University of Windsor

Mechanical, Automotive, & Materials Engineering
401 Sunset Avenue
Windsor, Ontario, Canada N9B 3P4
519 253 3000 (2616)
www.uwindsor.ca/mame

E-Portfolio Guideline
MECH 4200
Capstone Design

Yichao Ma
104520350

August 5, 2020

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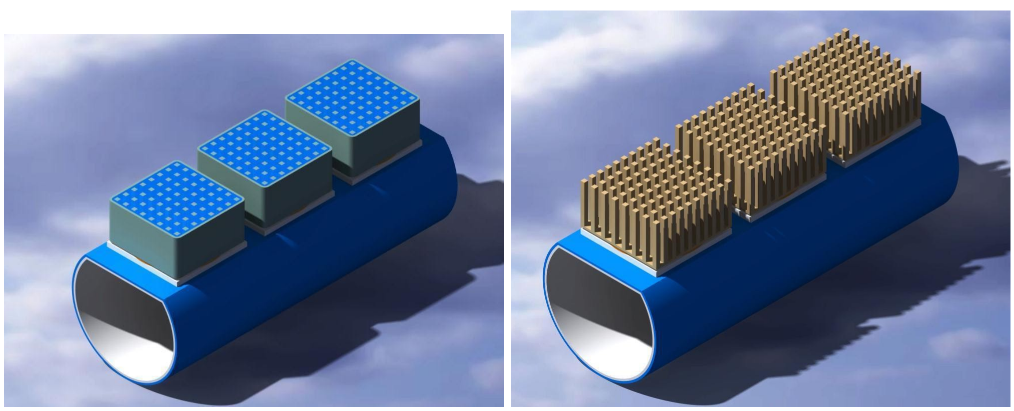
1 Introduction

Among all the courses across 4-year-undergraduate program, the Capstone Design is one of the most comprehensive courses due to its high integrity among knowledge and judgements from various fields. The project we working on is the "Thermoelectric Phone Charger". It is such a great project that integrate the knowledges from "Heat Transfer", "Computer Aided Design", "Thermodynamics", and "Control Theory".

Under the situation which students have no choice but to simulate the designs rather than build up physical models, the ability of modeling and coding dominates the project. In the following of the guideline, detailed explanations of how these learned knowledges applied to the project will be presented. In terms of the individual work, I participate in the modeling design and simulation for PCM heat sink design.

2 Procedure of Modeling and Simulations

To begin with, during the model design period, two distinct and creative model are created by CATIA as shown in Figure1.



(a) Fins scheme **(b)** PCM scheme

Figure 1 – Two distinict models' schemes

Then, the handwritten calculations for PCM heat sink design has been done based on the "Fourier's law", "Newton's law of cooling", and "Analogous Thermal Resistance Circuit".

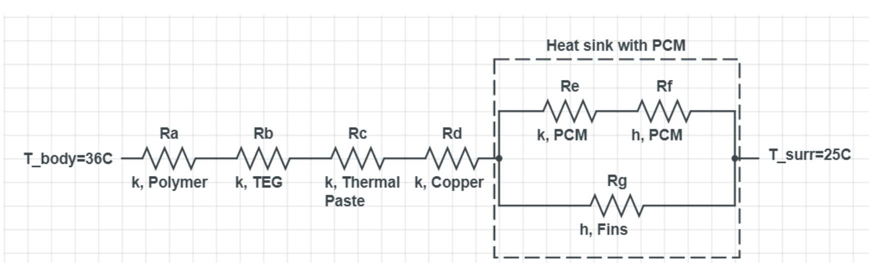


Figure 2 – Thermal Resistance Circuit of PCM Design

When it comes to the simulation part, even though ANSYS is not the software we familiar with, we got the idea of general setup of the simulation as the idea of modeling and simulation are similar to CATIA. After importing the CATIA model, we, firstly, need to mesh the entire model. In this case, only adjusting the size element is inadequate for proper and sufficient simulation. As a result, both face meshing and edge sizing method are applied as Figure3 and Figure4 shown.

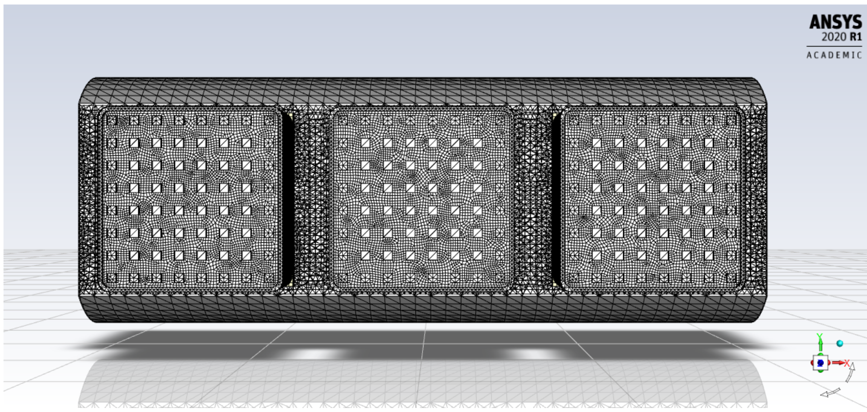


Figure 3 – Front view of Mesh

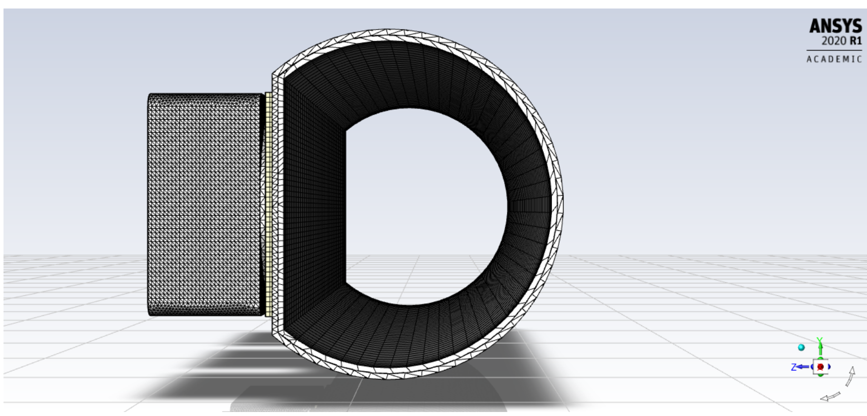


Figure 4 – Side View of Mesh

Next, last step before triggering on the simulation is to setup the boundary conditions.

