# Fluid Motion of Fluid Filled Heat Sinks

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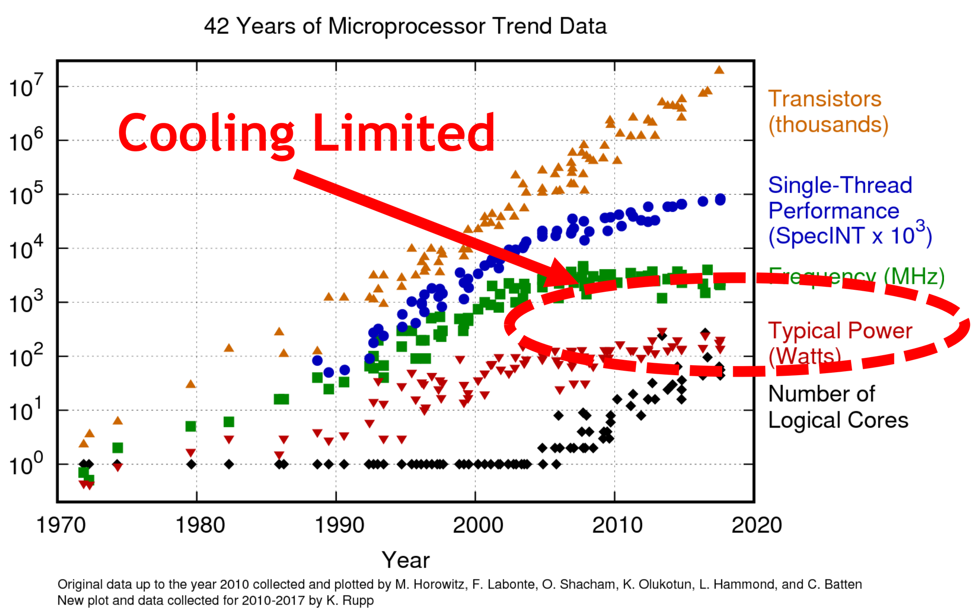
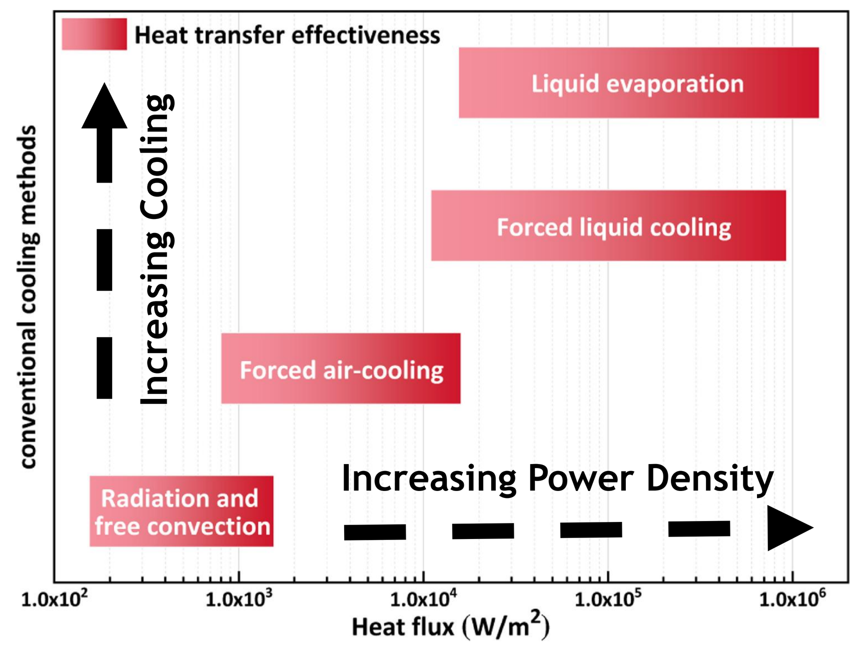
## Background

- Heat dissipation devices, such as heat sinks, heat spreaders, and heat pipes, are essential in many applications to prevent component failure.
- The rapid advancement of technology and a continual increase in power density drive the need for lighter and more compact heat dissipation devices.




