

CPU Heatsink Design Project

September 2023

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1. General Information

<https://drive.google.com/file/d/1Lajgt2AT7G7Zlsw9Qn7NlnJONjGSqvb0/view> (Official Report)

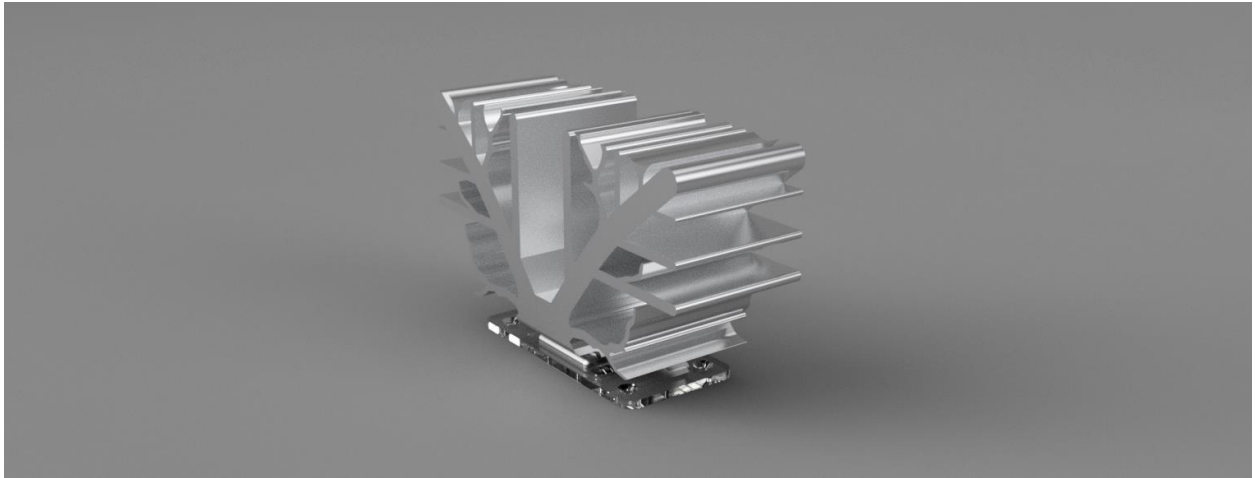


Figure 1: CPU Heatsink Final Design with CPU and CPU housing

1.1 Goal

As a part of a design challenge, my partner and I tasked ourselves with creating a **custom CPU heatsink** that performed more thermally efficiently than an engineering drawing we were provided as an example. Utilizing concepts of heat transfer, we created a more efficient natural convection heatsink, backed with **thermal simulations** used to **test thermal efficiency, manufacturing methods, material and cost research, and future areas of improvement.**

1.2 My Role

- Re-engineered and CAD'ed the different root, stem, and shape iterations for the heatsink design
- Performed thermal simulations to test design iterations
- Researched thermodynamic principles relating to heatsink design and fluid dynamics
- Researched various methods of manufacturing and materials

1.3 Solution (Description)

For our design, we utilized fundamental knowledge of thermodynamics and natural convection, to create a more efficient CPU cooler. We were able to lower the maximum temperature of the heatsink from **198°C** → **132°C** between the first and the last designs that we created.

