CPU Heatsink Design Project

September 2023

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1. General Information

https://drive.google.com/file/d/1Lajgt2AT7G7ZIsw9Qn7NInJONjGSqvb0/view **(Official Report)**

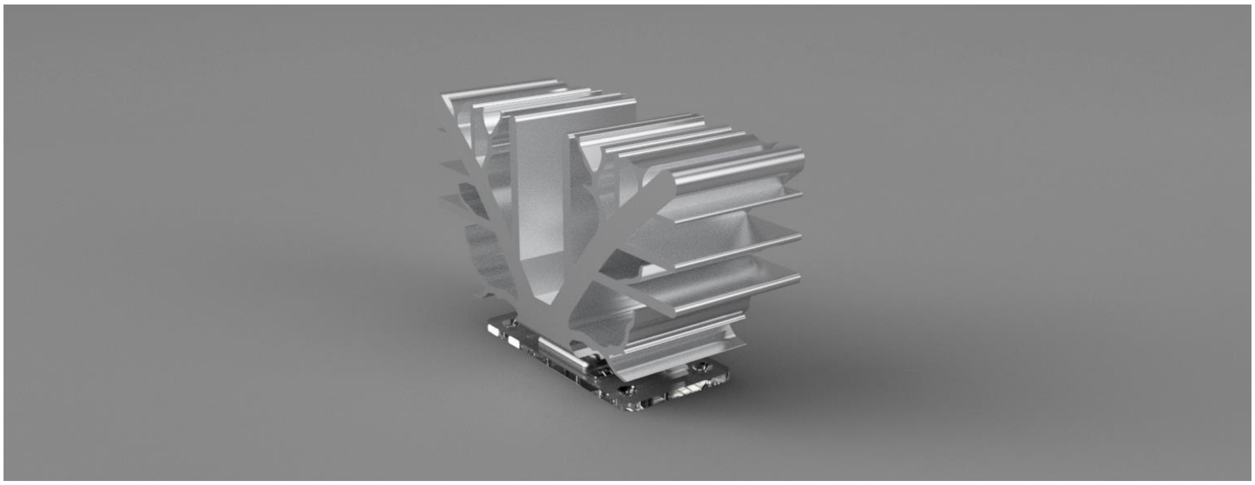

Figure 1: CPU Heatsink Final Design with CPU and CPU housing

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 efficency, 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