Microprocessor Historical Power Trends




Conventional Cooling Methods [1]

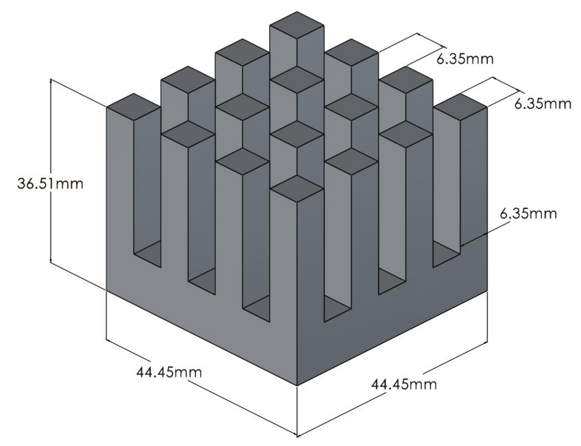
## Preliminary Research

- Previous research was done to determine whether a hollow heat sink filled with fluid is more effective than solid heat sinks for heat dissipation.
- The study designed, developed, and tested hollow copper and aluminum heat sinks filled with water and acetone, respectively and compared the two heat sinks to solid versions.
- Each heat sink was tested at nine operating points (varying applied heats and air velocities).
- The hollow copper heat sink had approximately the same overall heat sink thermal resistance while the hollow aluminum increased by 7%.
- The considerable decrease in mass without significant loss in thermal resistance demonstrates the potential widespread application across technologies requiring low-weight components.

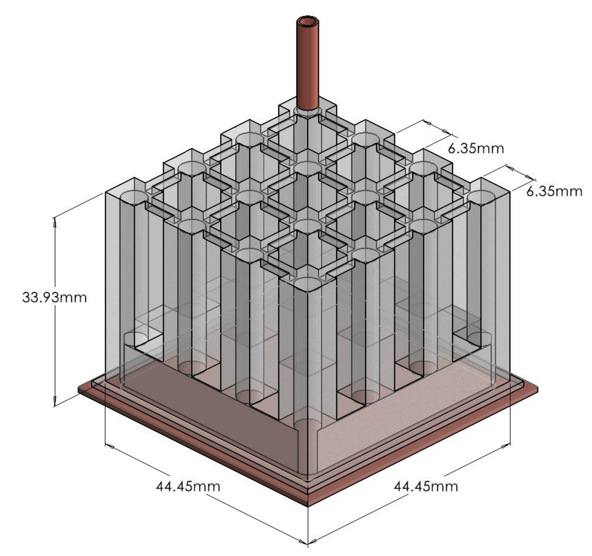
## Objective

- In this study, the goal is to observe the fluid motion in a fluid-filled fin array to determine how the water assists the heat dissipation. The hollow structure of fluid-filled fin array integrates characteristics of both heat sinks and heat pipes.

