Heat Exchanger Testing Apparatus (HETA)

Department of MECHANICAL ENGINEERING
THE UNIVERSITY OF UTAH

BEN ESTILL, SHAINA FLOYD, CHAD PHILLIPS, KISHAN VISWANATHAN
FACULTY ADVISOR: RANDALL MORRILL

L3HARRIS™
FAST. FORWARD.

What is a Heat Exchanger?

A heat exchanger (a.k.a. heat sink) is a device used to transfer thermal energy (heat) between two separate mediums having different temperatures. They are used in numerous engineering applications from microchips to nuclear power plants. By maximizing the surface area of contact between the two mediums it allows the heat to be more efficiently exchanged between the two. This keeps expensive electronic systems cool for maximum efficiency and lifespan.

What is the Problem?

With ever increasing technologies and the ability to manufacture complex shapes and designs of different heat exchangers using 3D-printing, companies like L3Harris can now manufacture heat exchangers faster than they can run computer analysis on them.
Even further, L3Harris builds electronic devices for applications, from sea to space, requiring testing of heat exchangers in heat and altitude chambers.

The Solution

A Heat Exchanger Testing Apparatus (HETA). This project requires the design, manufacture, and construction of a laminar-flow wind tunnel. Using temperature (RTD) and pressure (pitot) sensors along with a fan with variable flow rate enclosed in a chamber. In doing so it will then be possible to calculate the convective heat transfer coefficient, *h* of complex heat exchanger deigns, by using the data output of the HETA.

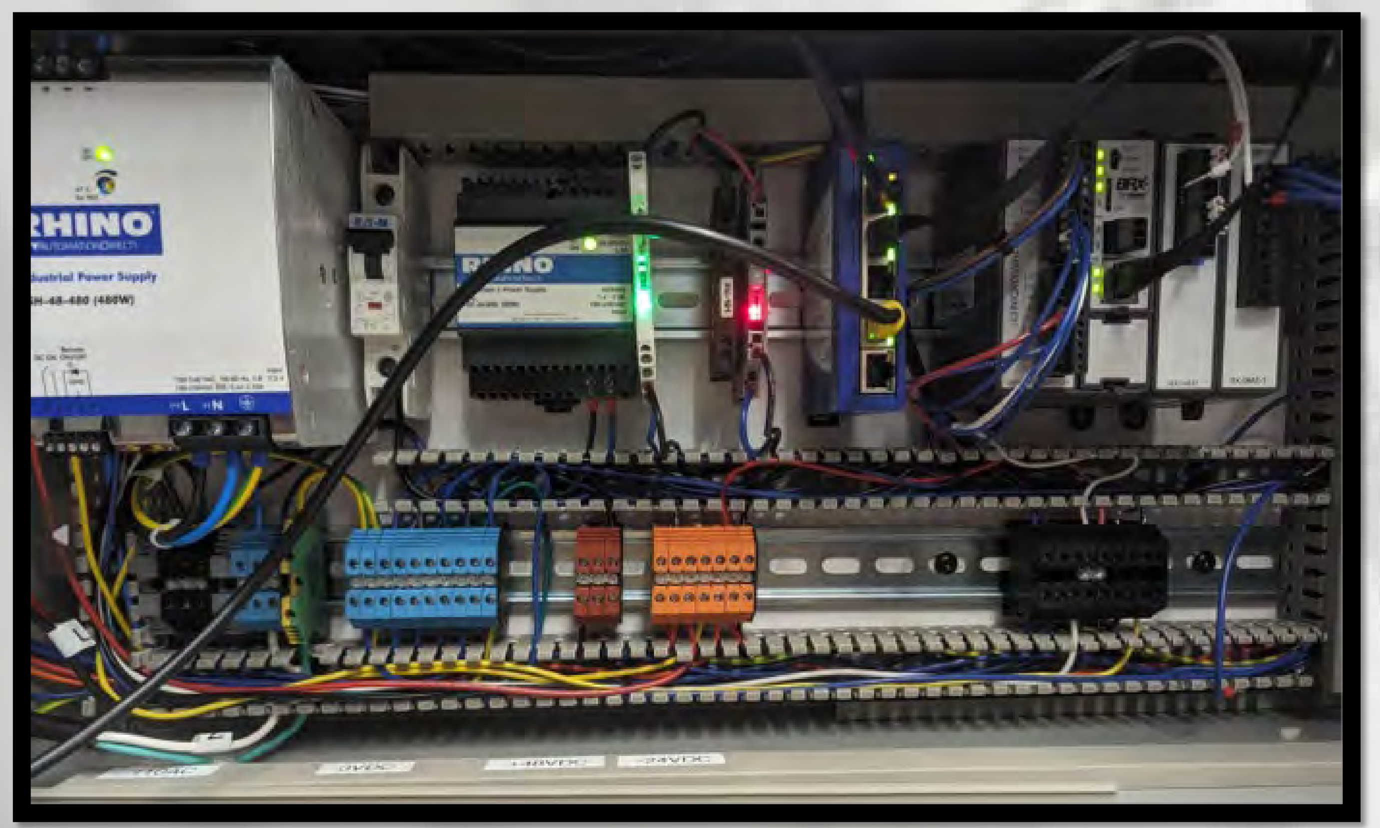

Figure 3: An inside look of the removable electrical cabinet with power supplies and instrumentation.