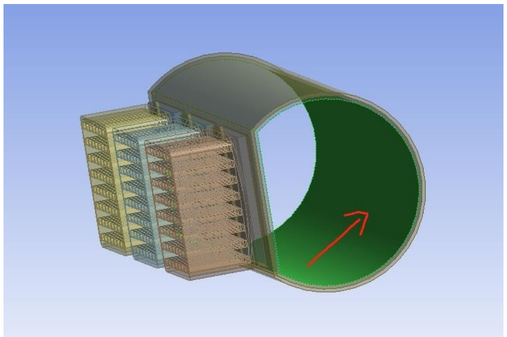
The coefficient of free convection is determined with the help from Dr. Stoliov.

$$\boldsymbol{h} = \frac{\boldsymbol{k}}{\boldsymbol{L}}(0.825 + \frac{0.387\boldsymbol{Ra}_L^{1/6}}{(1 + (0.492/\boldsymbol{Pr})^{9/16})^{8/27}})^2 \tag{1}$$

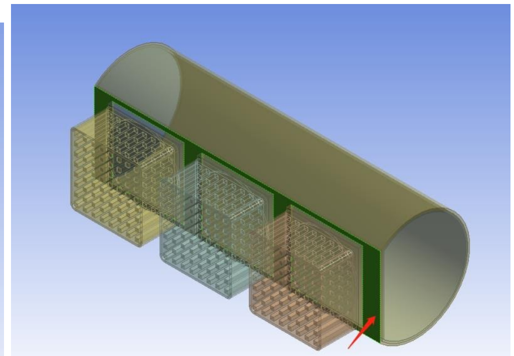
where,

$$\boldsymbol{Ra_x} = \frac{\boldsymbol{g\beta}}{\boldsymbol{\nu\alpha}}(\boldsymbol{T}_s - \boldsymbol{T}_\infty)\boldsymbol{x}^3 \tag{2}$$

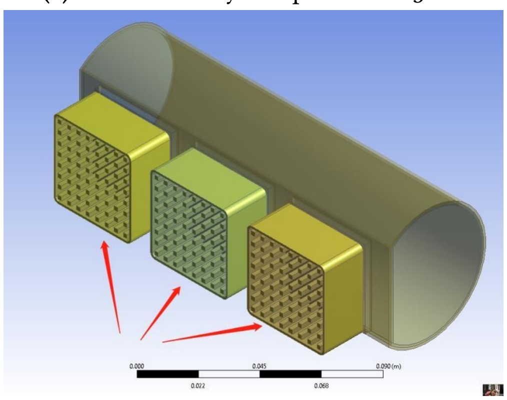
All the parameters are determined using the knowledge and assumptions from "Heat Transfer" course.



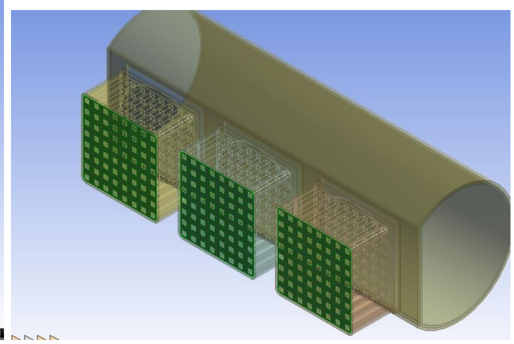
(a) Constant Body Temperature = 310K



(b) Copper Free Convection



(c) Aluminum Heat Sink Free Convection



(d) PCM Top Free Convection

Figure 5 – Boundary Conditions

Finally, the simulation has done and the result is shown in Figure6. The way of validation the result is to converge the results by reducing step size and extend the total simulation time and then compare with the handwritten result.

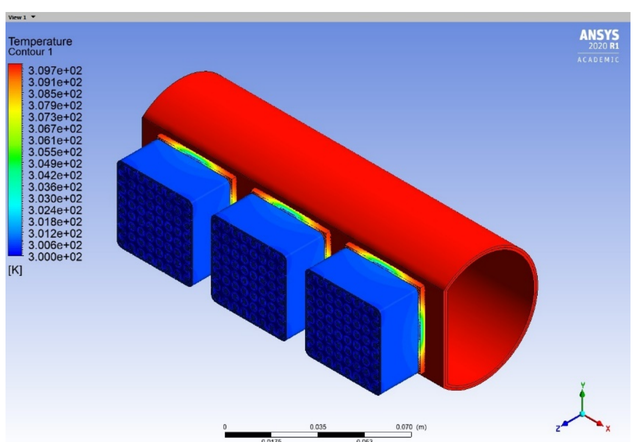


Figure 6 – Result of Simluation

3 Conclusion

In conclusion, the project of Capstone Design is comprehensive and time-consuming. The team and myself spent tons of hours on the design and simulation stages; consequently, we accomplished the desirable and reasonable results. More importantly, we would like to acknowledge Dr. Stoilov for his support and guidance through this project.