Koops Thermal Manufacturing Process Cycle Time Improvement

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KOOPS AUTOMATION SYSTEMS

Pre-design

Koops' current conduction-based thermal manufacturing process has a high part to part cycle time of 75 to 90 seconds, with 20-30 seconds of heating and 20-30 seconds of cooling time per part typically. The aim of this project is to utilize IR and active cooling to reduce the part-to-part cycle time by 30%. To be considered a definite improvement, due to changes in geometry for the test station compared to the true machine, heating and cooling times of less than 8 seconds, or a combined total of less than 16 seconds were required. For a likely improvement, combined times of 22 seconds or less were required.

The Team at the 50 nights Banquet from left: Nik Short, Camryn Lozon, Brian Koelzer, Matt Pavlock, Emily Battey, and Prof. Philip Hittepole.

The Team at work, building the machine

Project Goal:

- Design and build IR test station to help Koops achieve a decreased cycle time
- Perform experiments using test station to analyze cycle time feasibility for both conduction and infrared heating

Functional Requirements:

- Design and build functional IR test station to provide data on heating and cooling times for several different materials
- Perform heat transfer analyses and experiments on feasibility of IR and conduction heating methods

Two heating methods were compared for this project. The previous method used by Koops, conduction heating, was tested utilizing a test station (right) that Koops already possessed. An IR test station had to be designed for comparison to conduction cycle times. For IR, bulb distance, bulb power, and heating and cooling times all play a role in the effectiveness of the finished product. Unlike IR, for conduction the main factors which affect performance are limited to heat and cool times.

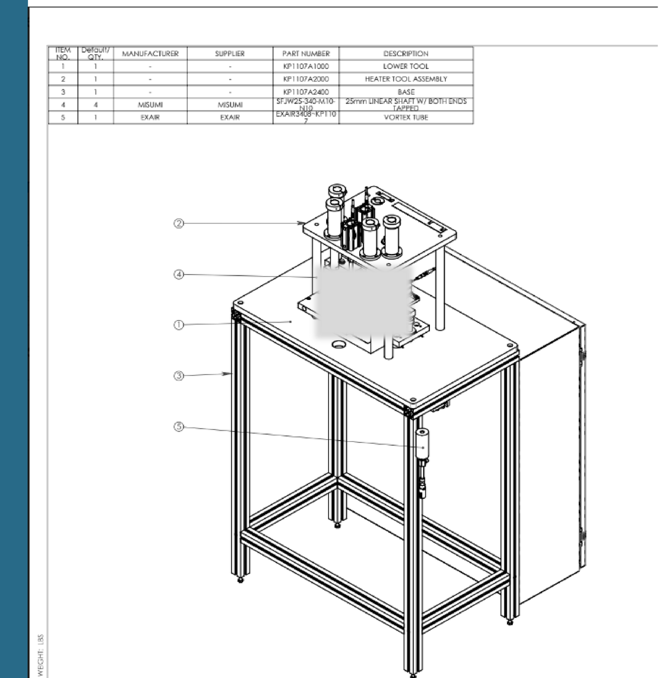
Old Conduction Test Station

Key Specifications

- Maximum budget: $12,000
- Test station temperature range: 370 °F - 700°F
- Maximum test station size: 5' x 5' x 5'
- Minimum sample size: 6" x 6"
- Must provide IR and conduction heating calculations and heating data
- Test station must allow for testing to help reduce thermal manufacturing process cycle time

Thermal Imaging Photos

Mechanical Design of IR Test Station



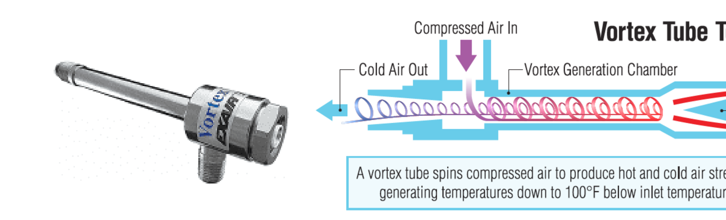
Assembly Drawing of Test Station

The IR test station was designed to be as similar as possible to the previous conduction station. The tooling itself is confidential, but the overall design includes table space for sample storage and a mounting table for ease of use.

The HMI and Estop were mounted to the electrical cabinet.

