.

Comparisons of different models 1,2,3 are performed to validate the results.

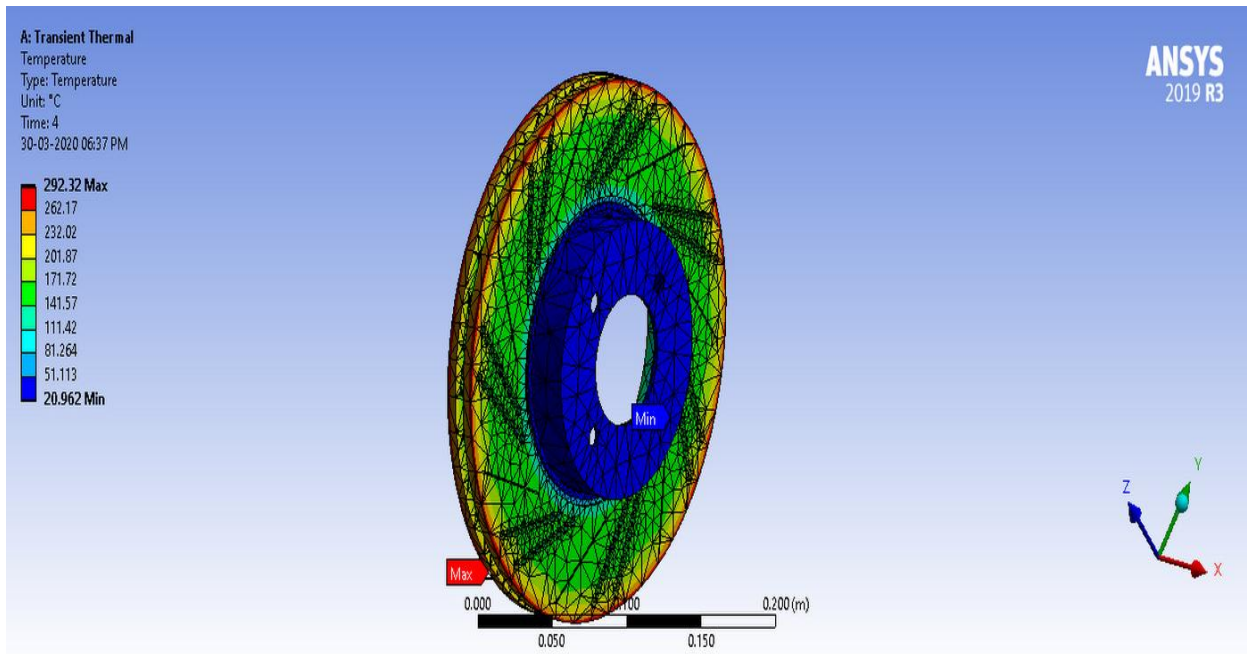


Fig 8:Model-1 Transient thermal analysis result

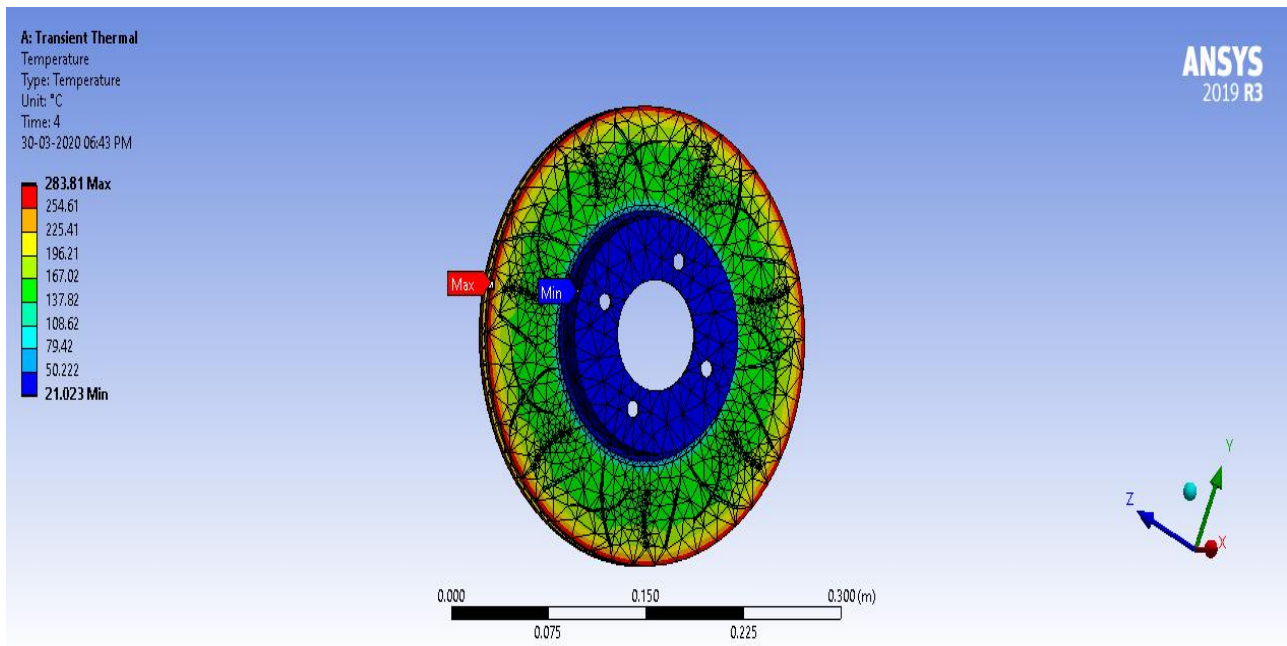


Fig 9:Model-2 Transient Thermal analysis result

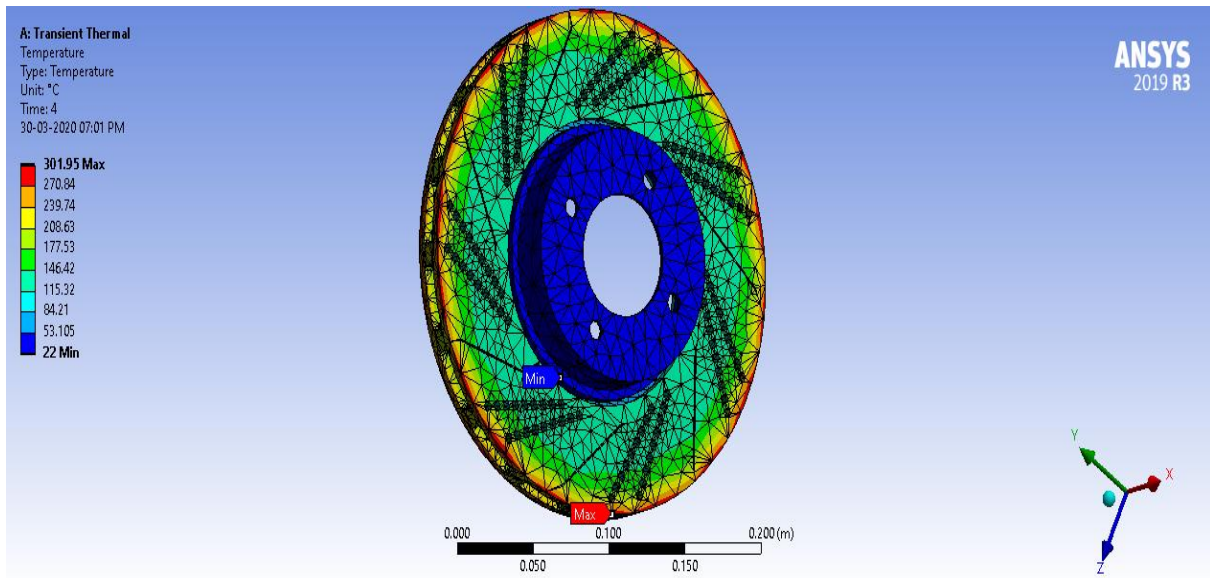


Fig10:Model-3 Transient Thermal analysis result

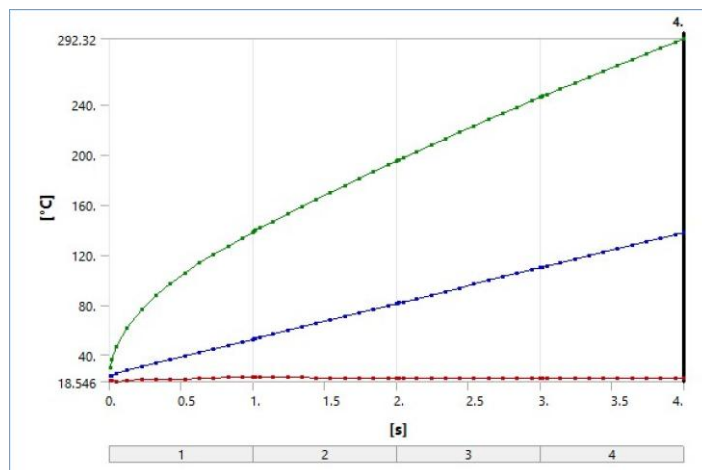


Fig11:Graph between temperature and time interval for model-1