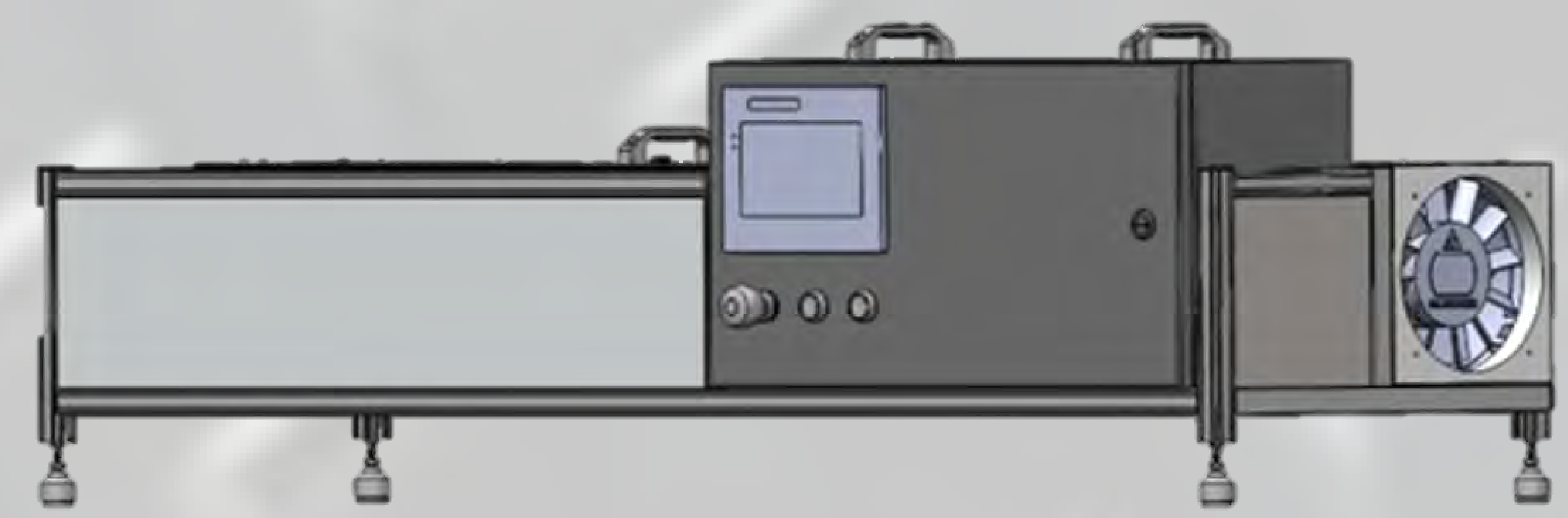

Figure 1: Final CAD design showing removable electrical cabinet with touch screen controls on back side of the HETA.