Final Build Photos of Test Station

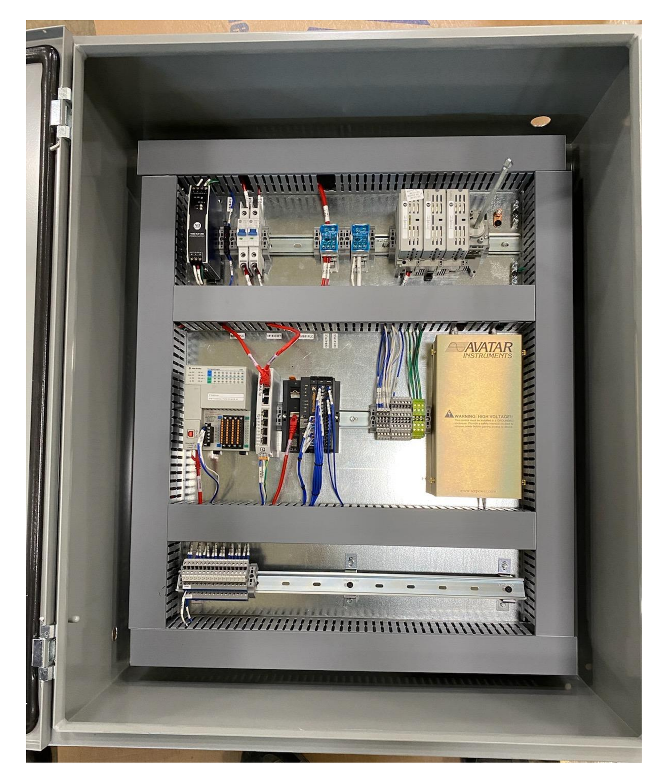
- Build was completed under-budget
- Test station size was within limits
- Test station accommodates samples larger than 6" x 6"



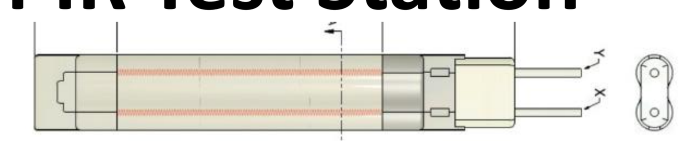
Vortex tube utilized for cooling

Vortex tube compressed air cooling was tested to try to reduce cooling times.

Controls Design of IR Test Station



Electrical Panel Build

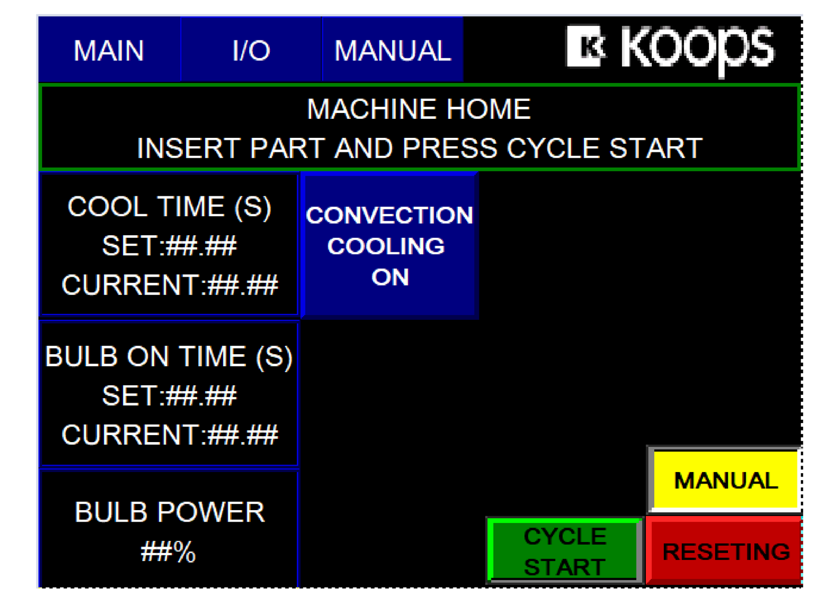


IR bulb Schematic

The bulb was selected to achieve part temperatures of 700 °F or 370 °C

Bulb Power is controlled by a variable voltage heater controller, through analog outputs on the PLC.

The PLC selected was an 1769 L18ER-BB1B (right), which Koops had in stock.



