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Thermal analysis of ventilated and drilled disc brake

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ABSTRACT

In the recent automotive industry, braking system is considered to be very important in terms of safety of the driver. FEA is a basic simulation of a physical component and is used for performing mechanical analysis. FEA is very essential before the production of any component of a vehicle. In this paper a ventilated and drilled type of disc brake is taken as the component which has been thermally analyzed. This thermal analysis is done with the use of Ansys Workbench 2020 R1 and the component is modelled using the SolidWorks software. In this paper a brief idea about the effect of different meshing size as well as the type of meshing using finite element analysis is considered and consequently the thermal analysis of the same has been calculated. The results obtained illustrate the effect of the difference in mesh size and type and how it plays an important role in the analysis of any component.

Keywords: Finite element analysis, meshing size, Ansys Workbench 2020 R1, SolidWorks, ventilated disc brake, drilled disc brake.

1. INTRODUCTION

The braking system is always considered to be a crucial factor in all automobiles. With the advancement in technology, disc brakes are now widely used for the braking system. A disc brake uses the rotors to create a considerable friction which stops the vehicle. The kinetic energy of the rotors gets converted into heat energy into the disc brakes. The brakes absorb the heat energy generated. The temperature of this heat generated varies from the type of automobile used. Racing cars generally have a higher temperature due to the faster rotors whereas commercial cars have lower temperature produced in them due to the slower rotors. The analysis done in this paper helps us to understand how different meshing patterns affect the heat distribution, the thermal flux and the direction of this flux which in turn enables us to create a better model of a disc brake.

The mesh size plays a significant role in the analysis and a considerable change in the values should be expected depending

on it. The objective of this paper lies in the decision to choose a proper mesh size and a proper type of mesh to consider an appropriate analysis of the component. We perform the thermal analysis of the disc brake in order to analyze the changes occurred in the component due to the high temperatures.

2. MODEL

The 3D model is made in SolidWorks software. A 288 mm diameter of disc brake is made with drilled holes on the inner circumference. The inner portion has vents to allow the flow of heat through them. The material used is stainless steel.

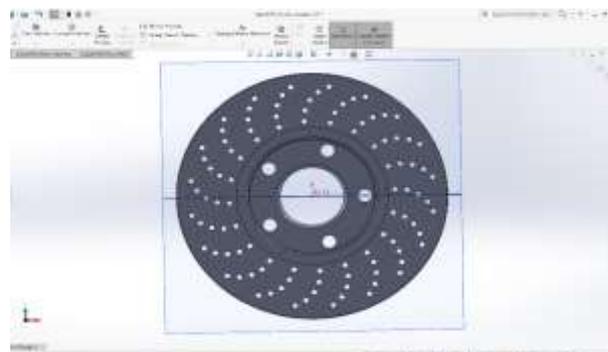


Fig. 1: Front side of the disc brake

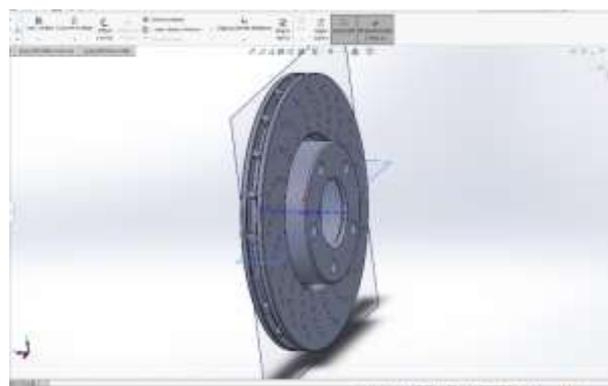


Fig. 2: Free view of the disc brake

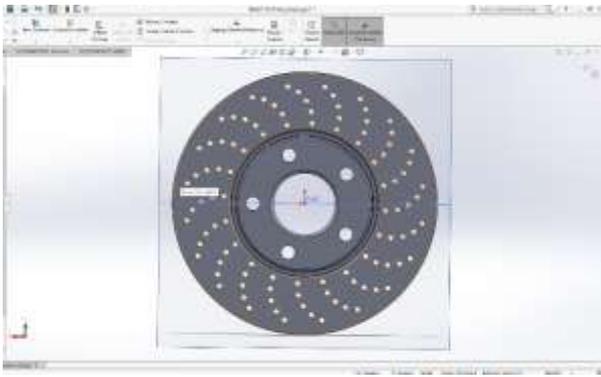


Fig. 3: Back side of the disc brake

3. MODELLING IN ANSYS (3mm tetrahedral mesh)

The modelling is done in Ansys Workbench 2020 R1. The first step is to select the Steady State Thermal in the project schematic. The component is selected to be stainless steel. Stainless steel performs better than cast iron and is now widely used in industries. The lifespan is also more than cast iron as stainless steel does not get corroded easily.

