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Satellite Water Propulsion: Electrolyzer Development & FMEA

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Abstract
The Institute of Space Systems (IRS) at the University of Stuttgart is developing a green electrolysis-based water propulsion system for satellites. One primary goal is to replace the commonly used but highly toxic hydrazine. The use of water instead, which gets split through electrolysis in orbit, allows a higher fuel efficiency and dramatically decreases the handling complexity and costs, making it attractive to smaller institutions. The water propulsion system in development is one of the technology demonstrations on the institute's ROMEO mission, a small satellite with a planned launch date in 2025 [1]. A prototype of this propulsion system has previously been successfully built and tested at IRS [2, 3]. This work's scope lies in the new design of the 30 W, 50 bar electrolyzer operating through the static-water-fed principle. Additionally, an FMEA for the flight-capable system is conducted, and an adequate redundancy and valve concept are elaborated and integrated into the system design.

One major flaw of the previous design lay in severe current density drops at pressures above 15 bar, reducing its efficiency and gas production rates. For the new generation, the bipolar plates are redesigned, using porous titanium and adding the ability of variable cell compression. Additionally, a third fully redundant cell was added to the design, enabling the possibility of increasing the cell area in case of persisting current density drops. In the course of this paper, the new electrolyzer cells are characterized through their characteristics, gas quality, and impedance spectra.

Membrane ruptures in electrolyzers can lead to catastrophic failures, especially in the static water feed system, with cells directly connected to the gas tanks. The same occurs through hydrogen diffusion through the membrane. This paper will also discuss the designed valve plan to mitigate the existing risks and avoid a loss of mission.

References
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