Paper ID: 63484
oral
student

24th IAA SYMPOSIUM ON HUMAN EXPLORATION OF THE SOLAR SYSTEM (A5)
Human Exploration of Mars (2)

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OPTIMIZATION OF A MARS ISRU SYSTEM USING DATA FROM THE MOXIE EXPERIMENT

Abstract

The Mars Oxygen In-Situ Resource Utilization Experiment (MOXIE) is a payload that recently landed on Mars onboard NASA's Perseverance rover. It is the first off-world demonstration of In-Situ Resource Utilization (ISRU), producing oxygen by reducing the carbon dioxide in the Martian atmosphere. MOXIE uses solid oxide electrolysis (SOE) to generate up to 8 g/hr of high purity oxygen. It is a demonstration unit with the purpose of informing the design of a full-scale system to support human exploration that would produce all of the oxidizer needed for a Mars Ascent Vehicle (MAV) capable of lifting 4-6 astronauts off the surface of Mars, which would require an oxygen production rate of approximately 3 kg/hr. This oxygen would also be used for breathing and habitation pressure during the crew's mission. By producing oxygen on Mars using ISRU rather than bringing it from Earth, mission cost and risk for a crewed mission to Mars will be substantially reduced.

This paper describes a model that has been developed to optimize the design of a full-scale ISRU system. The model includes detailed calculations of several key subsystems of the ISRU plant, including the carbon dioxide acquisition and compression (CAC) system, the SOE system, the oxygen liquefaction system, and a heat exchanger to increase power efficiency. Several architectures for each subsystem are modeled, and a simulated annealing optimization algorithm is used to determine the optimal combination of subsystems. Power, Mass, and Risk are the three competing objectives that the algorithm attempts to minimize in its construction of the optimal ISRU design. This paper emphasizes the use of MOXIE data to validate the model, including data taken from the Engineering Model (EM) on Earth and the first data from the Flight Model (FM) on Mars. Results from the simulation show that a mechanical compressor, highly modularized SOE system, and tube-on-tank liquefaction architecture may yield the optimal design. Current estimates from the model for power and mass of the full-scale system are 17,000 W and 6,500 kg, respectively.