MSE 321 Course Project

Comparing different types of Fin Geometries for an Electronic Chip’s Heat Sink

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ENGINEERING THERMODYNMICS AND HEAT TRANSFER PROJECT REPORT
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Requirements

A 90-W Electronic Chip needs to be accommodated by a Heat Sink that reaches the Maximum temperature of 100°C (373K) at its base. The Ambient Air temperature of 25°C (298K) surrounds the Chip. The Heat Sink must have the maximum Permitted area of 5cm X 5cm. Similarly, the maximum permitted height is 5cm. The restriction applies to the material choice as well. It can either be Aluminium or Copper.

Goals

The goal here is to Minimize the footprint in terms of weight and Cost.

Assumptions

1. The thickness of each triangular and rectangular fin is assumed to be 2mm as changing the thickness has minimal effect on the heat transfer and on the material usage.
2. The convection heat transfer coefficient of the air is 50W/m^2.K as it will be used in a same manner for all three fins, that is to estimate the heat transfer.
3. Aluminium is chosen over copper. Aluminium is cheaper. Also, as observed in design study optimization for rectangular fin, Copper is heavier than Aluminium. It is also because density of copper is more than that of Aluminium.
4. The fabrication cost is same for all types of fins.
5. From the graph for efficiency of straight fins of rectangular, triangular, and parabolic profiles, the efficiency of rectangle and triangle are in a close range when above 90%. The circular pins have relatively less efficiency.
6. The Heat Transfer is one dimensional. The major heat transfer is due to forced convection by the electric chip of power 90W.
7. There is no radiation heat transfer.
8. The affect of adjacent fins is neglected.

Design Strategy and Solution

To begin the optimization for the fin that is most suitable according to the Given parameters and aligns with our goals, three choices are made that includes:

1. Rectangular Fins.

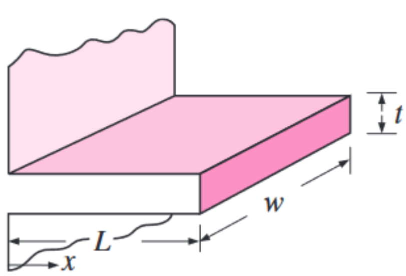

Figure 1: Rectangular Fins Geometry

2. Triangular Fins.

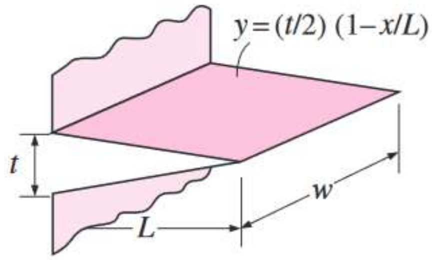

Figure 2: Triangular Fins Geometry

3. Round Pin fins.

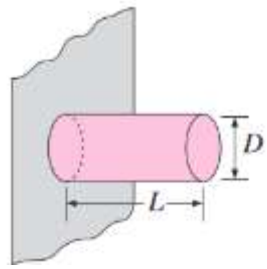

Figure 3: Round Pin Fins Geometry

Solidworks is used to conduct the design optimization. The goal is to at first create the Design with Maximum area and maximum height permitted. Then creating the study to minimize the mass and maximize the thermal efficiency. The constraint chosen is the Thermal simulation data. It is provided the maximum base area of the fin must not reach 100°C. At first the rectangular fin material Aluminium alloy is used, and the thermal study results are obtained as below:

