National Aeronautics and Space Administration

FY24 R&TD Innovative Spontaneous Concepts (ISC)

Low-Vibration Compressor for 20 Kelvin Cryocooler

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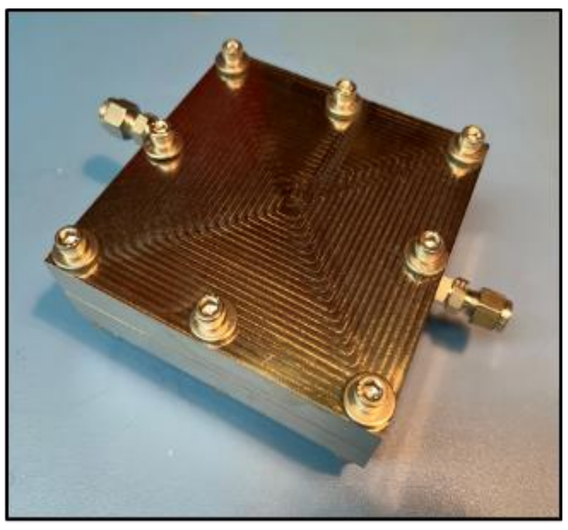
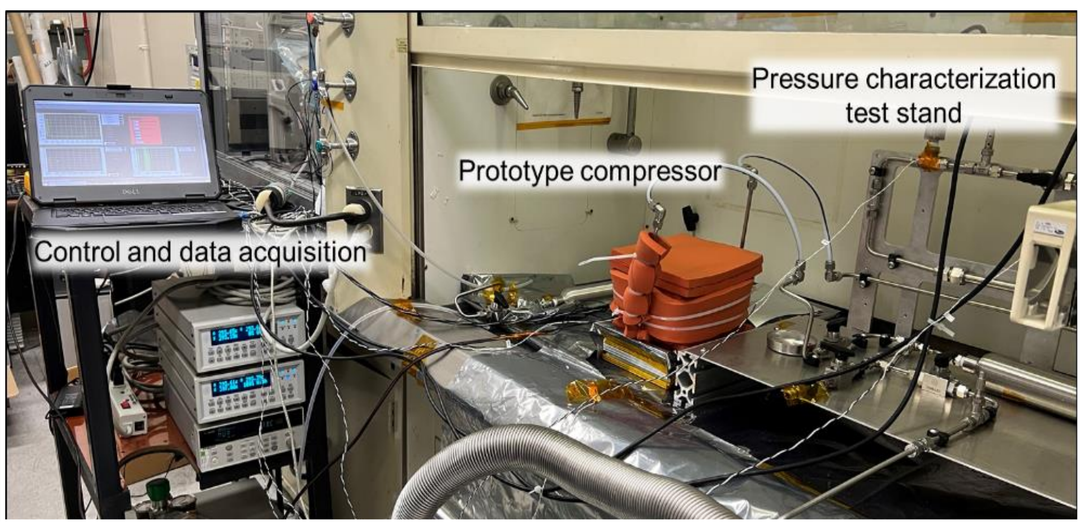
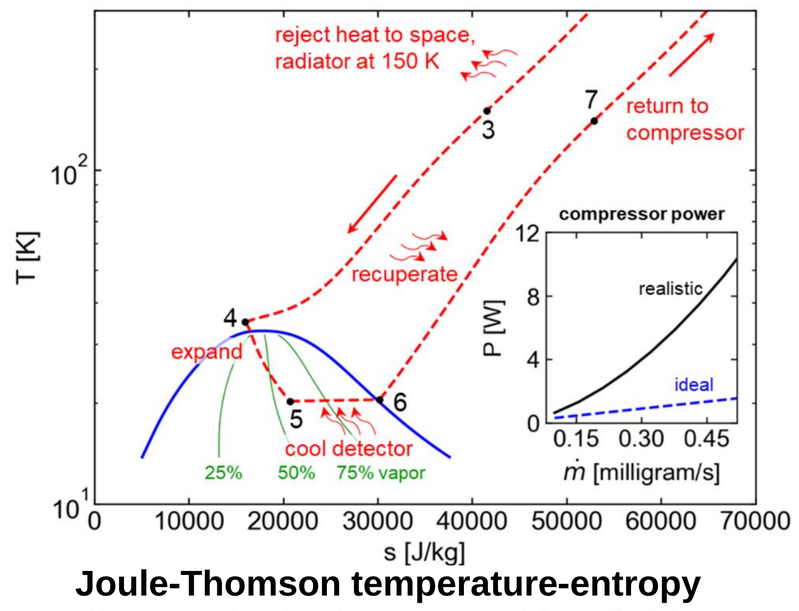
Strategic Focus Area: Innovative Spontaneous Concepts





