# SCHOOL OF ENGINEERING & COMPUTING

# Thermal Performance Optimization through Custom Heat Sink Design

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## ABSTRACT

Efficient cooling in electronics has made heat sink design an area of innovation. This project compares the performance of different types of heat sinks using 3D modeling, ANSYS simulations, and experimental testing. Teams will design and optimize heat sinks to improve heat transfer while meeting specific constraints. Final designs will be evaluated on innovation, performance, and accuracy. This iterative process combines creativity and engineering to enhance thermal management solutions.

## INTRODUCTION

- The objective of the project is to analyze and optimize heat sink designs by comparing the performance of physically different configurations through simulation, experimentation, and iterative improvements.
- The goal is to enhance heat transfer efficiency while adhering to design constraints and fostering innovative solutions.

## METHODOLOGY

- The project began with creating accurate 3D CAD models of pinned and finned heat sinks, capturing their detailed dimensions and geometries. These models were then analyzed through ANSYS simulations
- We used an Armfield Free & Forced Conversion Heat Transfer Apparatus, a heat sink made from a copper + PLA mix
- The infill density used was 100%, or solid. As such there was no pattern used.
- ANSYS settings consisted of a long list of settings to follow given to us by our instructor. Some key parameters were going from 20W to 80W in 20W increments, focusing on simulating the temperature distribution along the fins or pins, saving and documenting the results for comparison with experimental data, as well as capturing temperature at various points on the heat sink (e.g., base, mid-fin, and fin tips) for comprehensive analysis in the next phase.

## MODEL FORMULATION

Fig. 1. Heat sink (front view)

Things to note:
- Honeycomb design
- Surface area
- Compartmentalization of fluid
- Inflow vs outflow

