Heat Sink Test Device

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Abstract

L3Harris is testing the efficiency of heat sinks with complex geometries. This can be done in simulation software like ANSYS but can take 8+ hours to complete for more complex shapes. The company would like to quickly generate a heat transfer coefficient for a group of heat sinks, determine the best ones, and only run simulations on those. Heat sinks function as passive heat exchangers, which means when they have a colder fluid passing over them, they can pull heat away from an object. This is often seen when a computer fan blows over a heat sink attached to a computer chip. This cools down the computer chip, which extends the life of the electronics.

In our test device, we simulated a comparable environment. This involved a wind tunnel with a heat source to heat the test heat sink, where we could measure temperature data to calculate a heat transfer coefficient.

Problem Statement

Create a device to calculate heat transfer coefficients quickly and easily for different heat sinks, under variable conditions.

Computational Fluid Dynamics (CFD) Analysis

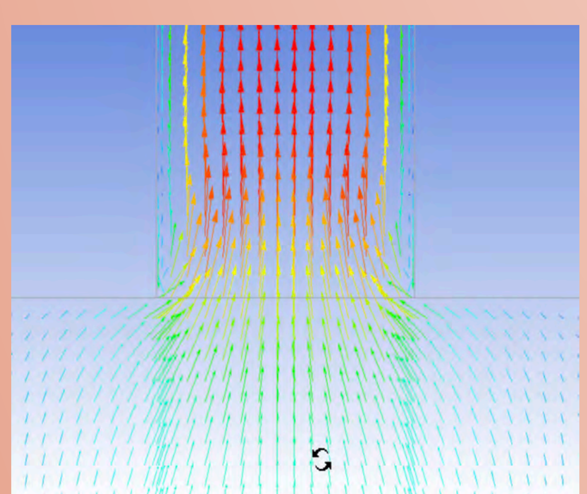
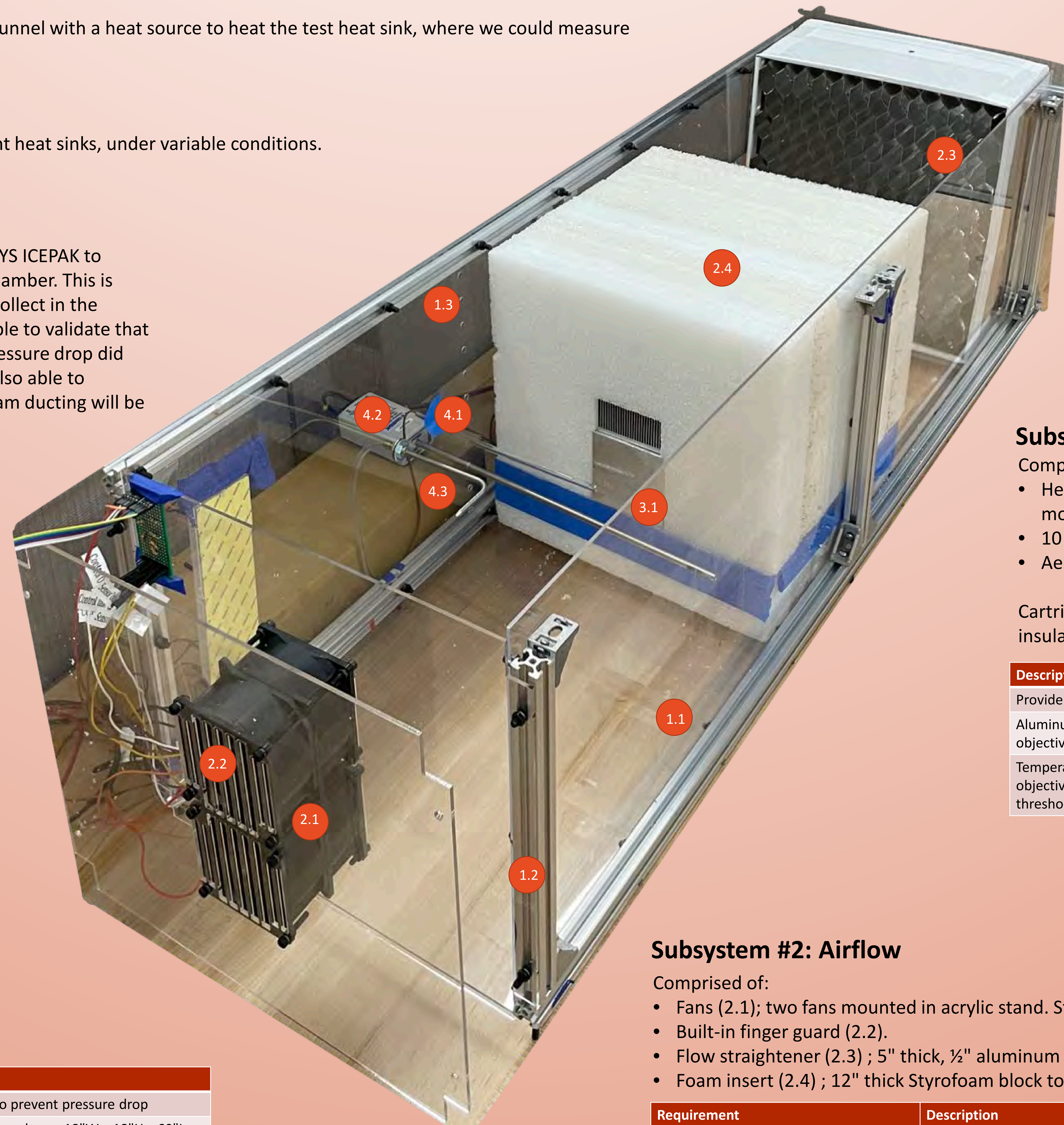