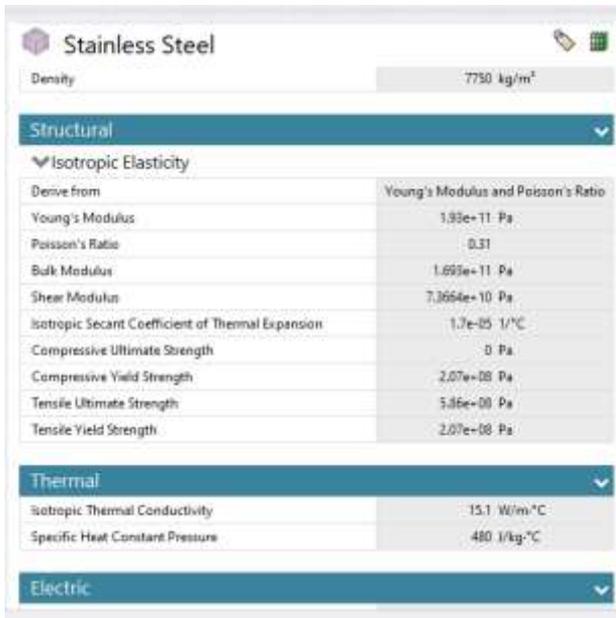


Fig. 4: Properties of Stainless Steel from Ansys

The next step is creating the mesh. Here 4 types of mesh have been taken into consideration. 3mm fine tetrahedral method, 3mm coarse tetrahedral method, 1mm fine tetrahedral method and 1mm coarse tetrahedral method. These 4 mesh types have been compared using their temperature, total flux and directional flux analysis. The meshing plays the most important step in the analysis of the component. The more precise the mesh is, more accurate the results are expected to come. Here the mesh defeaturing is considered for the mesh sizing.