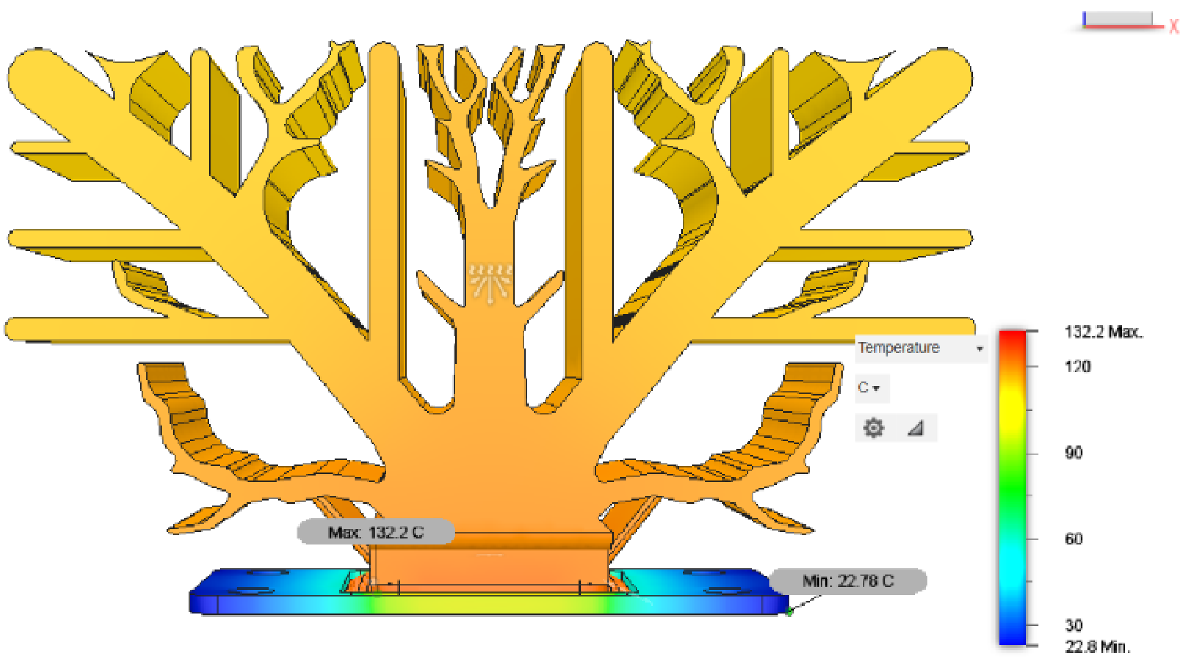

Figure 2: CPU Heatsink Thermal Analysis

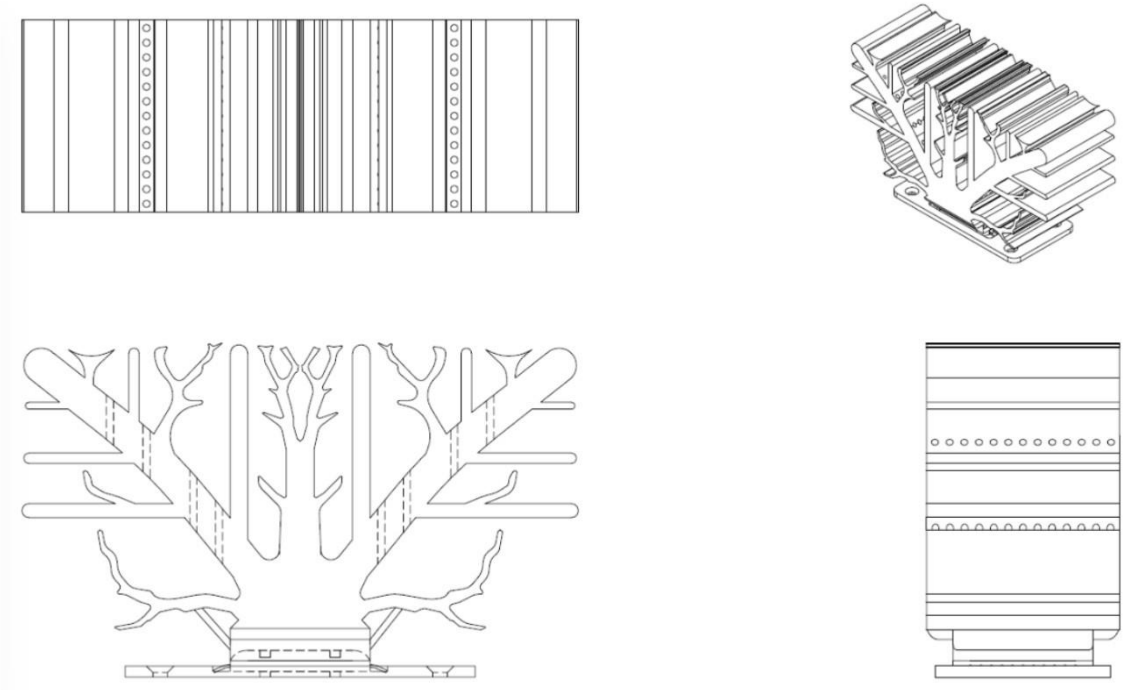

Figure 3: CPU Heatsink Final Engineering Drawing

