# Optimization Study of Heat Dispersion in Additively Manufactured Heat Sinks

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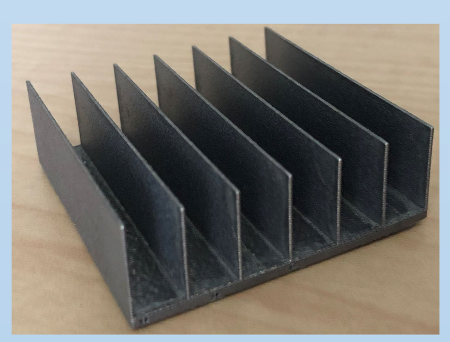
## Abstract

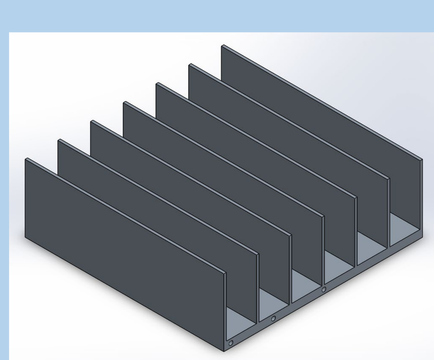
Heat sinks are commonly used today; virtually every large computational device incorporates at least one heat sink in its design. This is because computer processors experience losses in performance as they accumulate heat. The addition of a heat sink can disperse this heat and subsequently increase performance.

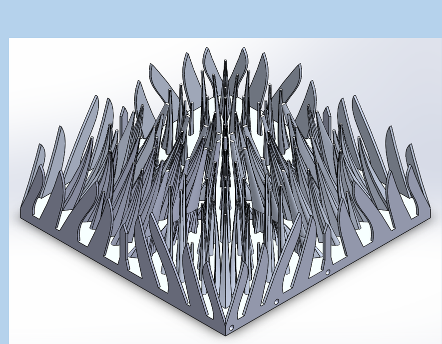
The purpose of this project is to determine if the design of heat sinks can be improved upon. Specifically, the way the protrusions, or “fins,” are arranged on the surface of the heat sinks will be tested in order to determine which design most effectively disperses heat. Two designs will be tested: a traditional rectangular fin design and one with more optimized topology. Due to the complex geometry of the second design, Selective Laser Melting (SLM) additive manufacturing is used to create both prototypes, and the heat dispersion is evaluated through experimentation. The results of this experiment will conclude which design is most effective.

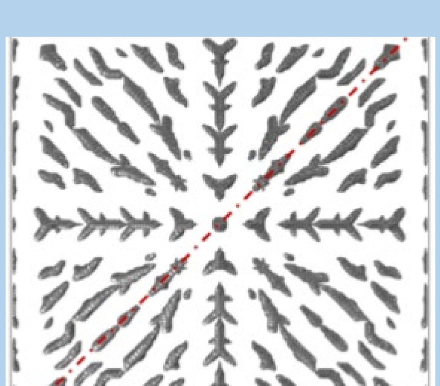
## Manufacturing

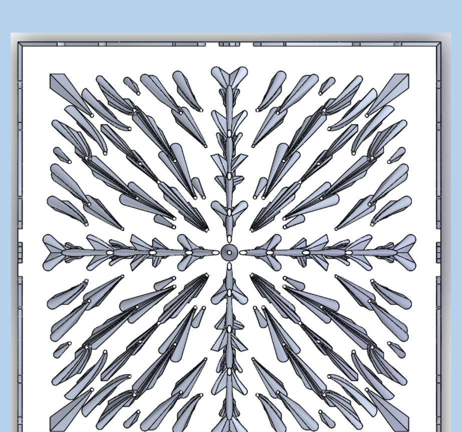
The design of the optimized heatsink was based on a 2015 study by the American Society of Mechanical Engineers[1] (ASME). The purpose of the unconventional topology was to allow for increased air flow from the top of the heat sink. The construction of such a part would be cumbersome or impossible through normal machining methods due to the complex geometry; therefore SLM additive manufacturing was employed. Solidworks was used to model both parts. It is important to note that the surface areas and volumes of the respective parts were made to be essentially the same, in order to test only the geometry of the designs.