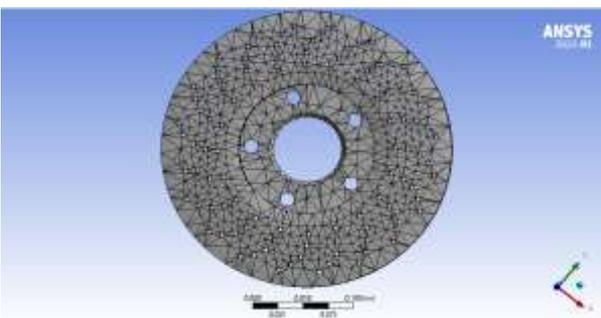


Fig. 5.1: 3mm coarse tetrahedral mesh

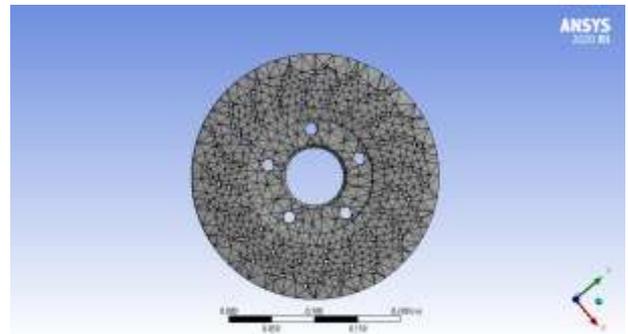


Fig. 5.2: 3mm fine tetrahedral mesh

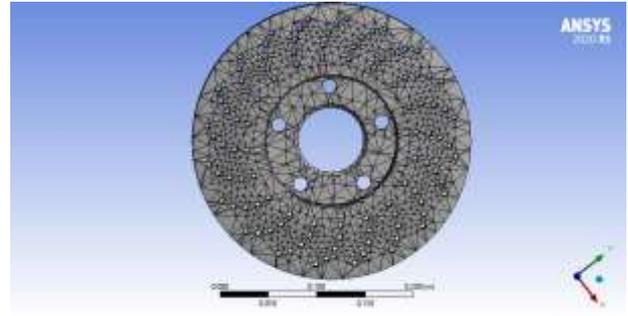


Fig. 5.3: 1mm coarse tetrahedral mesh

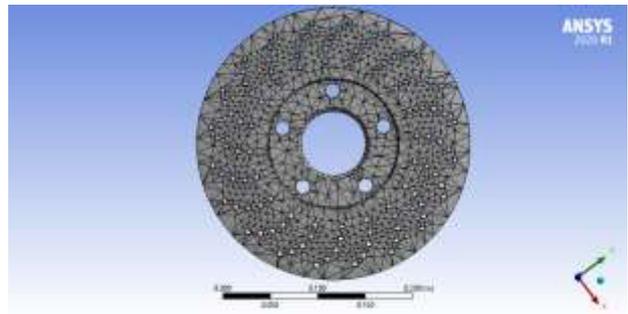


Fig. 5.4: 1mm fine tetrahedral mesh

Table 1: Statistics of the meshing

Statistics	Nodes	Elements
3mm coarse	19407	9940
3mm fine	20511	10516
1mm coarse	26329	13346
1mm fine	29201	14974

4. ANSYS SOLUTION

Two conditions such as surface temperature and convection through the 5 inner surfaces are taken into consideration before carrying on the results. The normal surrounding temperature is taken to be 22°C and the maximum temperature occurring in the disc brake is taken to be 100°C.

1. Temperature Analysis in the Disc Brake-

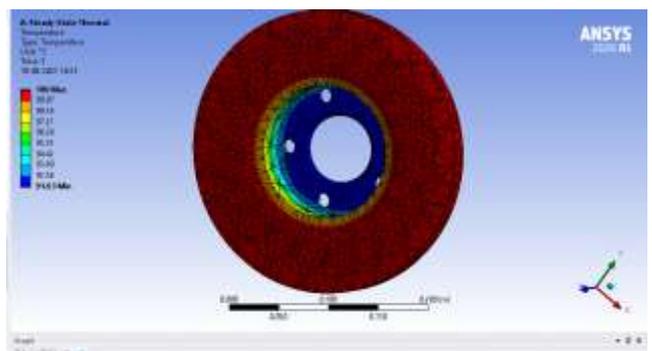


Fig. 6.1: Temperature analysis (3mm coarse mesh)

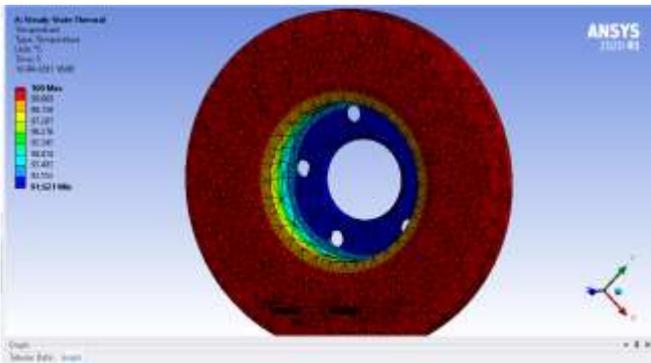


Fig. 6.2: Temperature analysis (3mm fine mesh)

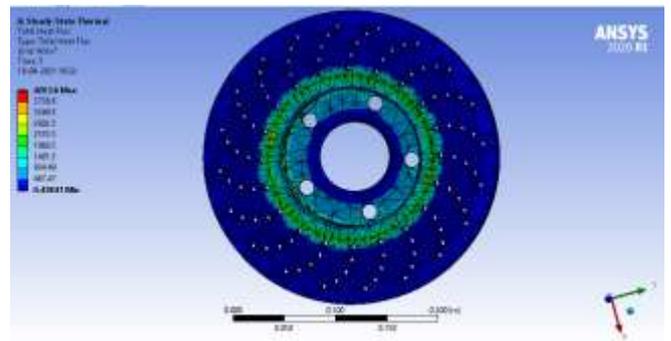


Fig. 7.3: Total heat flux (1mm coarse mesh)

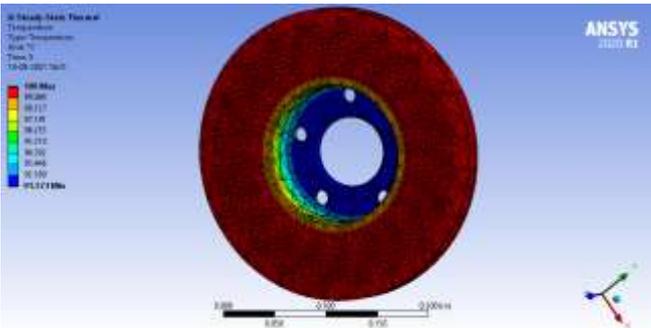


Fig. 6.3: Temperature analysis (1mm coarse mesh)