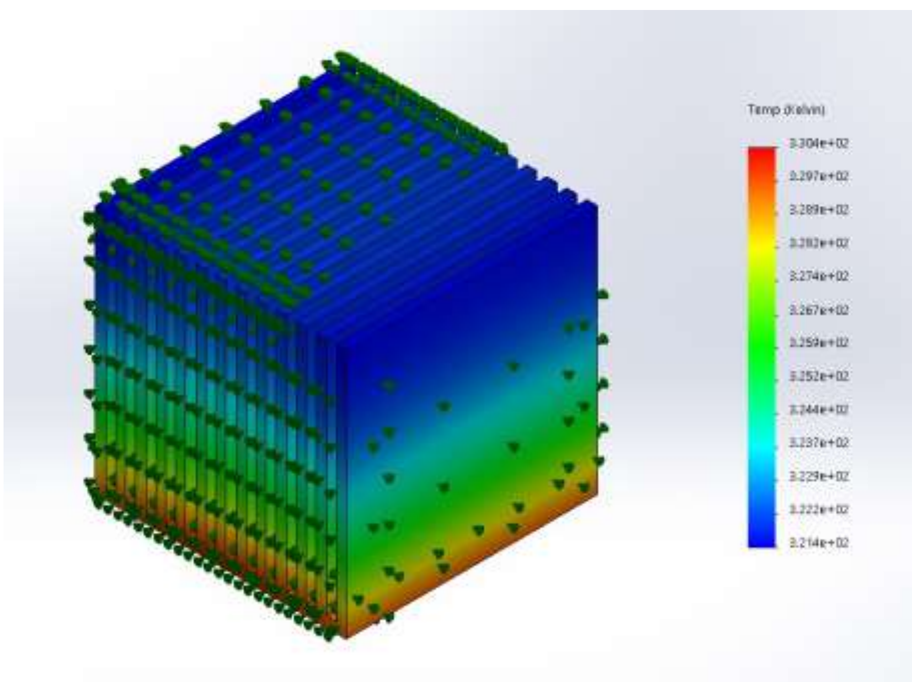

Figure 4: The maximum dimension (5x5x5 cm^3) geometry using Rectangular Fins

Each fin has a thickness of 2mm and the spacing in between is also 2mm. The Forced convection heat transfer coefficient of air is set to be 50W/m^2.K. The ambient temperature is 298K. The power is applied at the base of the fins that is 90W. After creating the mesh and running the study, the above results are obtained. The temperature is maximum at the base however is not exactly 373K. It is only 330K. This provides the evidence that the fin can be optimized because we have extra 43K to reach at the base that can be achieved by reducing length, width, and height of the fins. After performing optimization for the rectangular fins in Solidworks, the following results were obtained:

Height	25mm
Width	35mm
Length	50mm
Material	1060 Aluminium Alloy
Thermal	371.753K
Mass	70.875g

Table 1: Optimized dimensions for rectangular geometry

The optimized thermal study can be observed in the following Figure:

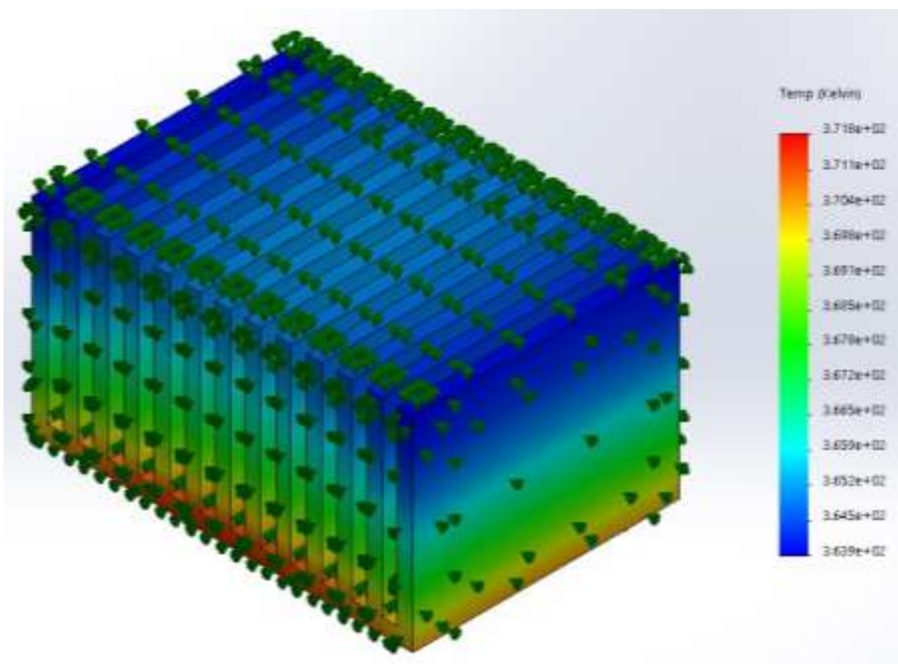

Figure 5: The optimized dimension geometry using Rectangular Fins

In the same manner the study is performed for the Triangular fins. Keeping the thickness as 2mm and the space in-between also 2mm, the initial results are obtained as:

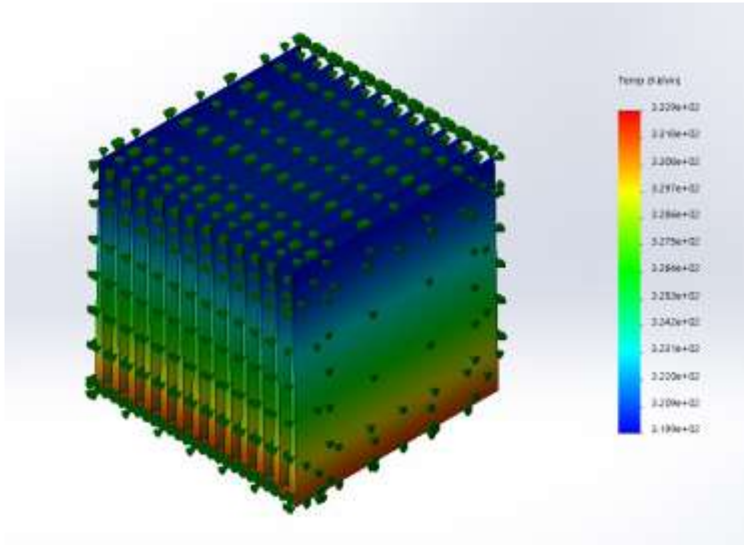

Figure 6: The maximum dimension (5x5x5 cm^3) geometry using Triangular Fins

The max temperature the base will reach is 332.9 K. The mass of the fin is 39.32g. This is about comparable to the 330K temperature obtained in the Rectangular Fin Case. Then the optimization is performed in a similar way to rectangular fin. The optimized results are obtained as follows:

Height	45mm
Width	25mm
Length	35mm
Material	1060 Aluminium Alloy
Thermal	372.279K
Mass	17.1225g

Table 2: Optimized dimensions for Triangular geometry

The optimized thermal study can be observed in the following Figure:

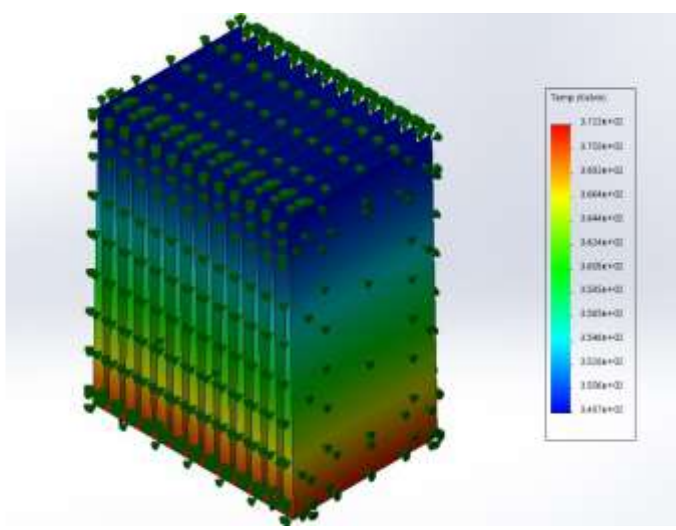

Figure 7: The Optimized geometry using Triangular Fins

Now for the Circular Pin Fins similar study with the constraints and parameters is conducted. The initial model is at a base of 5cm x 5cm with maximum height of pins as 5cm. In Solidworks is designed as follows:

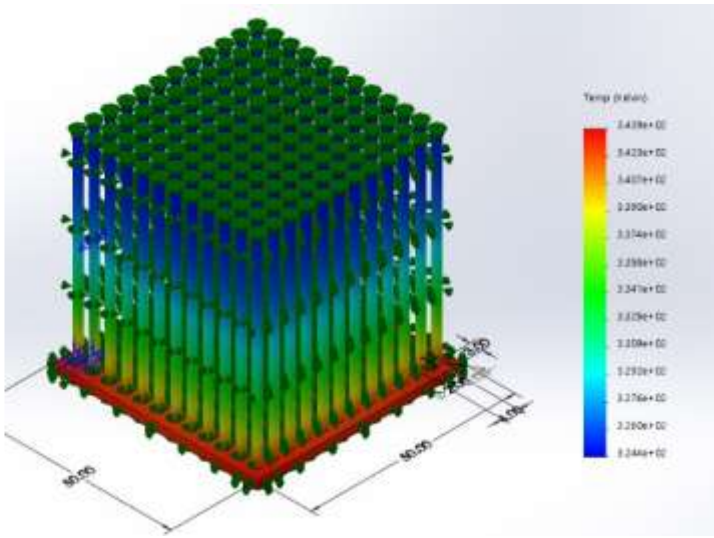

Figure 8: The maximum dimension (5x5x5 cm^3) geometry using Round Pin Fins

The optimized results for minimizing the mass and constraint of base temperature less than 100°C is recorded in the table:

Height	20mm
Width	50mm
Length	50mm
Material	1060 Aluminium Alloy
Thermal	368.8K
Mass	37.93g

Table 3: Optimized dimensions for Pin Fin geometry

The thermal study for the optimized model is pasted below:

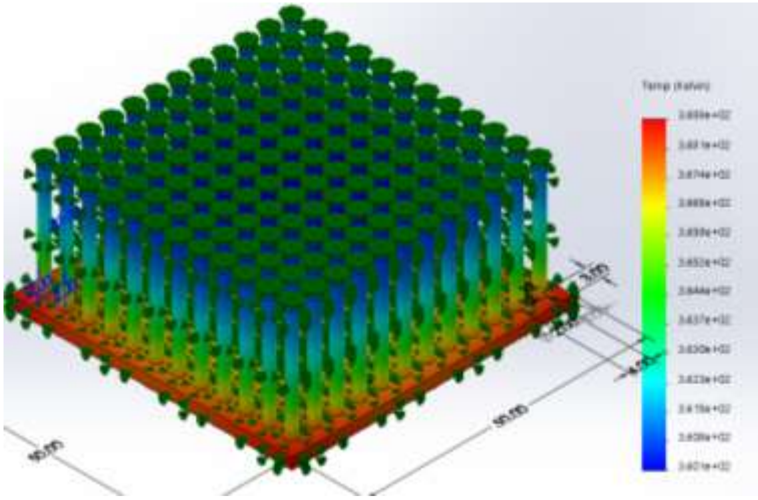

Figure 9: The optimized dimension geometry using Round Pin Fins

Comparison

From all the studies performed for all three types of fins the following comparison can be derived:

Type of Fin	Rectangular	Triangular	Circular Pin
Height (mm)	25	45	20
Length (mm)	50	35	50
Width (mm)	35	25	50
Max Base Temp. (K)	371.8	372.3	368.8
Mass (g)	70.88	17.1	37.93
Cost (CAD) (0.004/g)	0.284	0.068	0.15

Table 4: Comparison table for all type of Fins

Conclusion

Deriving from the table in the previous section, it can be concluded that the Triangular Fin has the most optimized heat transfer for the given maximum area, height, and the constraint of maximum base temperature. The result is somehow expected because triangular provides about the same amount of heat transfer in the volume about half of that of rectangle. Moreover, by increasing the height as much as we can for the triangle, the volume can be decreased significantly by reducing the base of the Fins. Speaking about the Pin Fins, they are also better than rectangular fins in case of the mass and cost of material. So, the rankings for all three materials are:

1. Triangular fins.
2. Round pin fins.
3. Rectangular fins.