## Methods

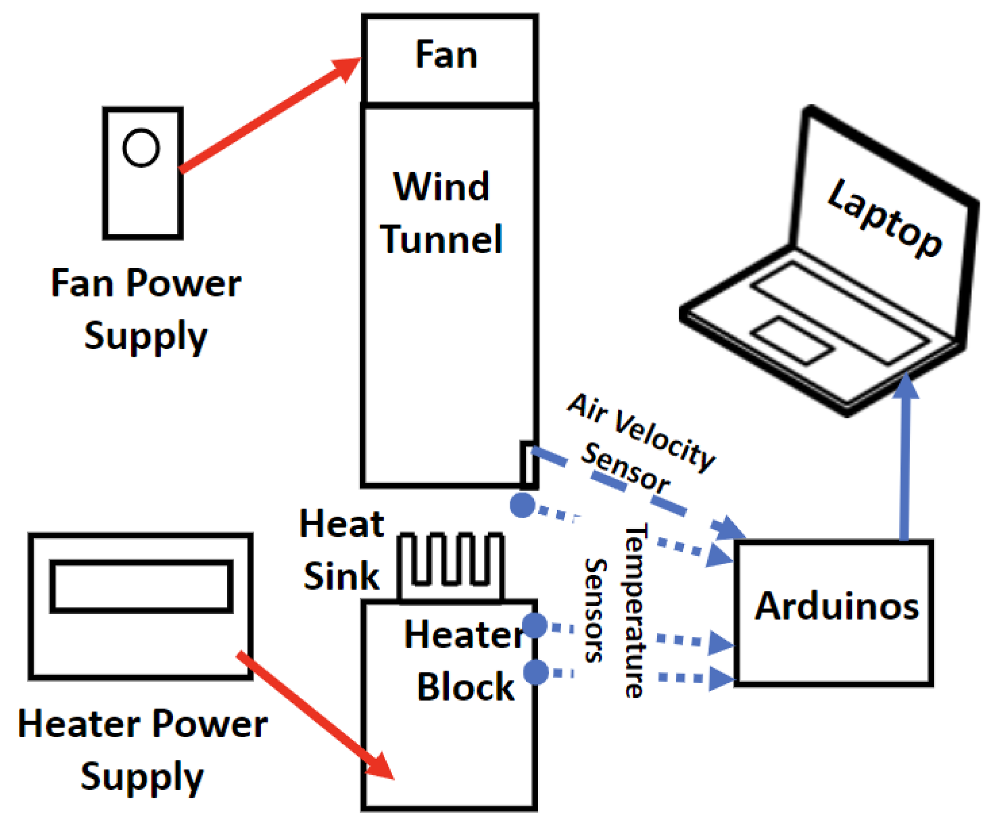


Solid Heat Sink
(not tested)

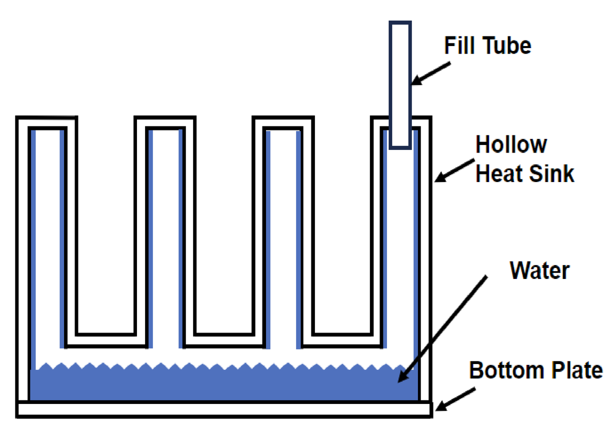


Hollow Clear Resin Heat Sink
(tested)

- The heat sink was SLA printed from a high temperature clear resin and epoxied onto the copper base plate to better see the motion within the heat sink.
- The heat sink was evacuated using a vacuum pump and filled with a syringe.
- The working fluid was water with a 33% fill volume.