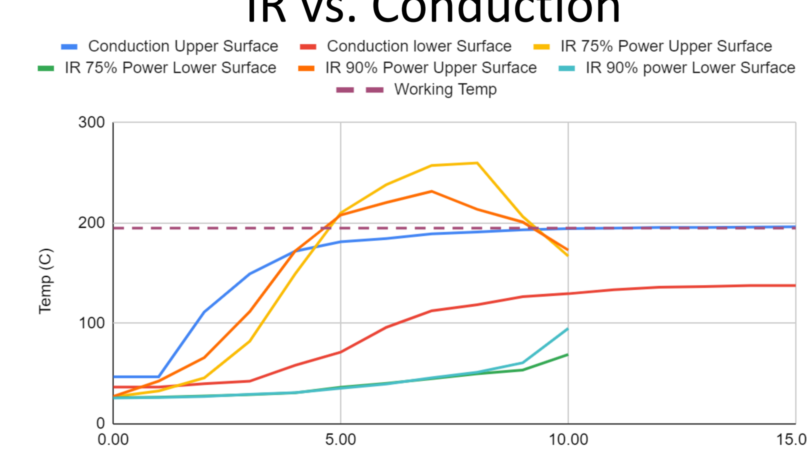
HMI design for Main Page

PLC, HMI, and remote I/O selected for this application

The HMI was designed to allow easy change of parameters, including cooling time, heating time, and bulb power. The program sequence was made as similar as possible to the conduction station, for consistency.

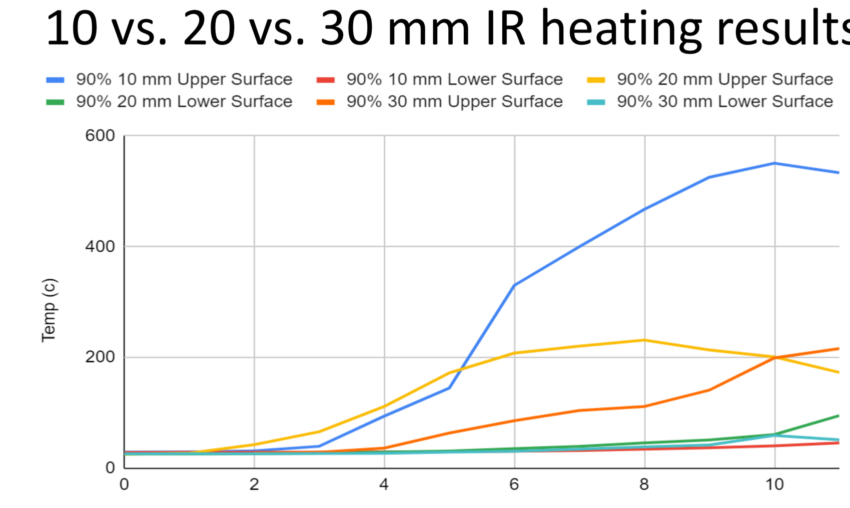
Results and Analysis

IR vs. Conduction



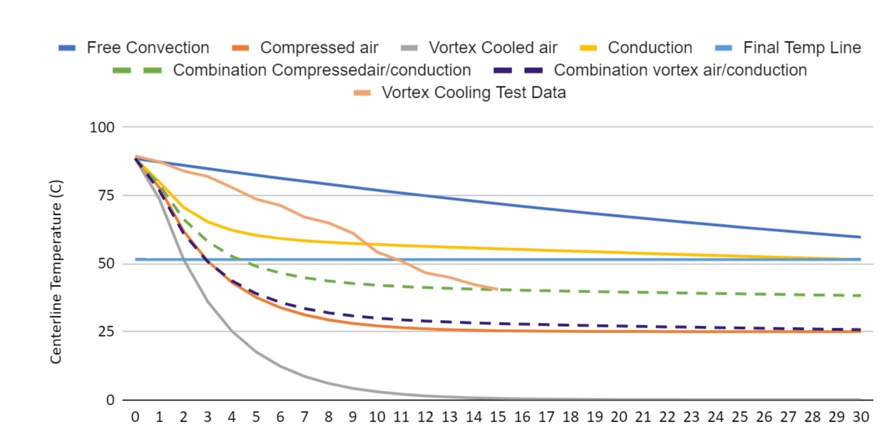
IR was able to reach desired temperatures in the 4 to 7 second range, while Conduction took closer to 10 to 15 seconds. As expected, 90% IR power heated faster than 75%, with up to a 200 °C difference in some tests.

10 vs. 20 vs. 30 mm IR heating results



When the bulb was placed closer to the part, average recorded temperature increased significantly for the upper surface. Parts heated at 10 mm often exhibited charring, but parts at 20 and 30 mm proved promising for cycle time reductions.

Theoretical vs. Measured Cooling



Vortex cooling results were less effective than anticipated for decreasing temperature but were an improvement over conduction results. Vortex cooling created a more effective final product with lower effective cooling times.

	Material 1	Material 2	Material 3
Heat time (s)	6	8	15
Cool Time (s)	5	10	5

After final testing, materials 1, 2, and 3 achieved combined cycle times of 11, 18, and 20 seconds, respectively. This indicates that IR would most likely be successful in reducing cycle time on a full machine.