2. Solution

2.1 Showcase

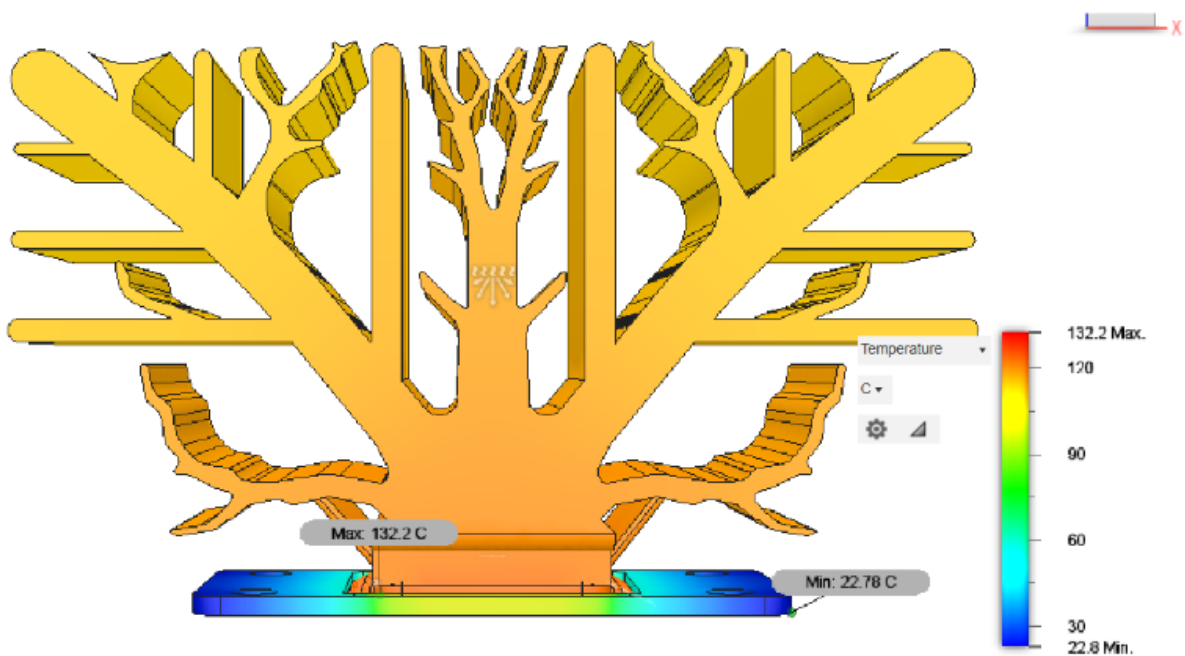


Figure 2: CPU Heatsink Thermal Analysis

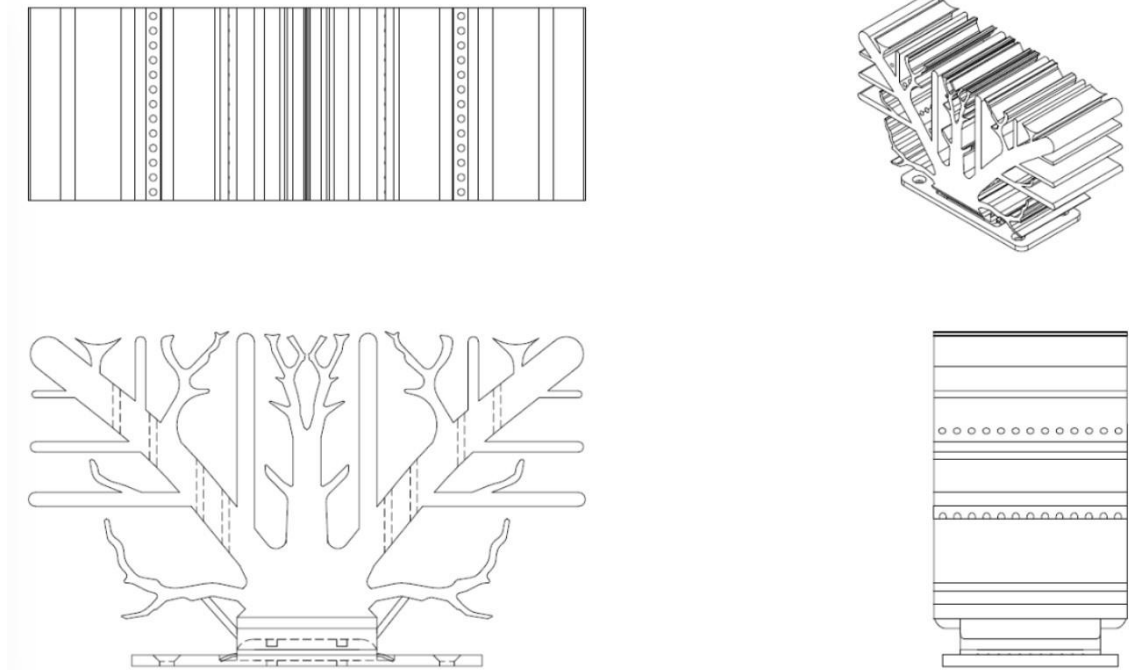


Figure 3: CPU Heatsink Final Engineering Drawing

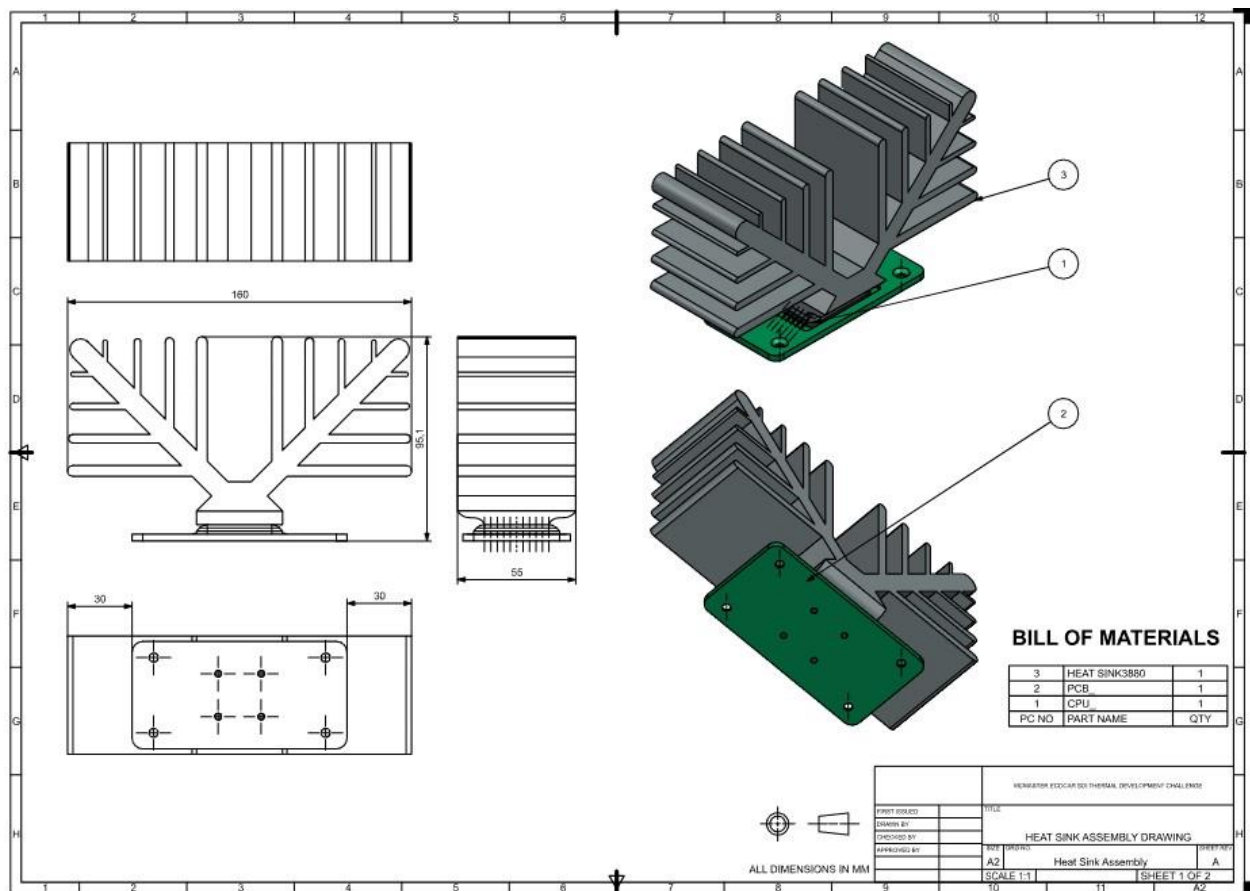


Figure 4: Initial Design of the Heatsink

2.2 Iterative Structural Design Decisions

2.2.1 Lattice Structure and Quantity of Holes

Heatsink temperature per number of holes

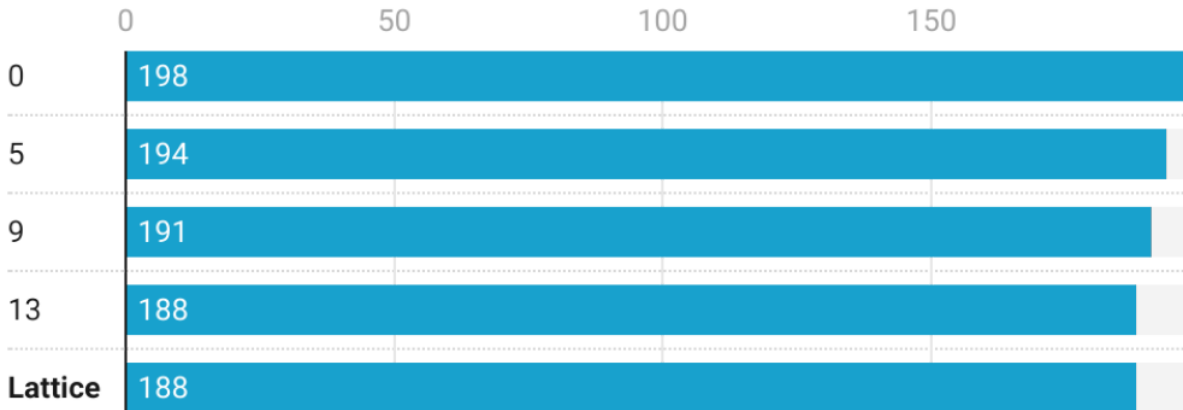


Figure 5: Iterative design adding holes in the heatsink