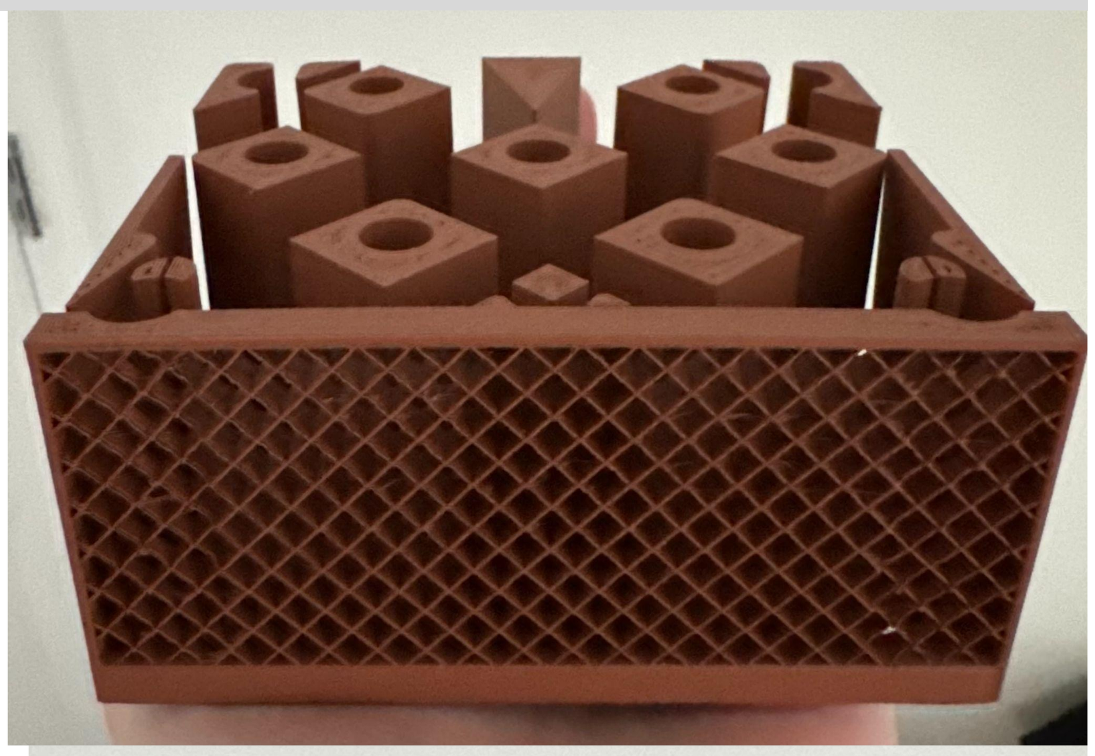
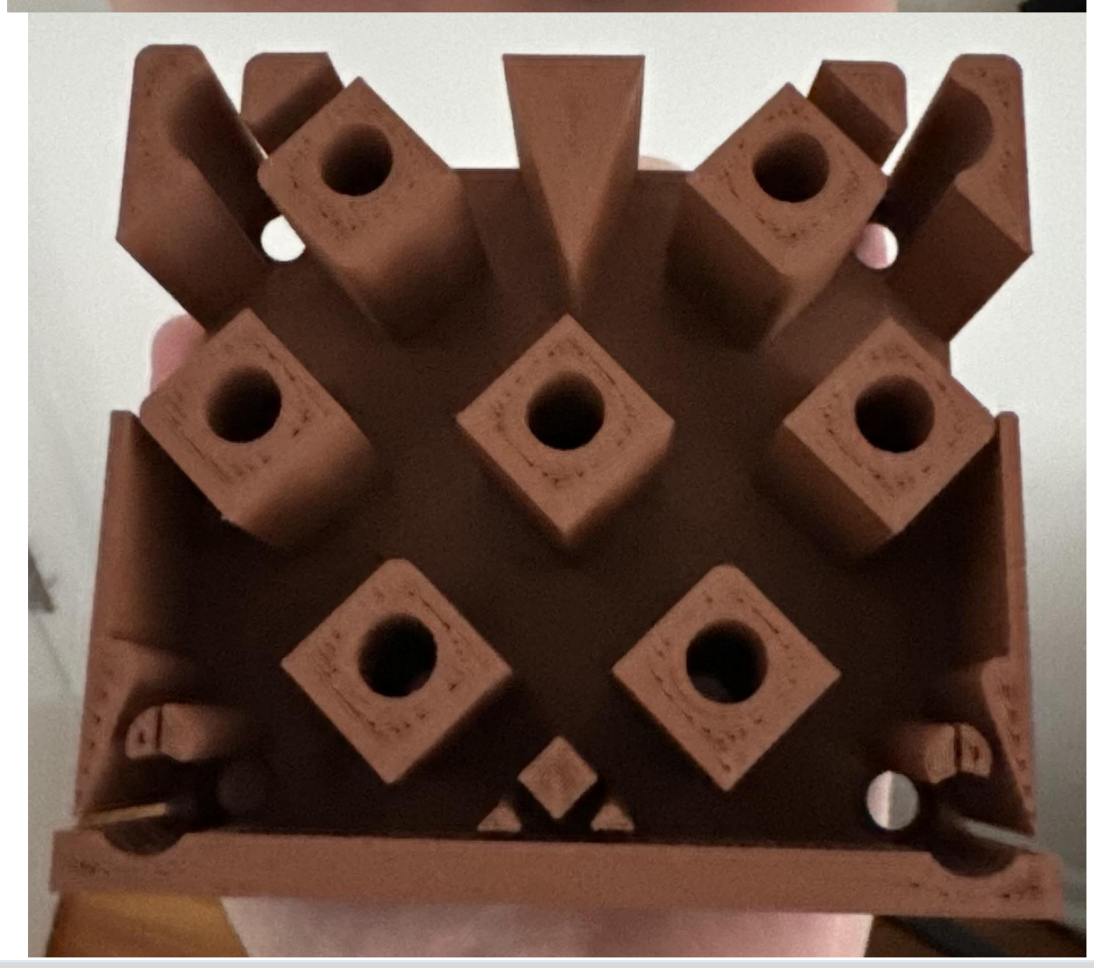


Fig. 2. Heat sink (top view)

Things to note:
- Flow direction(s)
- Thru-hole chimneys
- Slanted chimneys
- Random members