Fig 1: CFD velocity vector visualization, confirmed fluid becomes laminar shortly after entering heat sink.

We performed CFD modeling tests using ANSYS ICEPAK to validate the design of the heat sink testing chamber. This is similar to how L3Harris will use the data we collect in the device. Through the CFD analysis, we were able to validate that for the required CFM range of 25-150, the pressure drop did not exceed the objective 0.5' W.C. We were also able to validated that any flow obstruction by the foam ducting will be dissipated within <1" of the heat sink.

Conclusions

We created a device that can test the relative performance of heat sinks across complex geometries. The aim was to quickly determine the performance of heat sinks without having to run complex CFD models that can take multiple days. The system at its current state can provide values of the measure data and the calculated heat transfer coefficient value. Future work would entail implementation of a sophisticated GUI, and exhaustive error testing.



Subsystem #1: Shell

Comprised of:

- Acrylic panels (1.1)
- Aluminum t-slot extrusion (1.2)
- Holes are cut along back face of shell (1.3) to allow insertion of sensors.

Acrylic allows heat sink to be seen, as requested.

Requirement	Description
Airtightness	The test assembly SHALL be airtight to prevent pressure drop
Assembly Size	The test assembly SHALL fit within the volume: 18"W x 18"H x 60"L
Form factor	Test assembly SHALL remain static when placed on flat surface
Visual	The unit under test (i. e., the heat sink) SHALL be visible while test is underway
Handling	The test assembly SHALL provide handles for 2-persons

Subsystem #2: Airflow

Comprised of:

- Fans (2.1); two fans mounted in acrylic stand. Stand can easily be flipped to change flow direction.
- Built-in finger guard (2.2).
- Flow straightener (2.3) ; 5" thick, ½" aluminum cores to create laminar flow. Can be moved depending on flow direction.
- Foam insert (2.4) ; 12" thick Styrofoam block to duct flow and insulate heat sink and heat block.

Requirement	Description
Fan Performance	Variable flow 25-150 CFM @ 2 inH2O @ MSL (T) Variable flow 25-150 CFM @ 3 in H2O @ MSL (O)
Flow Direction	The test assembly SHALL provide the capability of bi-directional flow with minimal set-up time required to switch flow direction
Flow Regime	The test assembly SHALL provide laminar flow upstream of the UUT

Subsystem #3: Heating

Comprised of:

- Heat block (3.1); a 3"x3"x12" aluminum block with holes on the top face for mounting heat sink, holes in the side faces for sensors.
- 10 Cartridge heaters; providing up to 45W each, variable through PWM.
- Aerogel insulation; to reduce the amount of heat lost to the system.

Cartridge heaters and insulation are not visible in photo but are under the foam insulation.

Description	Requirement
Provide variable power to heating block.	50-400 Watts
Aluminum block is rated to handle the objective temperature range of the system.	0°C to +55°C (T) -40°C to +71°C (O)
Temperature Sensors are not rated for the objective temperature range but does satisfy the threshold.	0°C to +55°C (T) -40°C to +71°C (O)

Subsystem #4: Sensors

Comprised of:

- Thermocouples; to measure temperature in different locations. Ten are embedded in the heat block (not visible) to calculate heat flux and base temperature, and two are suspended in flow to get ambient air temperature (4.1).
- Hot wire anemometer (4.2); to measure flow and ensure that desired CFM is achieved.
- Pitot tubes (4.3); to measure pressure drop across system.

Requirement	Description
Thermal Sensing	The test assembly SHALL allow for the use of multiple thermal sensors
Flow Rate	The test assembly SHALL measure flow rate
Pressure Drop	The test assembly SHALL measure pressure upstream and downstream of UUT
Power	All test equipment SHALL operate on 110VAC Power