# Improved Regenerative Fuel Cell Stack Design For Lunar Energy Storage

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**Project Objective:**

Capitalize on JPL's additive manufacturing capabilities to generate a stack design relevant to regenerative fuel cell systems with improved mass, volume, and/or thermal characteristics relative to state-of-the-art.

**Benefits to NASA and JPL**

Regenerative fuel cell (RFC) systems for energy storage scale more favorably than state-of-the-art battery systems when large amounts of stored energy and/or high discharge power are required for mission success (>250 Wh/kg at the RFC level vs. ~120 Wh/kg at the battery level, or 2X improvement). As such, RFC systems are currently targeted for lunar applications, where survival through the long lunar night (14 days long) is required. RFCs are also of particular interest for crewed missions, as they can be integrated with life support systems, providing heat and emergency oxygen for crew.

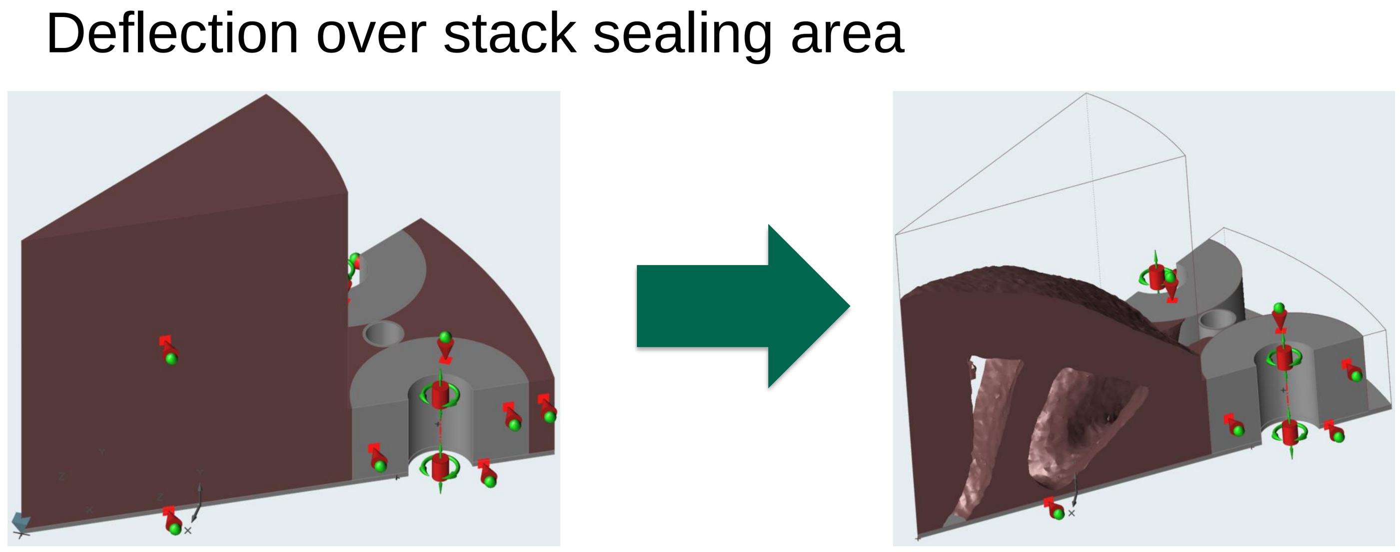
**Significant reductions in the mass and volume of RFC systems can be enabling factors for prospective lunar rovers and habitats**, improving science return and crew capabilities. The lessons learned from this task may also be applicable to many high pressure electrolysis applications, including life support and ISRU. **This task is only a small first step into the possible improvements to RFC systems enabled by the application of novel modeling and fabrication capabilities.**