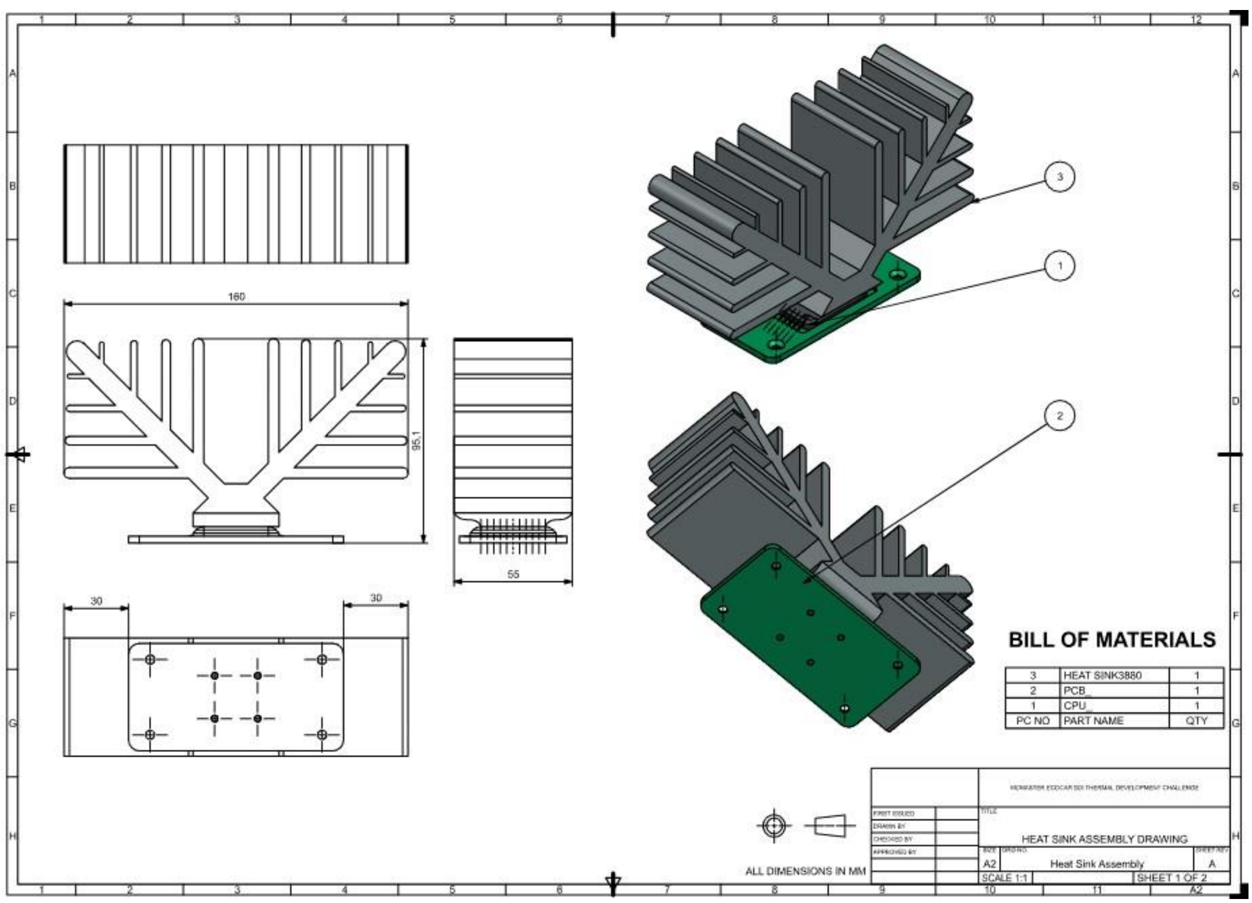

Figure 4: Initial Design of the Heatsink

2.2 Iterative Structural Design Decisions

2.21 Lattice Structure and Quantity of Holes