Implementing a lattice structure using Fusion360's lattice feature allows for maximum surface area for natural convection.

Adding holes creates more surface area for natural convection and allow hot air to flow upward (buoyancy) between tree branches while reducing total volume.

2.2.2 Quantity, shape, and location of fins

Maximum Temperature Per Fin Design Created

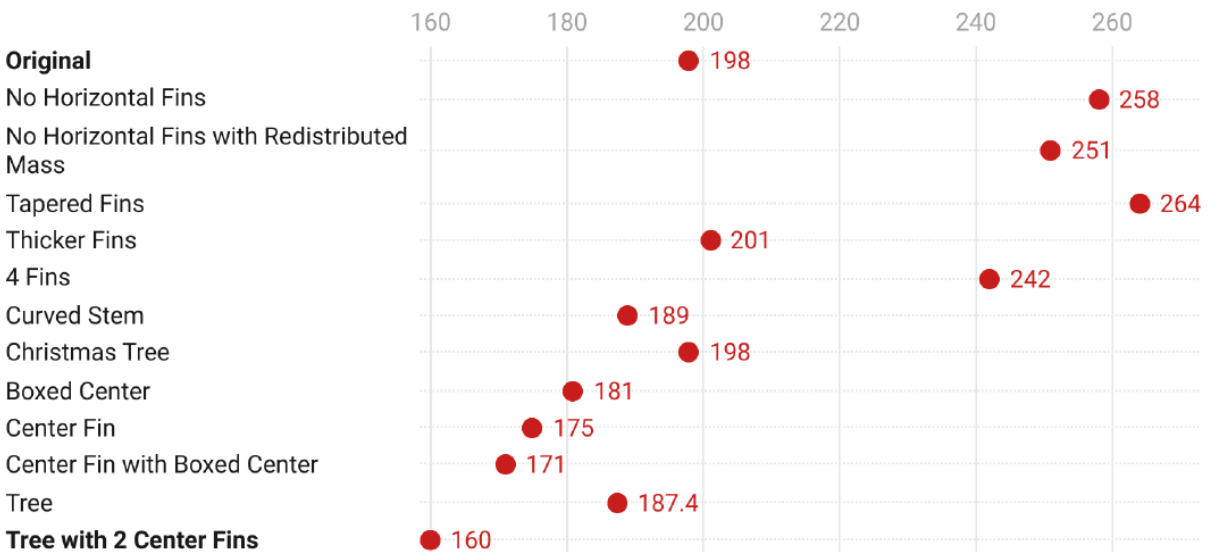


Figure 6: Maximum temperature per fin designed