Prototype compressor without foam insulation (left). Compressor test stand showing insulated prototype compressor, control and data acquisition system (right).

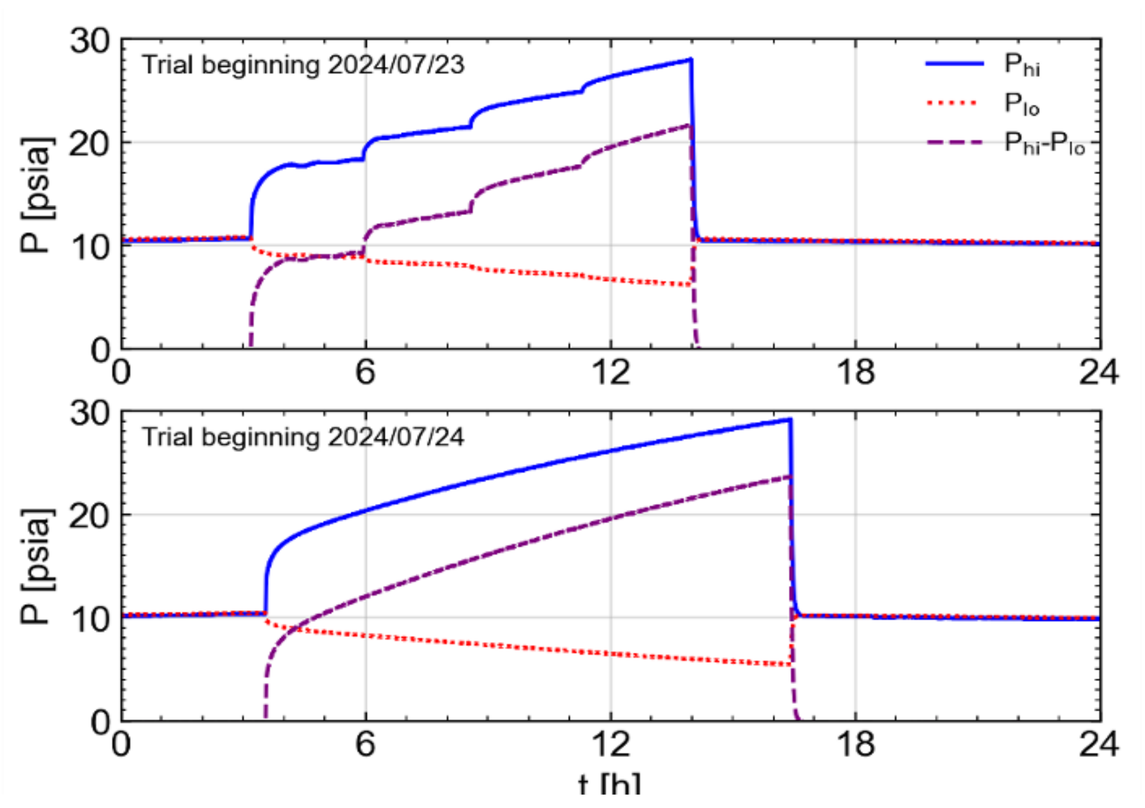


Joule-Thomson temperature-entropy diagram for hydrogen working fluid.

Objectives: To demonstrate that an electrochemical cell-based hydrogen compressor is capable of circulating and pressurizing working fluid at levels sufficient to drive a low vibration cryocooler.