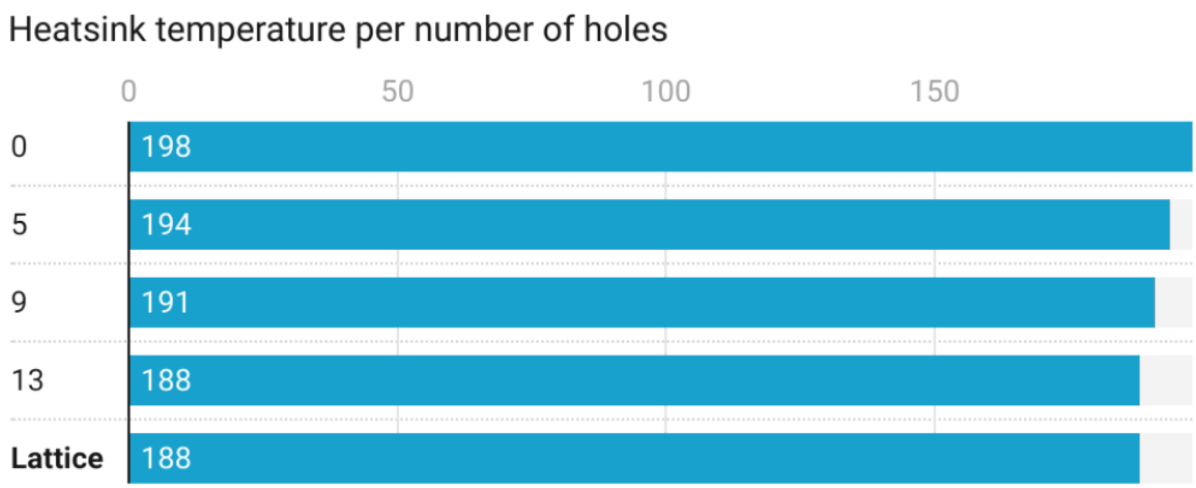

Figure 5: Iterative design adding holes in the heatsink

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.

