National Aeronautics and Space Administration

Additively Manufactured Rover Chassis with Integrated Thermal Control for Extreme Cold Environments

Principal Investigator: Benjamin Furst (353); Co-Investigators: Takuro Daimaru (353), Eric Sunada (353), Scott Roberts (357), Ryan Watkins (357), Alicia Kim (University of California, San Diego), Massoud Kaviany (University of Michigan)

Program: FY22 R&TD Strategic Initiative
Strategic Focus Area: Moon and Mars Extreme Cold, Steep Terrain Rover - Strategic Initiative Leader: John D Baker

Objectives:

The goal of this three-year strategic RTD task is to develop a topologically optimized additively manufactured (AM) rover chassis that incorporates heat switch and thermal insulation elements to enable new mission concepts to the Moon and Mars. The resulting rover chassis will be a mutlifunctional thermal-structural system that incorporates high performance thermal control systems. This year was the first year of the task and the high-level goals were to mature the basic thermal technology elements (AM heat switch and AM thermal insulation), as well as develop a notional rover chassis design. The final goal will be to qualify at TRL 5 an AM rover chassis that has been thermally/structurally optimized and incorporates a heat switch and insulating elements.

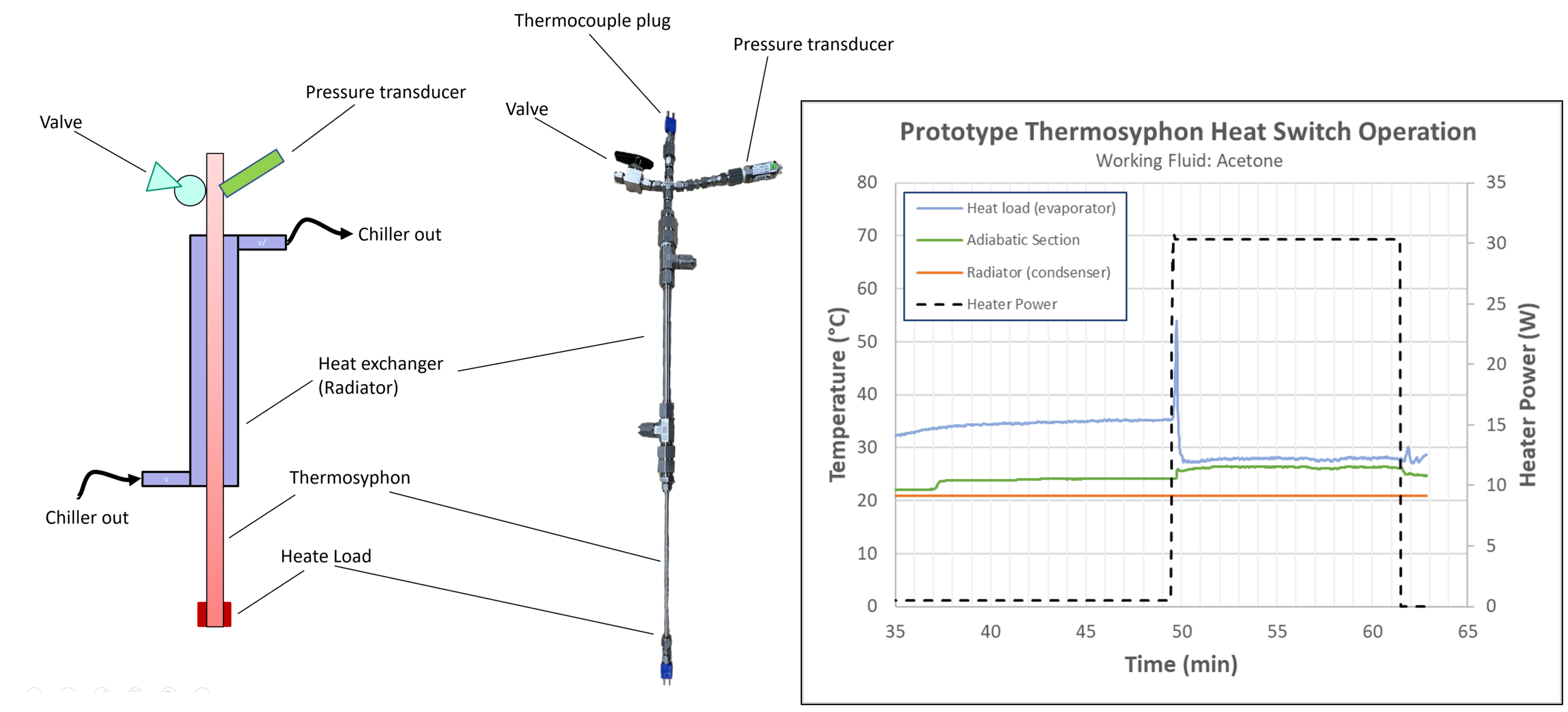
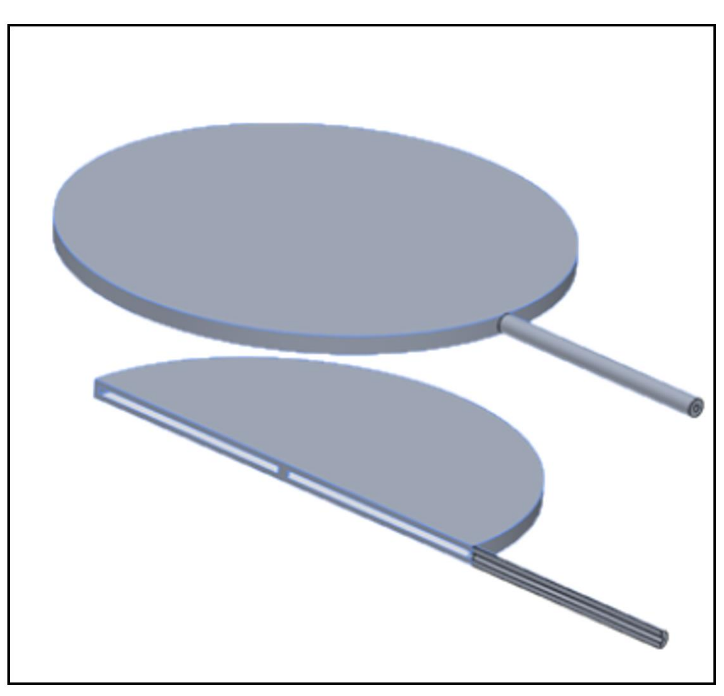
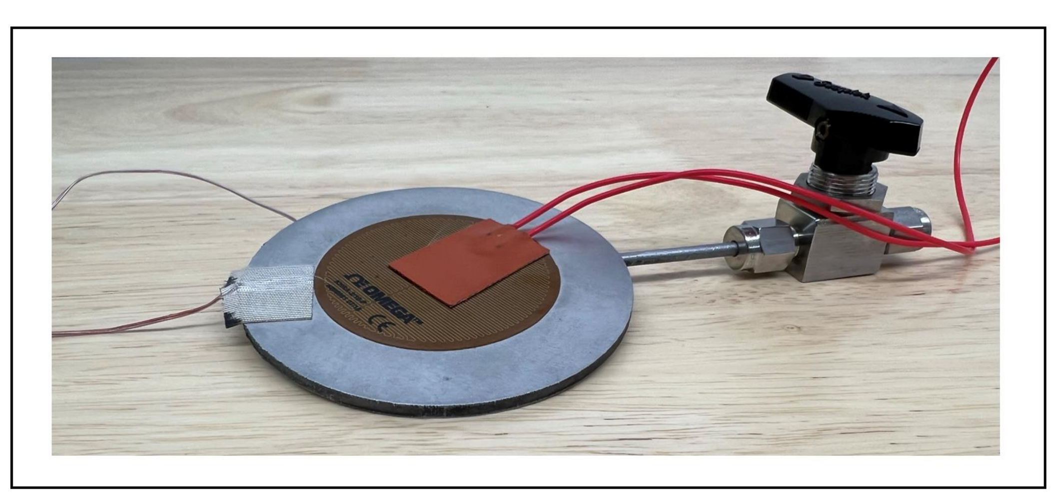