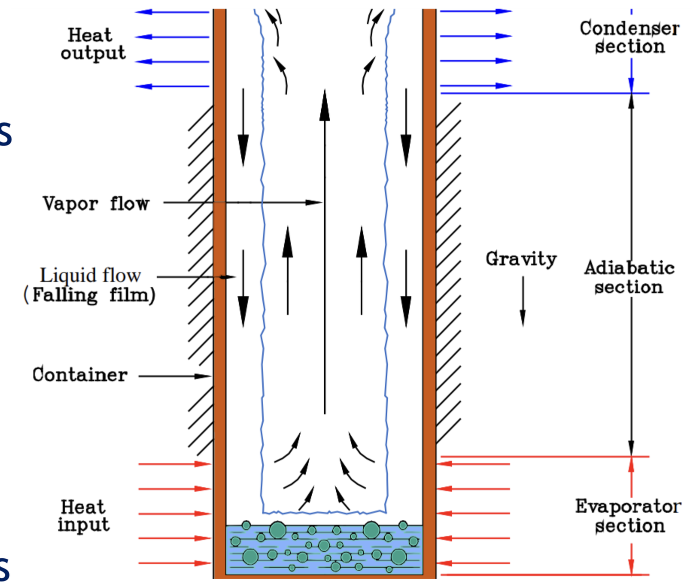

Schematic of Experiment Setup




Schematic of Clear Resin Heat Sink

## Theory

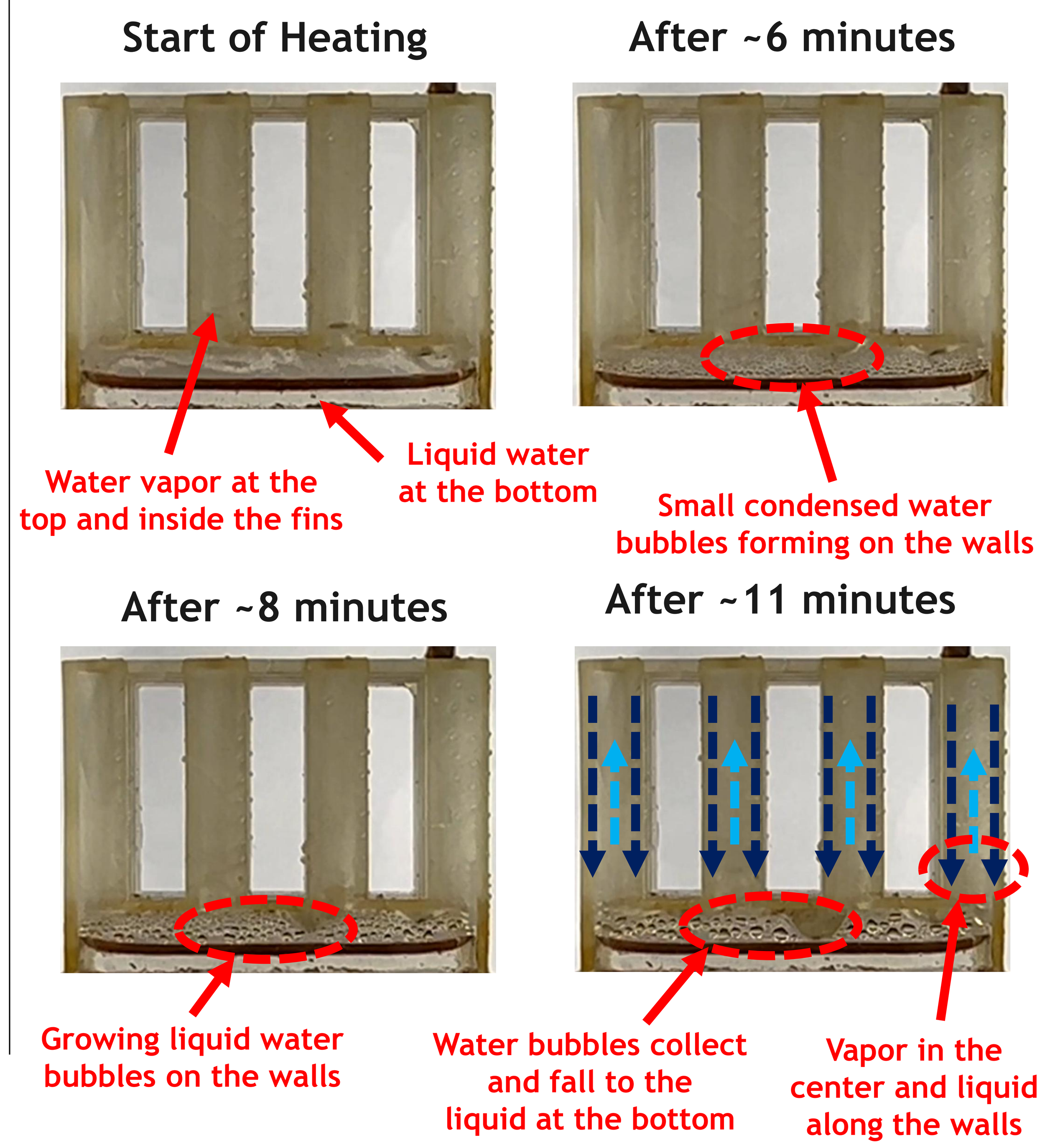
- Heat pipes utilize fluid phase changes to assist in heat transfer.
- They contain an evaporator, condenser, and adiabatic section.
- Wickless heat pipes rely on gravity to let the condensed working fluid flow down the walls to the evaporator section.




Gravity-Assisted Wickless Heat Pipe [2]

## Experimental Results

- Tested at 60 W, 5 m/s, transient
- 16 minutes long video collected
- Important frames are shown below




## Conclusions and Recommendations

- The anticipated fluid motion of the heat sink was validated through experimental observation and video documentation.
- The evaporator, condenser, and adiabatic sections of the hollow heat sink were clearly identified by utilizing a transparent resin model.
- The video footage captured the following phases:
  - Condensed water on the heat sink walls
  - Water vapor in the center of the fins
  - Bubble formation from the condensing water vapor
  - Water bubble growth
  - Falling water bubbles back to the liquid at the bottom

## Acknowledgements

- UNF's College of Computing, Engineering, and Construction
- UNF's Office of Undergraduate Research

## References

1. Zhang, Z., Wang, X., & Yan, Y. (2021). A review of the state-of-the-art in electronic cooling. e-Prime-Advances in Electrical Engineering, Electronics and Energy, 1, 100009.
2. Faghri, A. (2014). Heat pipes: review, opportunities and challenges. Frontiers in Heat Pipes (FHP), 5(1). doi: https://doi.org/10.5098/fhp.5.1.

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