2.22 Quantity, shape, and location of fins

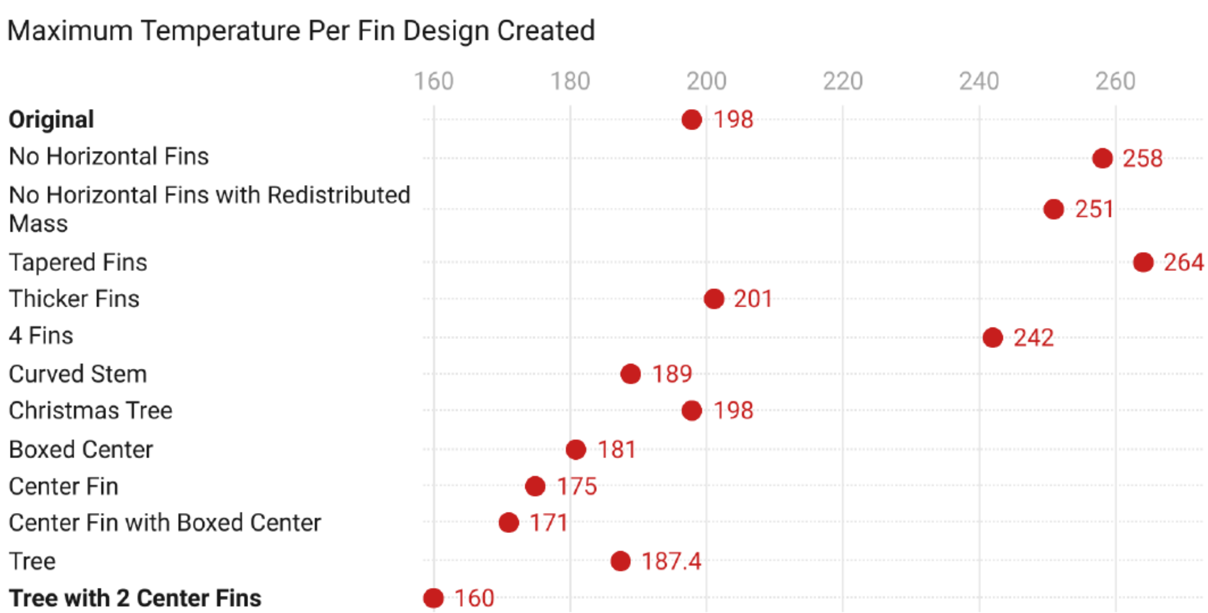

Figure 6: Maximum temperature per fin designed

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

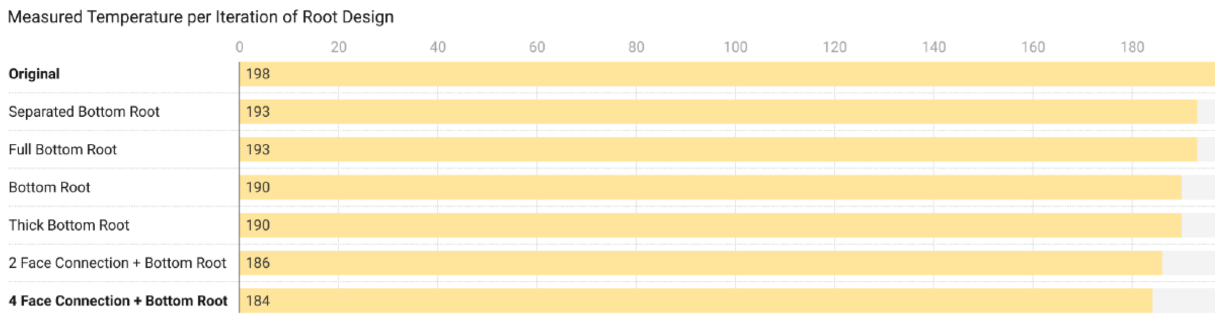

Figure 7: Measured temperature per iteration of root design

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

2.3 Material Design Iterations

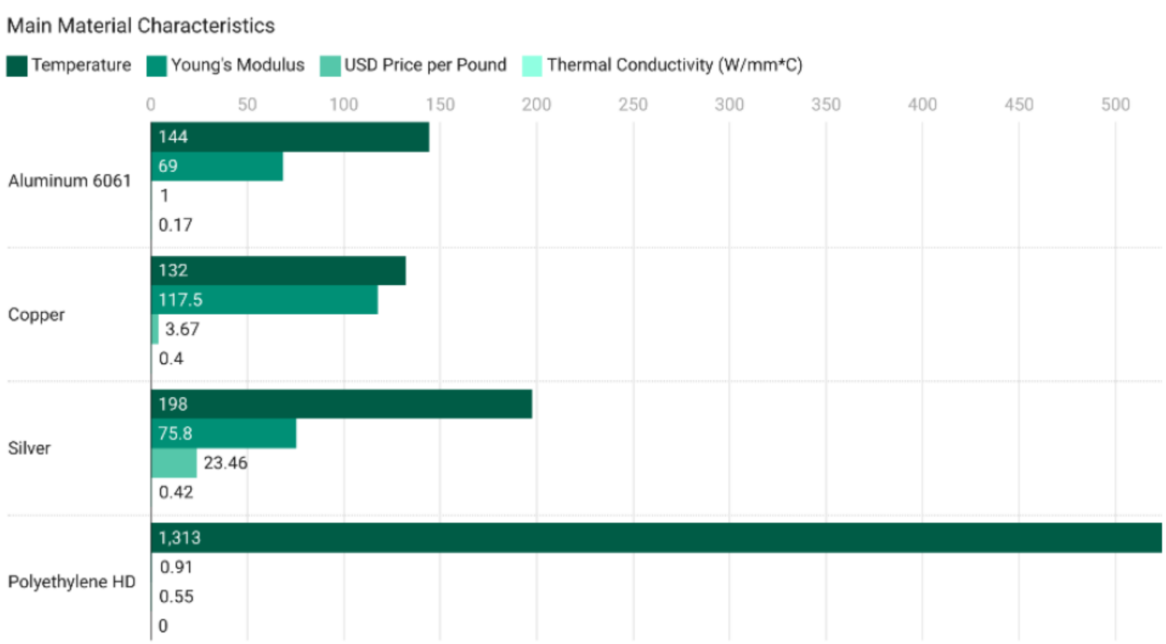