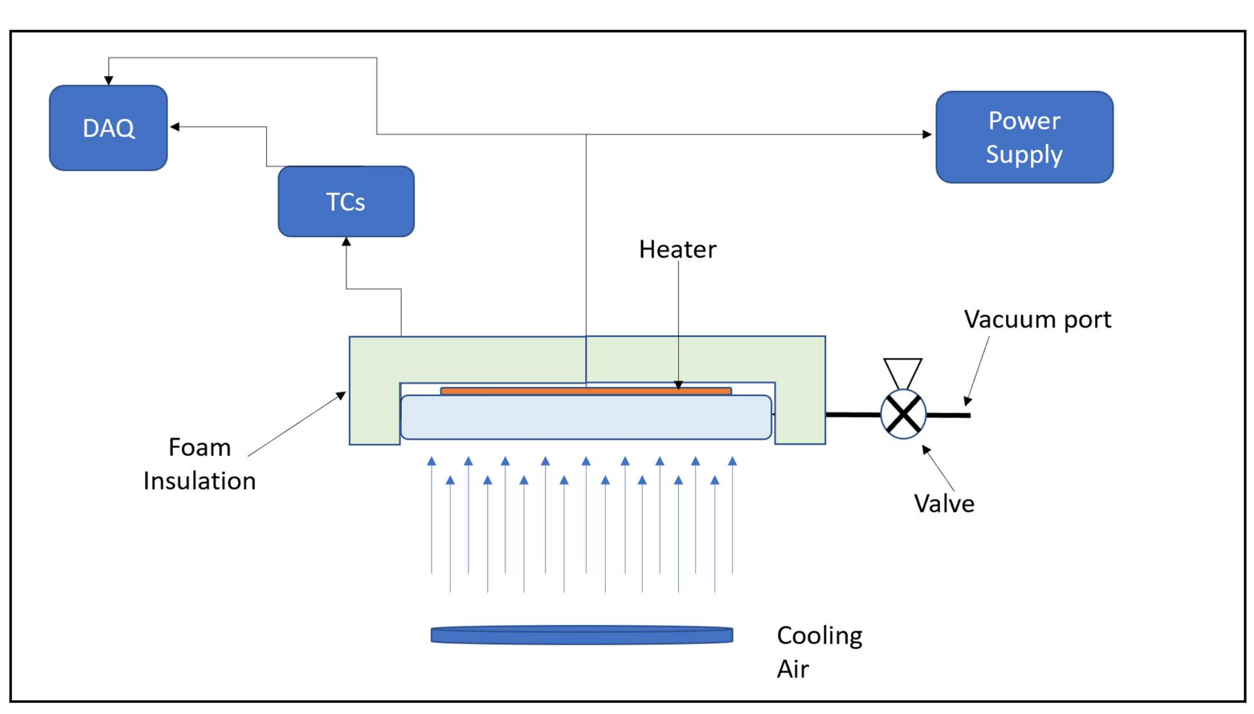
Figure 1: The thermosyphon heat switch test article schematic and hardware are shown on the left. Test data showing the thermosyphon behavior is shown on the right. For low heat loads (0.5 W between 35 min and 49 min) the thermal conductance is low at 0.03 W/K (the switch is off), for high heat loads (30 W between 49 min and 61 min) the thermal conductance is high at 4.1 W/K (the switch is on). The heat switching is passively activated by the interaction of the heat load and the working fluid and the non-condensable gas within the thermosyphon. Here a turn-down ratio of 124:1 is shown.



CAD for SVI v1 coupon



SVI v1 coupon printed out of Al 6061 RAM 2 with a heater and valve



SVI coupon test setup schematic

Figure 2: The additively manufactured structural-vacuum insulation is shown above along with the test setup used to evaluate its efficacy (right). The principle is to integrate a hermetically sealed cavity around the region that needs to be insulated, and to evacuate the cavity. This capability provides high-performance conformal vacuum-flask style insulation. Testing and analysis showed that integrating an evacuated region can reduce the effective thermal conductivity of the parent material by more than 100x.