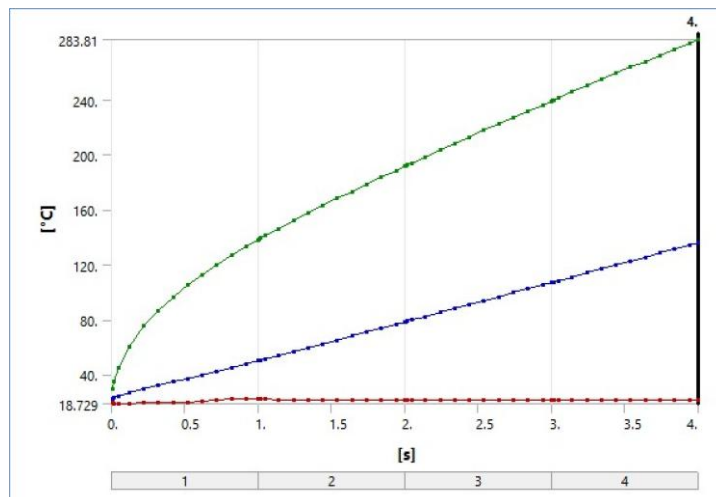


Fig12:Graph between temperature and time interval for model-2

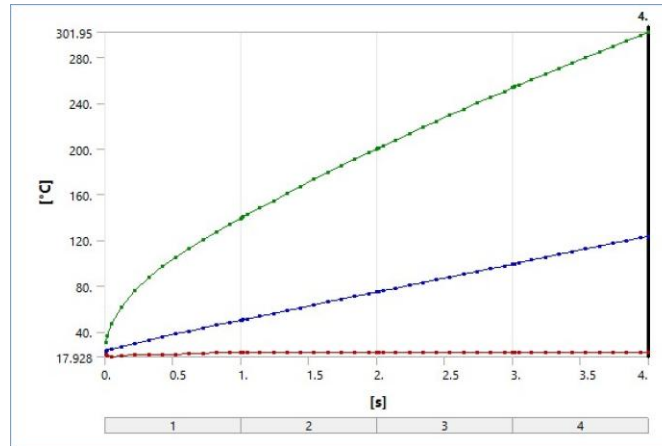


Fig13:Graph between temperature and time interval for model-3

a) Comparison of models

Sl. No	Model	Material	FEM Max.Temp(°C)	FEM Min.Temp(°C)
1	1	Grey Cast Iron	292.32	20.962
2	2		283.81	21.023
3	3		301.95	22

VII. CONCLUSION

In this work, we compared the different models with grey cast iron material we calculated the heat flux, Energy generated during braking, stopping distance and braking power and found that the model-2 is most suitable disc rotor and best on the thermal analysis.

So, from above we can conclude that model-2 is a combination of ventilated and drilled can be used in brake disc which will give moderate cooling at low temperature as compared to other models. So, it can be used in racing cars where high temperatures will be produced.

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