Adjusting the quantity, curvature and shape of the fins ultimately adds more surface area for natural convection and redirects heated air more smoothly preventing hot air pockets. The "tree" structured fins utilized topology optimization and additive manufacturing to develop the best shape to dissipate heat. [\[Research Article\]](#)

2.23 Geometry of Root

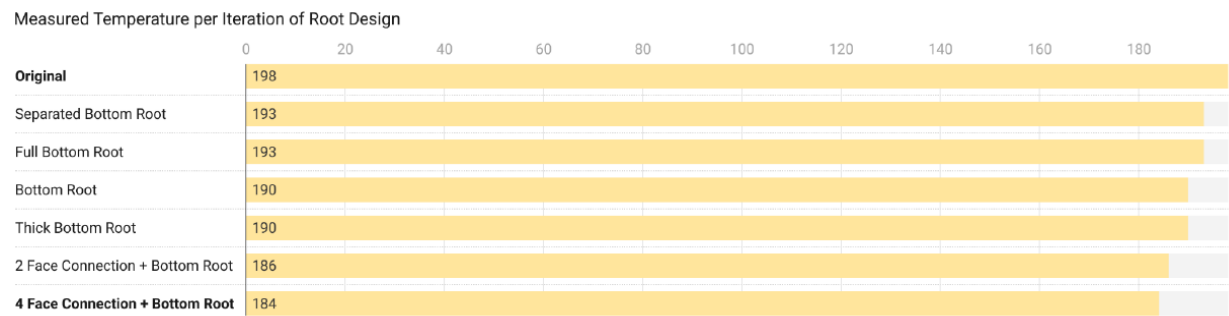


Figure 7: Measured temperature per iteration of root design

Adding more metallic volume directly contacting the CPU allows for better conduction of heat from the source.