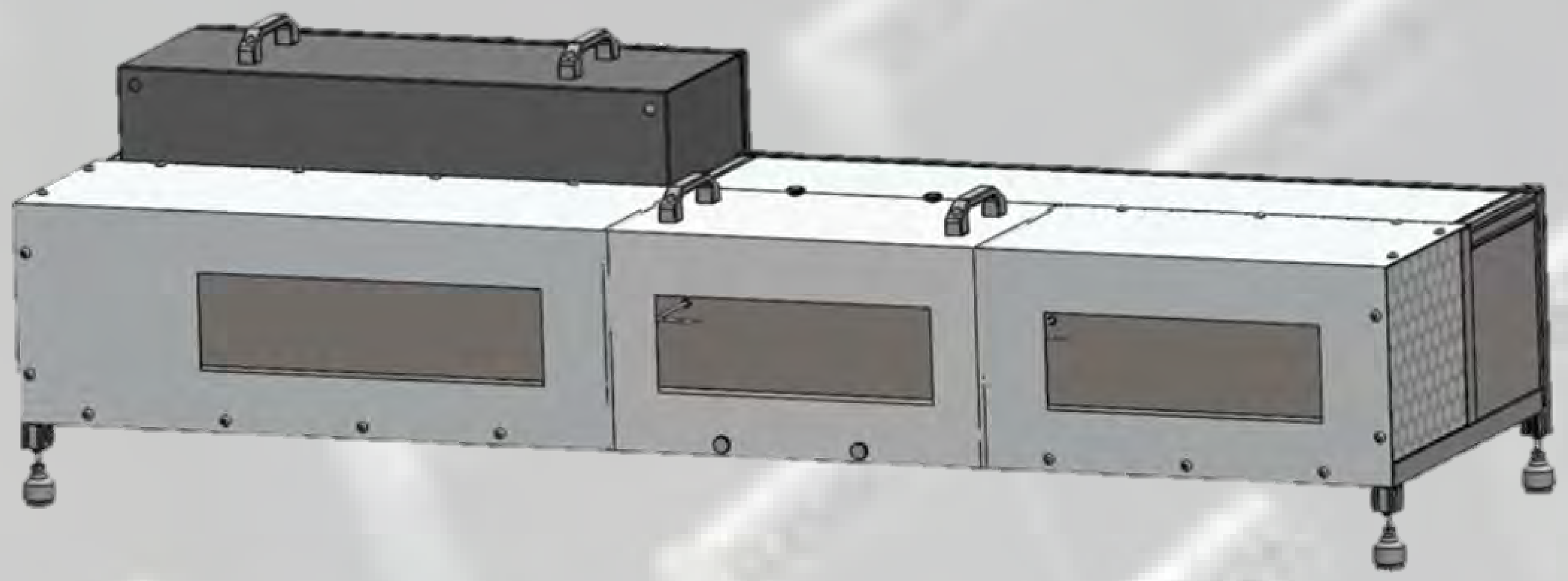

Figure 2: Front view of the final CAD design showing the clear acrylic windows and removable UUT panel.

Testing and Analysis Methods

- Used fog machine and HD slow-motion camera to visually check laminar flow
- $\boldsymbol{h_{conv}} = \frac{q_{conv}}{T_s - T_\infty} \left[\frac{W}{m^2}\right]$, Heat Transfer Coeff.
- Decibel meter to analyze noise level
- Learn and analyze fan curve graphs
- Made detailed CAD models for weight verification
- $\boldsymbol{Re} = \frac{\rho u L}{\mu}$, Reynolds Number (laminar flow Eq.)

Critical Design Metrics

Metric Description	Units	Marginal Range	Ideal
Fan (CFM 25-125) operation @ pressure	In.H_2O	2	3
Laminar flow upstream of test area	Re	<4000	<2300
System pressure drop	in.H_2O	0.5	0.25
Fan noise level	dBA	73	65
Assembly weight	lbs.	102	50
Dimensioning (Total)	in.	18 W•18 H•60 L	< MR

Table 1: List of engineering design metrics requested by our sponsor L3Harris.

Design Challenges

- Must be easily moved by two persons (light weight)
- Sensor data must be recorded and exportable to external source (data used for calculating the heat transfer coefficient)
- Must be able to withstand high temps and varying altitudes (operation in heat and altitude chambers)

Summary and Future Work

- To reduce costs on materials and ease of manufacture a square design was chosen.
- The original design required the use of steel to build the tunnel walls in order to keep the structure strong and reduce vibration. However, a quick modal analysis revealed slightly thicker aluminum should not cause any problems. Therefore, the final design was made of aluminum which weighed much less and gave a fresh new look to the tunnel.
- Analysis performed showed a tunnel length greater than our design metrics allow. As a solution, we tested and implemented multiple flow straighteners of varying cell geometries to achieve laminar flow.
- Multiple tests and calibration on the accuracy of the instrumentation and the GUI programing will be run directly at the L3Harris facility.
- We will also customize the HMI to L3Harris preferences of design and functionality during our final sit down.

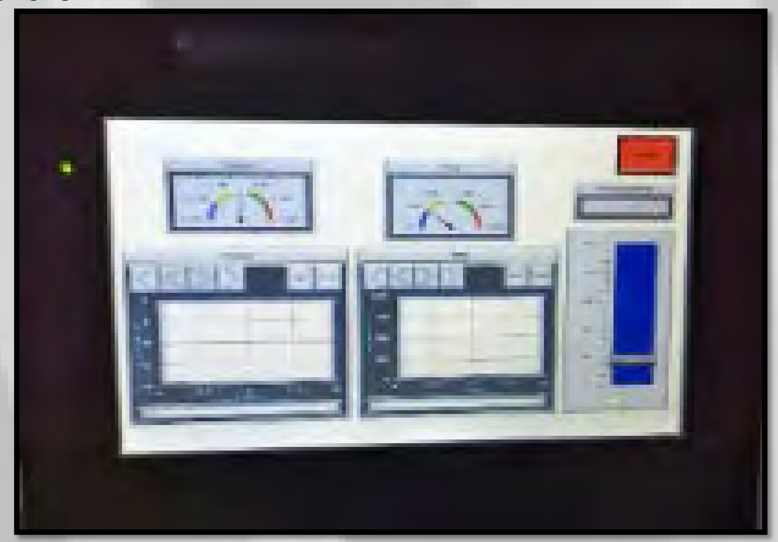

Figure 4: Human-machine interface (HMI) with controls for the fan flow. Also, meters for pressure and temperature in two locations.

Special thanks to Western Sheet Metal for the aluminum work and bending.