Progress Towards a High-Capacity 80K/20K Turbo-Brayton Cryocooler

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Concepts NREC is currently developing for NASA, in support of its Artemis program, a turbo-Brayton cryocooler for in-situ resource utilization on the lunar surface. To achieve this goal, an integrated two-stage turbo-Brayton cryocooler was developed to provide the necessary heat lift for hydrogen and oxygen liquefaction in a single integrated system that will be located on the lunar surface. Based on initial estimates to support the desired liquefaction rates of at least 11.7 metric tons per year (3.3 kg/hr of oxygen and 0.4 kg/hr of hydrogen), a net heat lift of 330 W is needed at 80 K and simultaneously a 130 W of heat lift is required at 20 K.

The cryocooler utilizes three compressors with intercooling to compress and circulate the helium cycle gas. The compressors operate on self-acting gas bearings, are driven by brushless permanent magnet motors at 4,000 rev/s, have a nominal input power capacity of 2 kW, and operate at a 185 K nominal temperature. As a result of the high speed and flow rates, the predicted aerodynamic efficiency is extremely high for all stages, resulting in net efficiencies of greater than 60% for the three compressor stages. The high compressor efficiency results in a cryocooler predicted input power of 6.5 kW, corresponding to specific powers of 7 W/W and 31 W/W for upper and lower stages respectively. In preparation for cryocooler integration, the compressors are tested at 185 K using helium at design flow rates. This paper describes the design, fabrication, and initial test results for these high-capacity compressors.