2.3 Material Design Iterations

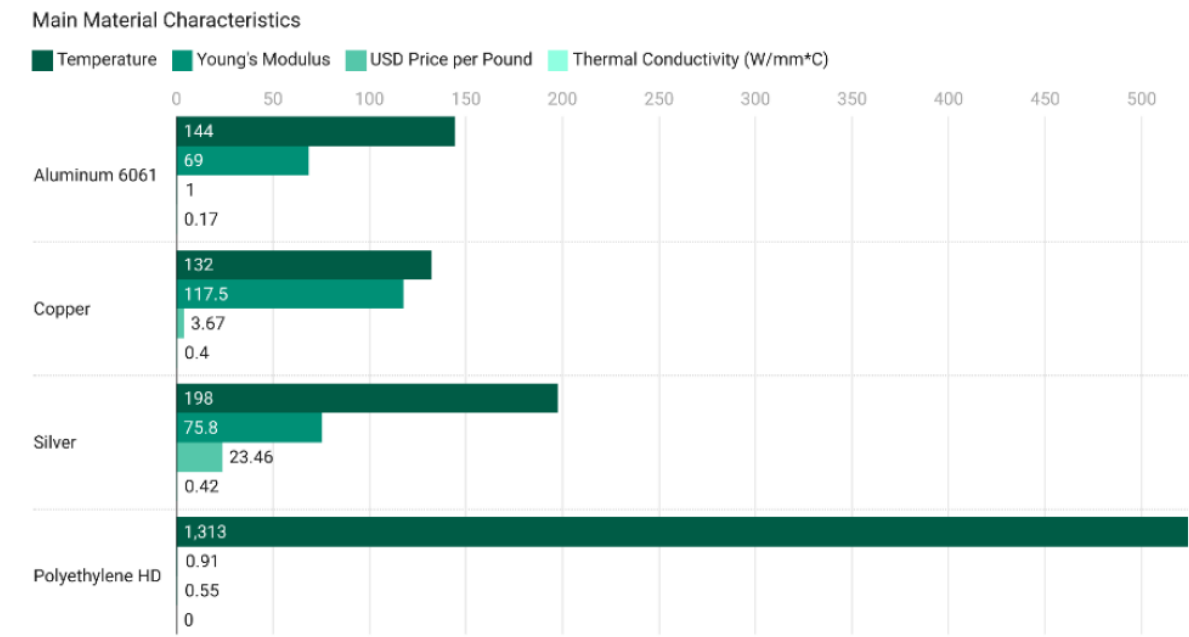


Figure 8: Material iterations with maximum temperatures

The primary criterion for the final material selection was its thermal conductivity. Silver was seen to have the greatest reduction in temperature. However, copper's temperature reduction was around 5C within silver. **Copper was ultimately chosen as the final material** for its temperature proximity to silver and a lower cost.

2.4 Structural Integrity

The main source of failure from shear stress would be at the **end of the branches**. This is mainly due to it's lack of material, and jagged geometry introducing many stress points.

2.5 Manufacturing Research



Figure 9: CNC Milling (Left) and Injection Moulding (Right)

2.51 CNC Milling

Advantages

- High level of precision compared to other metalworking applications, allowing our prototypes to stay consistent and precise.

Disadvantages

- Expensive to program the path and to operate the machine.
- Metal would be wasted as large blocks of metal are milled from a block, thus inefficient costs.
- Extremely difficult to mill the holes between the heatsink fins, as new designs would be necessary to accommodate the mill.
- Mass Production: Injection Molding

2.52 Injection Moulding

Advantages

- Allows for lowered material use, creating less waste per volume.
- Heatsink fin holes can be manufactured without complication by placing a cylinder inside of the mold.

Disadvantages

- Imprecise nature of the molding. However, since the final heatsink does not undergo any physical strain or hold fluids, it does not need to be extremely precise.