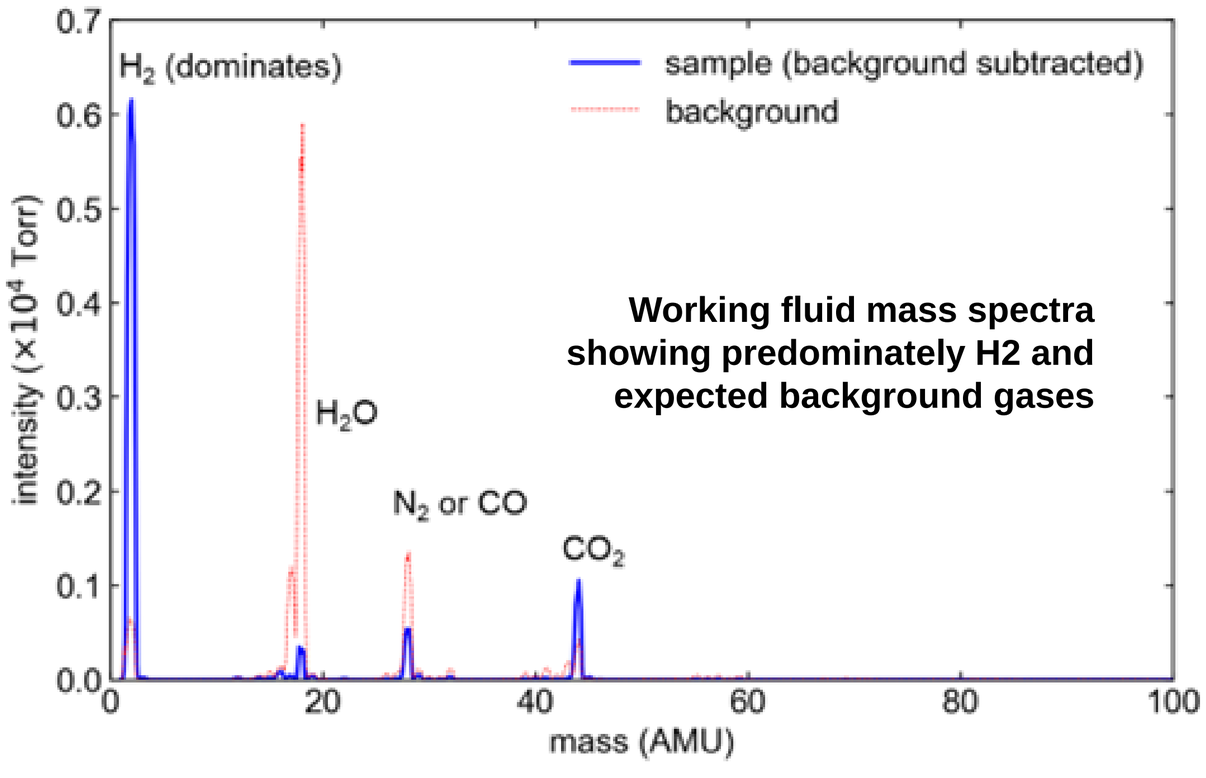
Background: Conventional cryocoolers typically use mechanical compressors to pressurize working fluid and induce cooling. Mechanical compressors generate vibrations, which can be transmitted to a jitter-sensitive imaging system. An electrochemical cell-based compressor has no moving parts and is basically vibration-free.

Approach and Results: A small commercially-available anhydrous electrochemical fuel cell membrane was re-purposed and incorporated into a compressor, which compressed hydrogen to approximately 23 psi (delta-P) with a mass flow rate of 0.04 mg/s. Based on the initial test results, it appears that pressures and flow rates sufficient to drive an 80mW cryocooler can be achieved by simply scaling up the compressor size and using thicker membrane materials. No major contaminants were observed in the working fluid.



Pressure histories for two trials showing up to 23 psi pressure differential

Significance/Benefits to JPL and NASA: A low-vibration compressor has been developed, which is capable of pressurizing and circulating hydrogen working fluid without moving mechanical parts. Future development is expected to yield a cryocooler capable of 80mW heat lift at 20 K with no vibration.



Working fluid mass spectra showing predominately H2 and expected background gases

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