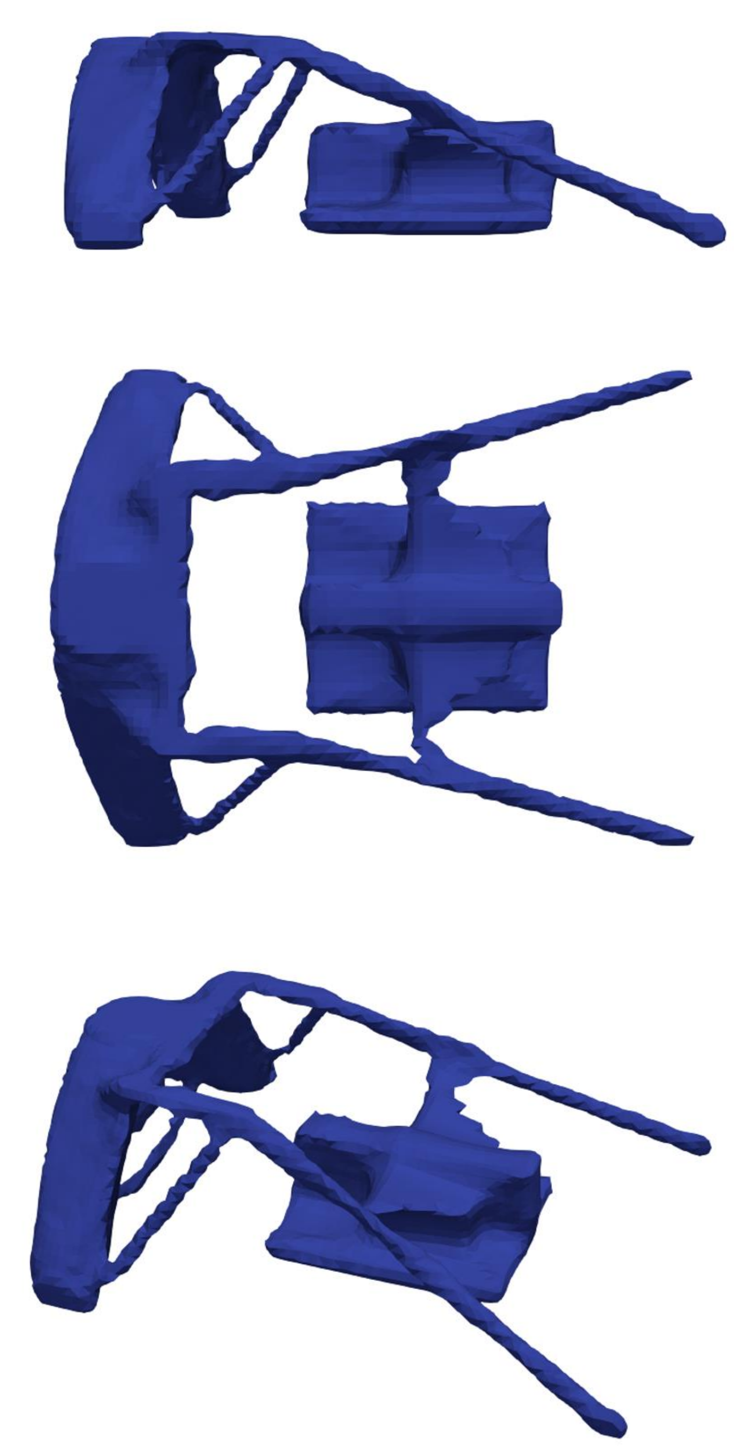


Figure 3: Preliminary test results of the topology optimization algorithm being developed to optimize the thermal-structural performance of a AM rover chassis. This early result shows the structural optimization of a rover chassis with structural boundary conditions to simulate a mobility system, camera mast and warm electronics box. Future versions of the algorithm will increase the node number (fidelity), and incorporate a thermal optimizer that is coupled with the structural optimizer.

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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

www.nasa.gov

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PI/Task Mgr. Contact Information:
Email: Ben.I.Furst@jpl.nasa.gov