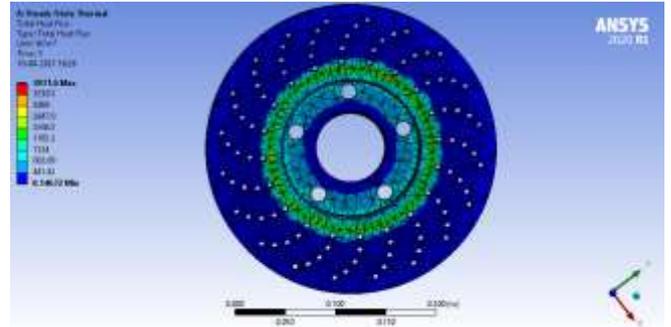


Fig. 7.4: Total heat flux (1mm fine mesh)

3. Directional heat flux in the Disc Brake-

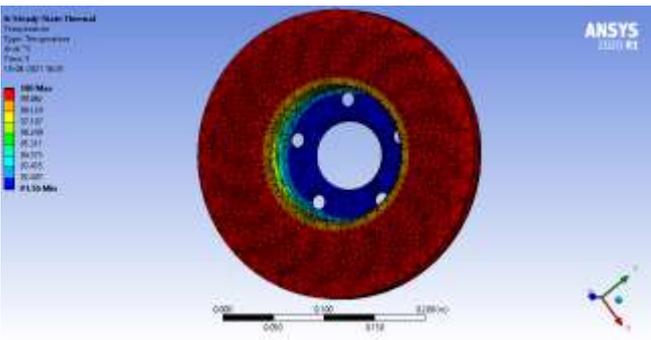


Fig. 6.4: Temperature analysis (1mm fine mesh)

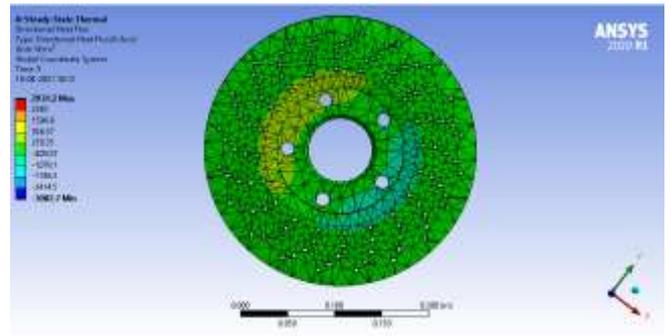


Fig. 8.1: Directional heat flux (3mm coarse mesh)

2. Total heat flux in the Disc Brake-

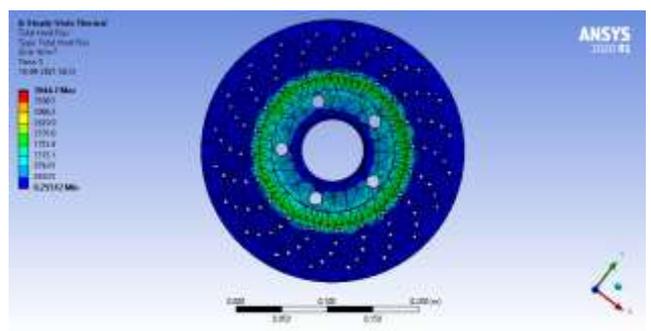


Fig. 7.1: Total heat flux (3mm coarse mesh)

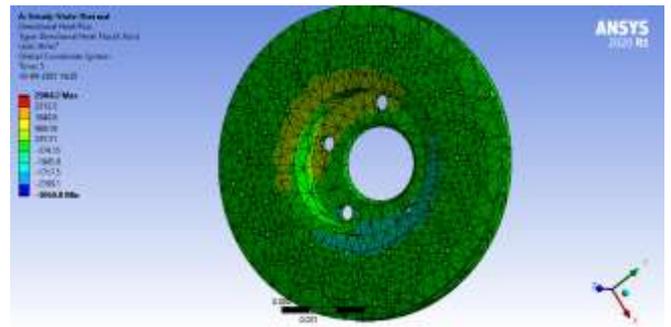


Fig. 8.2: Directional heat flux (3mm fine mesh)

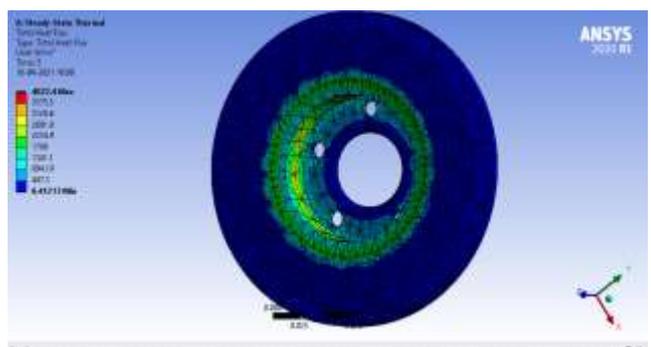


Fig. 7.2: Total heat flux (3mm fine mesh)