## RESULTS

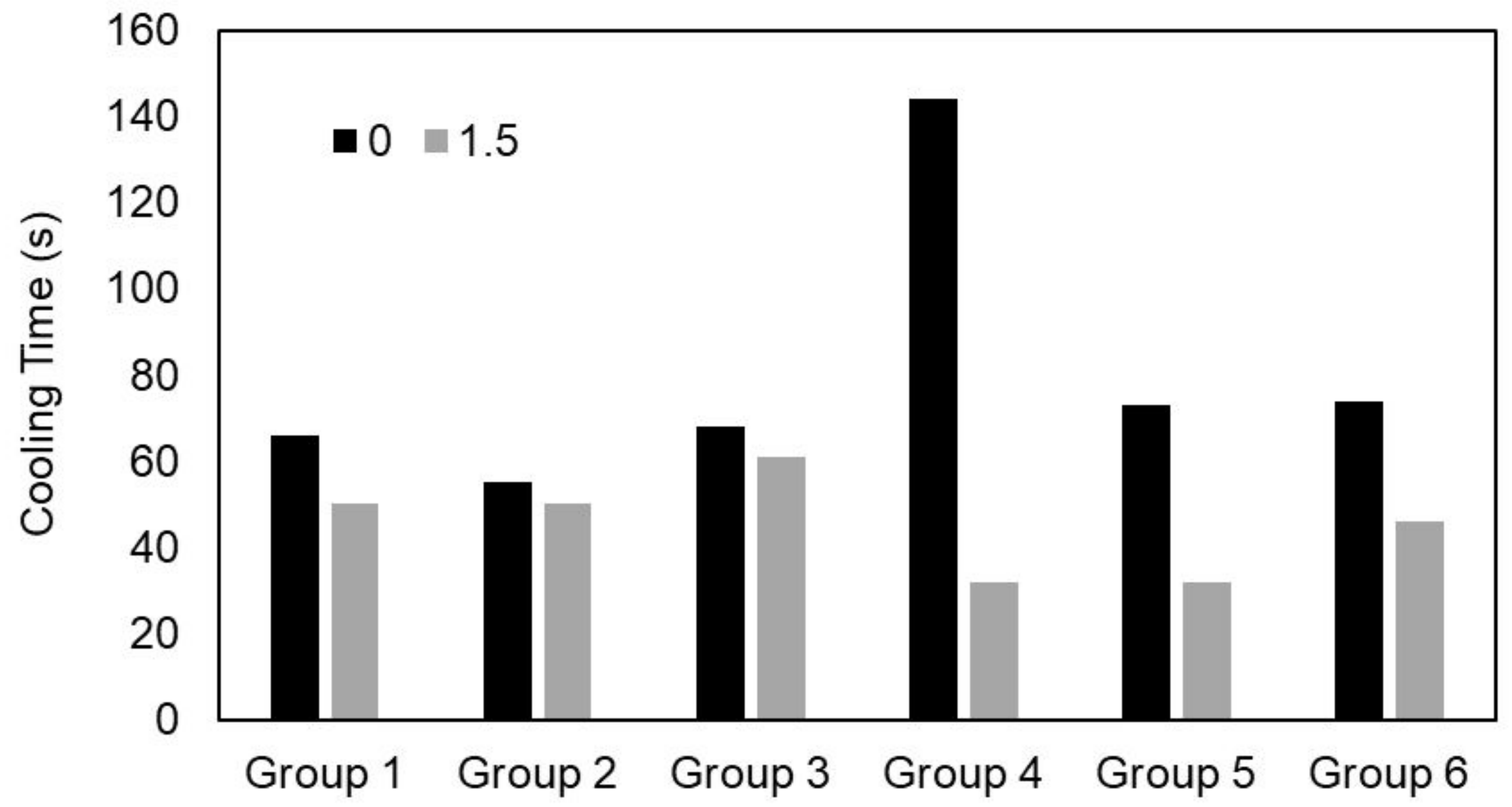



Fig. 3. Graphed cooling time for each group at different fan speeds

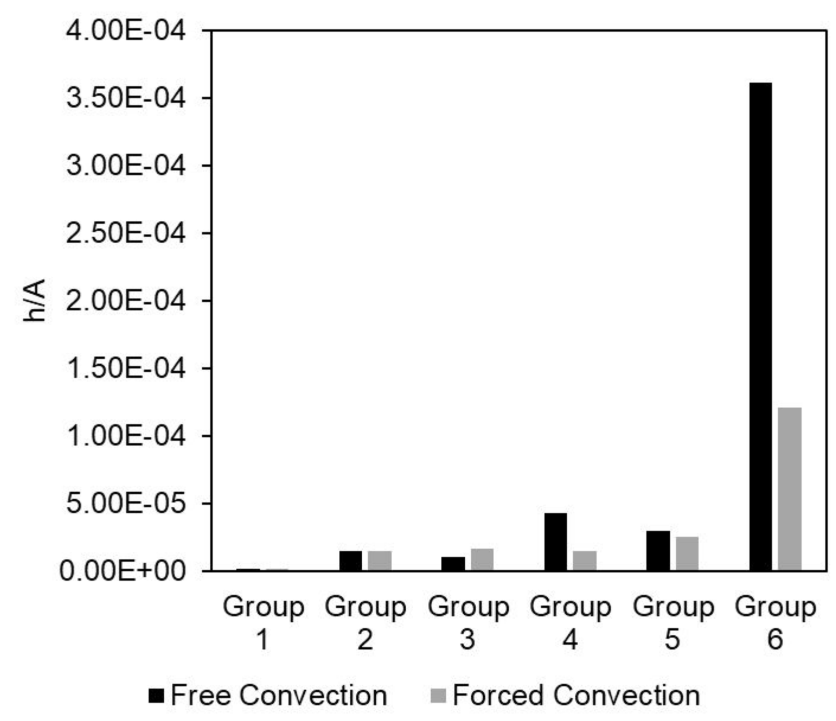



Fig. 4. Heat Coefficient per square centimeter

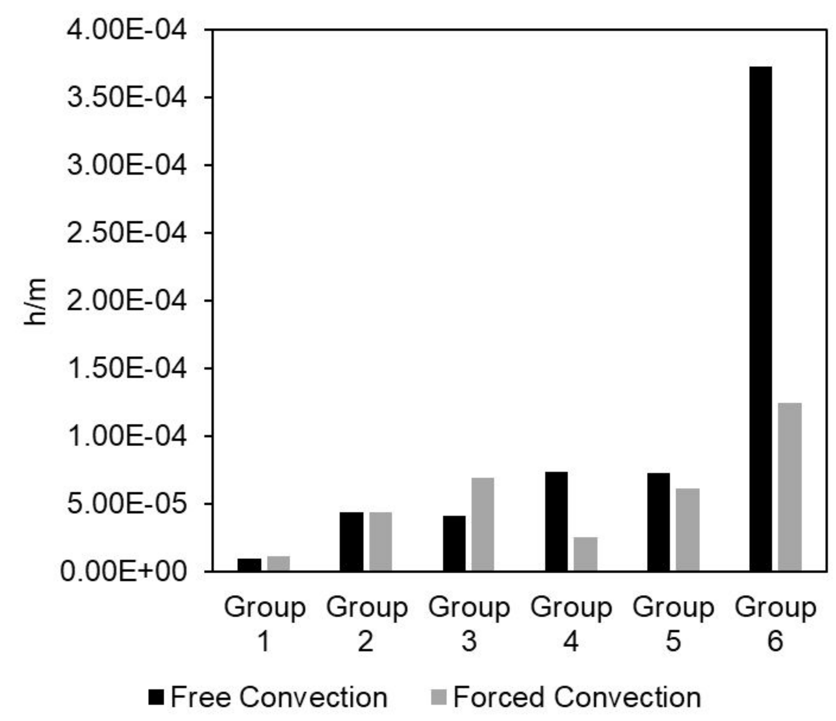



Fig. 5. Heat Coefficient per gram weight

## DISCUSSION

- G4 exhibited the longest cooling time under free convection (~140 seconds), indicating poor thermal performance without airflow
- Groups 1, 2, and 6 performed better with shorter cooling times (~40-60 seconds)
- Forced convection significantly improved cooling times for all groups, with G4 showing the greatest improvement, ergo its design benefits most from airflow.
- In Fig. 4, the heat coefficient per square centimeter under free convection was consistently low, with G4 performing the worst, but under forced convection,
- G4 showed the highest heat coefficient, indicating efficient heat dissipation.
- Fig. 5 revealed that G6 achieved the highest heat coefficient per gram under forced convection, emphasizing its lightweight and airflow-optimized design.
- Groups 1 and 6 showed balanced performance in both convection types, indicating versatile designs.
- Group 5 showcased the shortest time to cool in both free and forced convection, showcasing an important and well constructed balance between delivering on both fronts.

## CONCLUSIONS

- G5 performed the best in cooling time under forced convection at 31.9 sec.
- During free convection, it performed 4th best during free convection, but was only 33% slower than G2 at a 20 second difference.
- Heat coefficient vs square centimeter and heat coefficient vs gram weight, they are not the best indicators of performance. This was noted in the cooling times.
- In the future, other metrics should be considered (cost to manufacture, time to manufacture, expected lifespan)

## ACKNOWLEDGEMENT

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