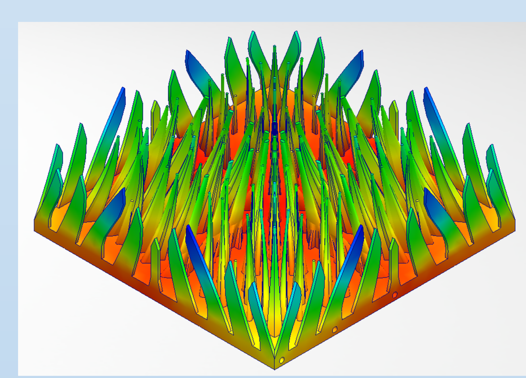


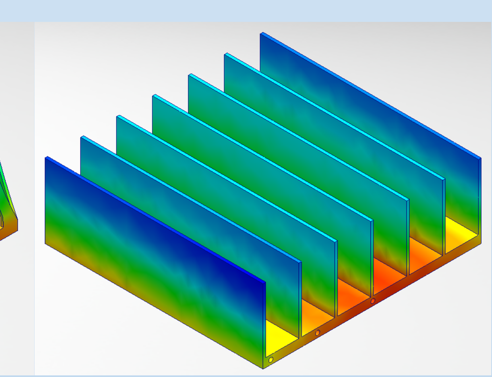


*ASME*[1]

## Simulation

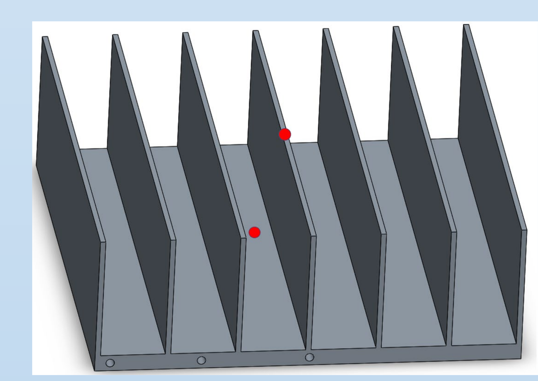
Heat transfer simulation was conducted using Solidworks as preliminary testing. Under conditions similar to the practical experiment, which consisted of a large heating power (92 W) applied to the base and minor convection heating (20 W) from the environment, Solidworks generated the figures below. With a quick glance, it can be seen that the optimized design has a more uniform and hotter profile than the traditional design. This would predict better heat transfer when heat is applied directly to the bottom of the base.