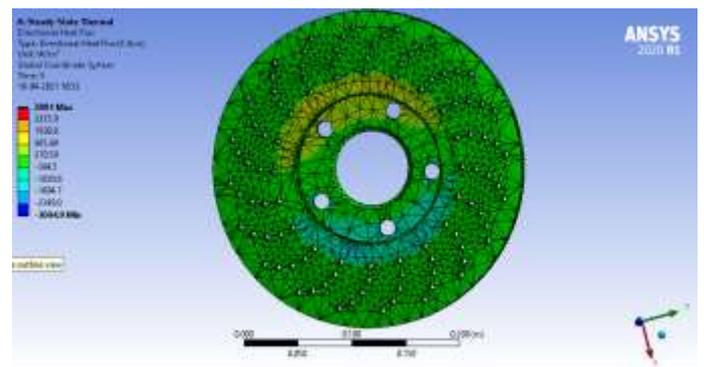


Fig. 8.3: Directional heat flux (1mm coarse mesh)

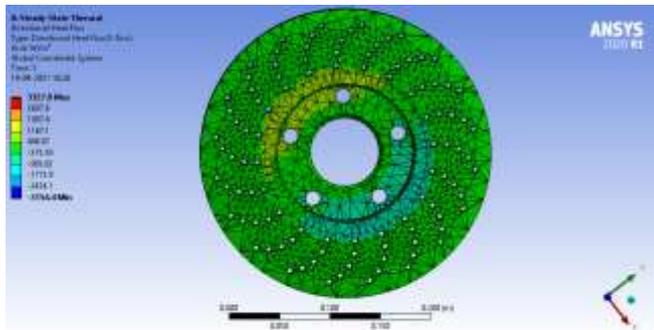


Fig. 8.4: Directional heat flux (1mm fine mesh)

Table 2: Thermal analysis of 3mm tetrahedral mesh.

Mesh Type	3mm Coarse	3mm Fine
Maximum temperature	100 °C	100 °C
Minimum temperature	91.63 °C	91.621 °C
Average temperature	99.093 °C	98.919 °C
Maximum total heat flux	3944.7 W/m ²	4022.4 W/m ²
Minimum total heat flux	0.25512 W/m ²	0.41213 W/m ²
Average total heat flux	299.67 W/m ²	304.38 W/m ²
Maximum directional heat flux	2931.2 W/m ²	2984.2 W/m ²
Minimum directional heat flux	-3092.7 W/m ²	-3060.8 W/m ²
Average directional heat flux	-1.1477 W/m ²	-2.3668 W/m ²

Table 3: Thermal analysis of 1mm tetrahedral mesh

Mesh type	1mm coarse	1mm fine
Maximum temperature	100 °C	100 °C
Minimum temperature	91.573 °C	91.56 °C
Average temperature	98.955 °C	98.659 °C
Maximum total heat flux	4203.6 W/m ²	3971.6 W/m ²
Minimum total heat flux	0.45841 W/m ²	0.14672 W/m ²
Average total heat flux	298.1 W/m ²	299.98 W/m ²
Maximum directional heat flux	2891 W/m ²	3327.9 W/m ²
Minimum directional heat flux	-3004.9 W/m ²	-3154.4 W/m ²

Average directional heat flux	-1.1421 W/m ²	-1.6112 W/m ²
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5. RESULTS

- It is evident that the average temperature of 3mm coarse/fine tetrahedral meshing is slightly more than the average temperature of 1mm coarse/fine tetrahedral meshing.
- The average total heat flux of 3mm coarse/fine tetrahedral meshing is also more than that of the average total heat flux of 1mm coarse/fine tetrahedral meshing
- The average directional heat flux of 3mm coarse/fine tetrahedral meshing is less than the average directional heat flux of 1mm coarse/fine tetrahedral meshing.
- The overall steady state thermal analysis has been carried out and necessary observations have been made.

6. CONCLUSIONS

- The study of different size and type of mesh has been performed and the results are gained.
- It is evident from table 1 that the total number of nodes and elements for 3mm coarse/fine meshing is much less than compared to 1mm coarse/fine meshing.
- The finer the nodes and elements are, the analysis can be done in detail and with precision.
- Due to the complex structure of the geometry, a smaller mesh size of fine nature is more preferable for better results.

7. REFERENCES

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