Figure 8: Material iterations with maximum temperatures

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

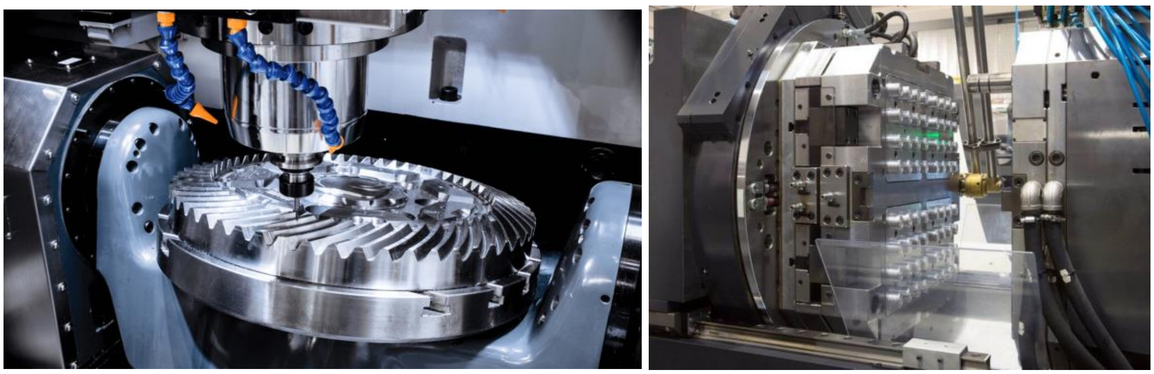

Figure 9: CNC Milling (Left) and Injection Moulding (Right)

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.

3. Solution with Model

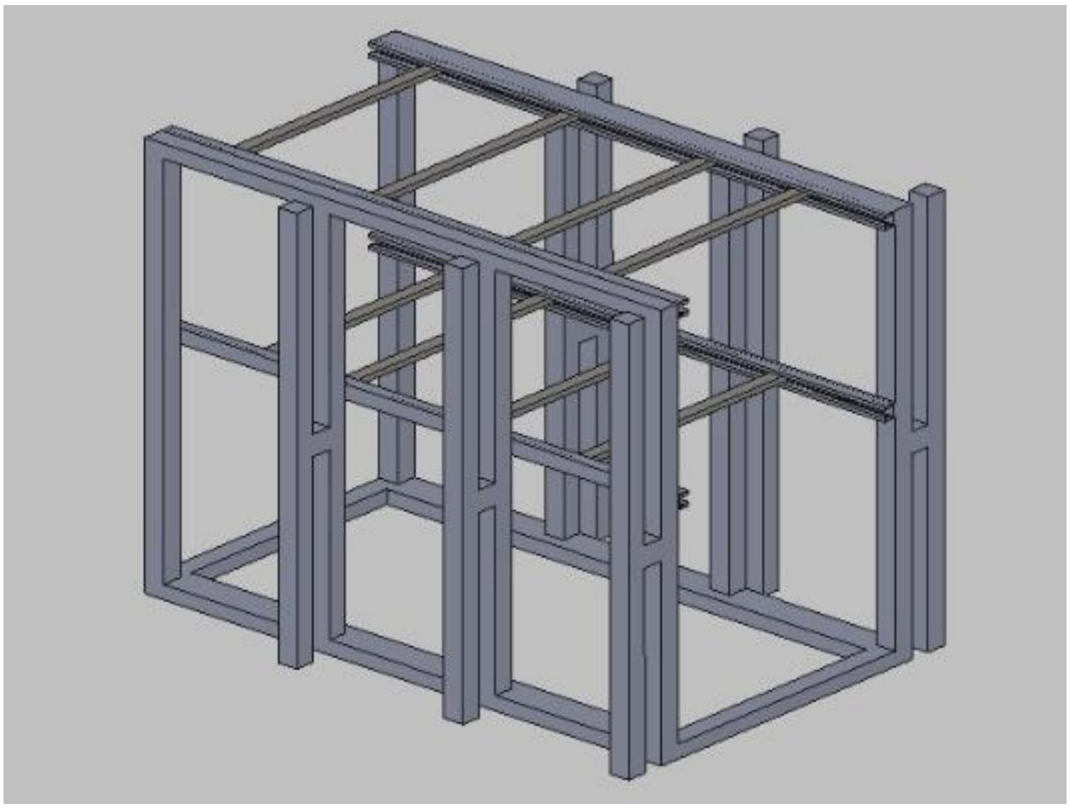

Figure 2: Isometric view of the ergonomic shelf, including sliding cross arms for variable sizing parts