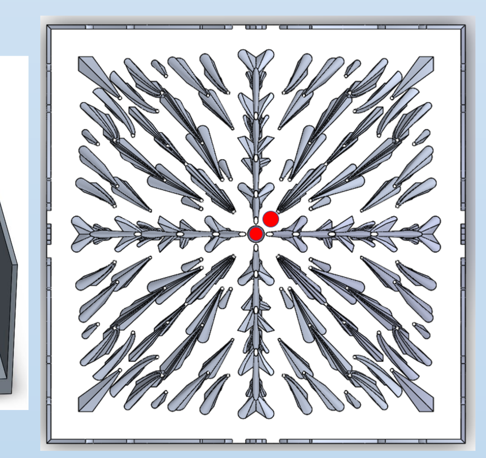




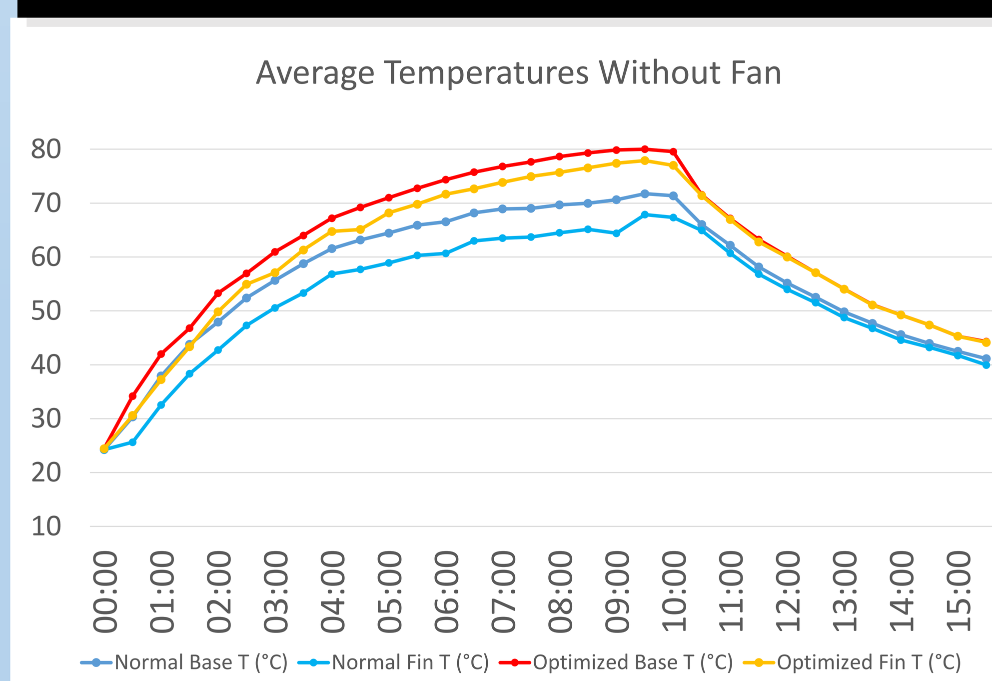
## Experimentation

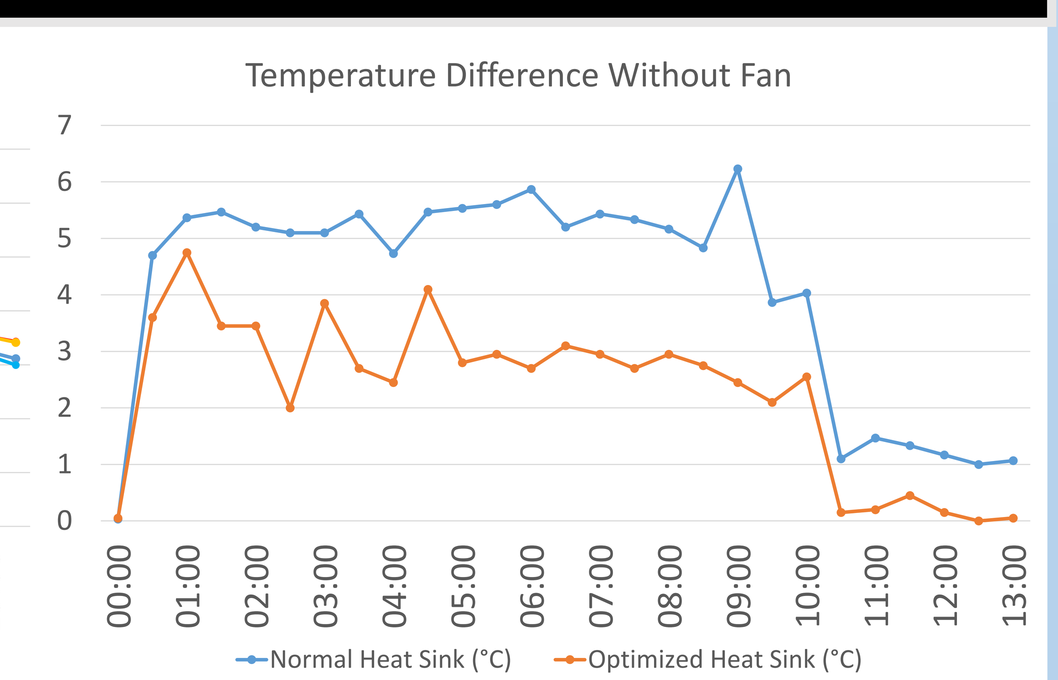
In order to determine the efficiency of the designs, a Peltier cooler was applied to the base of the heat sink with thermal paste in order to increase heat transfer. The voltage through the cooler was kept constant at 5 V. Heating was applied for 10 minutes from room temperature (24°C), then removed. Thermocouples were attached to the center of the base as well as the top of the most central fins (shown in red in the figures below) in order to analyze the difference in temperature between the two.

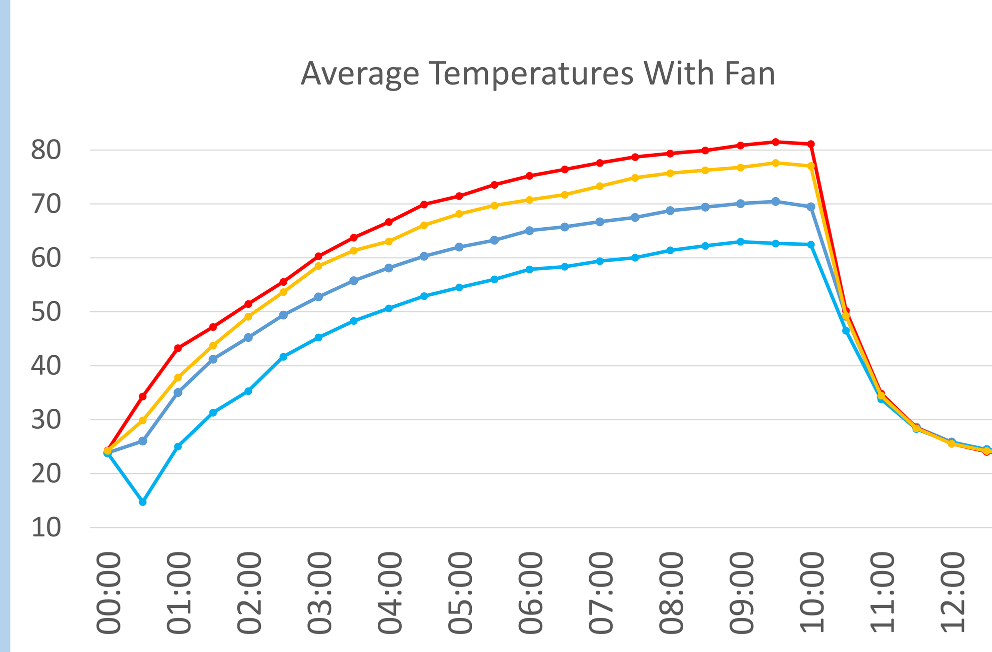


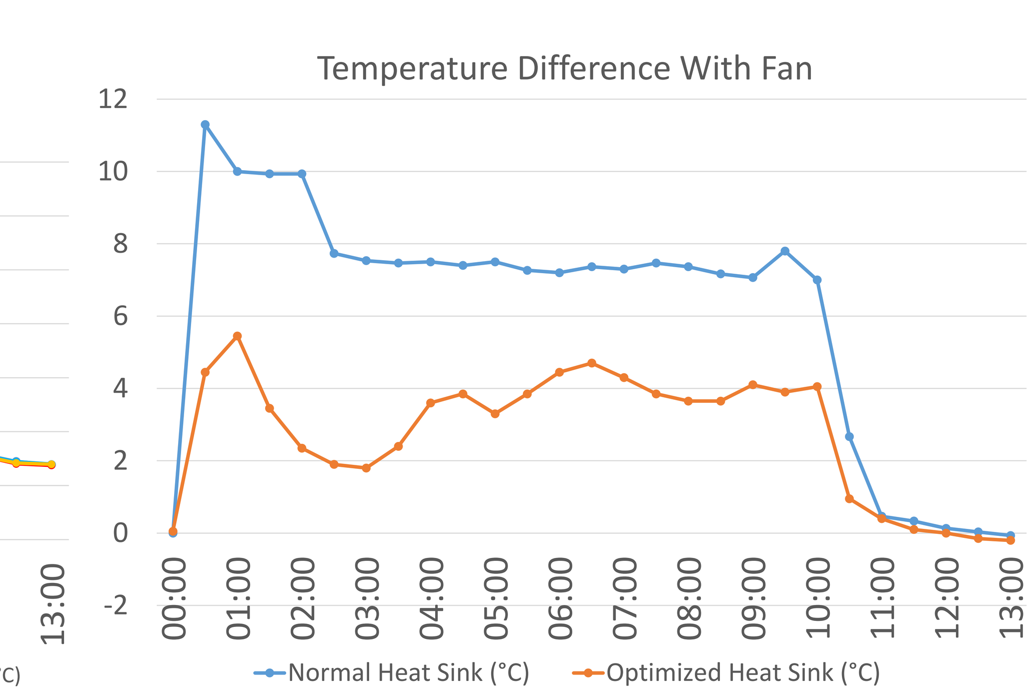


## Results




## Discussion

Six trials were conducted for each heat sink, three with a fan and three without. The averages of these trials are plotted below. These results show that the optimized heat sink reached a higher temperature in both the base and the fins; at the peak temperatures, the optimized heat sink was approximately 10°C hotter than the normal heat sink. Additionally, the difference in temperature between the base and the fins of each heat sink is plotted with respect to time. It is shown that the temperature of the base and the fins of the optimized heat sink were much closer together than the normal heat sink’s temperatures.

## Conclusion

The results would indicate that the optimized heat sink design is more effective at dispersing heat than traditional designs. The optimized heat sink remained significantly hotter throughout the trials when compared to the normal heat sink, suggesting that it is able to conduct heat more effectively. Additionally, the temperatures of the base and the fins of the optimized design were significantly closer together than those of the normal design. This[2] would suggest that the optimized heat sink is more efficiently able to disperse heat from its base to its fins, which allows for more effective dispersal of heat from, for example, a processor. Future research could be done to better quantify how much more effective this type of topology can be, and whether or not it would be cost effective to produce on a large scale.

## References

[1] Dede, Ercan M., Shailesh N. Joshi, and Feng Zhou. "Topology Optimization, Additive Layer Manufacturing, and Experimental Testing of an Air-Cooled Heat Sink." *Journal of Mechanical Design* 137 (November 2015): 1-9.

[2] Wong, M., I. Owen, C.J. Sutcliffe, and A. Puri. "International Journal of Heat and Mass Transfer." *Convective Heat Transfer and Pressure Losses across Novel Heat Sinks Fabricated by Selective Laser Melting* 52, no. 1-2 (January 15, 2009): 281-88.

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