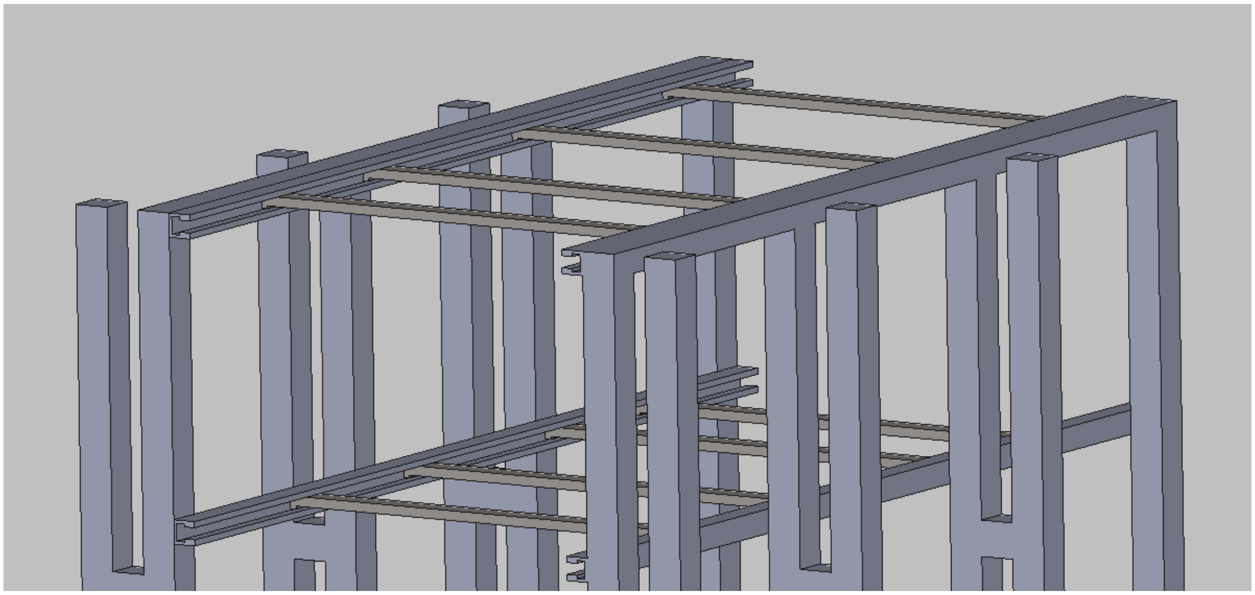

Figure 3: Top view of the ergonomic shelf, including side slots for vertical placement of NCR arms

A new shelf design was developed, utilizing SolidWorks, improving the organization of Paint NCR's, improving ergonomics, safety, and cost mitigation for damaged parts. Each cross arm can slide throughout the structure to adjust for any size of equipment. The maximum sizes of equipment was accounted for in the final dimensions. Along the sides of the shelf, specific NCR arms can be hung to make space as efficient as possible, as well as ease of access to parts as easy as possible.

4. Design Considerations

4.1 Structural Analysis

A comprehensive structural analysis was undertaken to ensure the harmonious integration of design elements, materials, and manufacturing processes, thereby upholding a robust and well-balanced structure.

4.2 Economics

Cost-saving analyses and payback periods were calculated and performance metrics were presented, leveraging insights from historical data related to paint NCR.

4.3 Safety and Ergonomics

Thorough safety and ergonomics research was conducted to ensure the well-being of workers who interact with the shelf, whether they are walking past it or engaging in the process of placing or removing components, were safe.

4.4 Materials and Manufacturing

Extensive research on materials and manufacturing processes was conducted to address cost considerations, all while upholding structural integrity and ensuring a seamless transition throughout the entire design-to-shelf creation process.