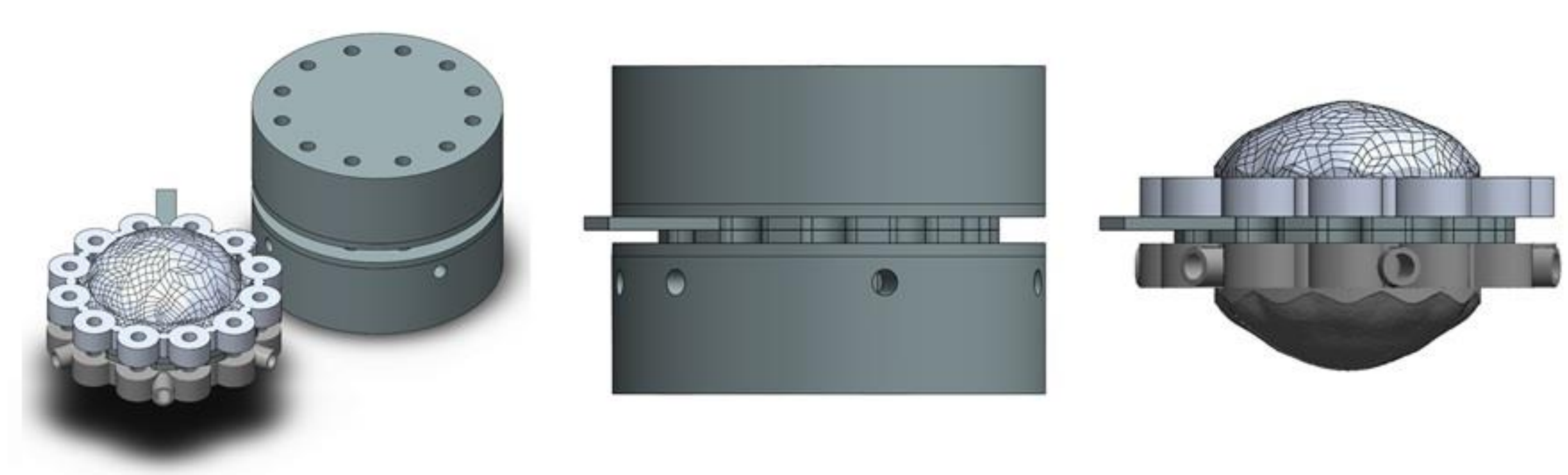
**Topology Optimization**

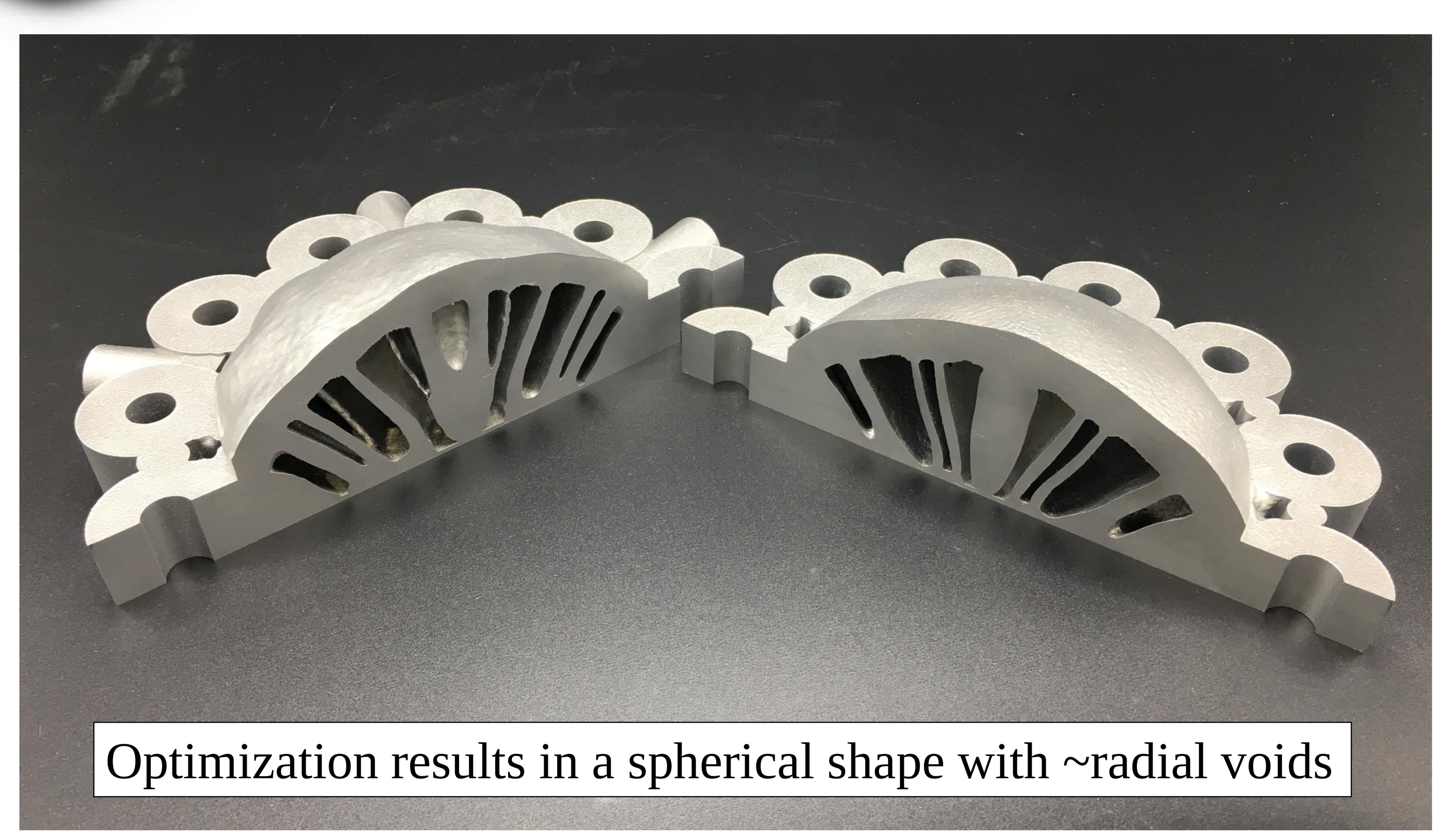
Computationally optimize the material layout in a given volume. Confirm results are acceptable using mechanical analysis.

Boundary conditions:

- Mechanical contact areas
- Deflection over stack sealing area







Optimization results in a spherical shape with ~radial voids

Baseline SS304 end plate vs optimized Ti-6Al-4V plate

**FY19 Results:**

A commercial high pressure electrolysis stack on hand at JPL was modeled for optimization. The endplates were primarily targeted, as they contribute the most mass and volume to the stack. Utilizing CAD, FEA, topology optimization, and materials selection; a novel, optimized structure was produced with an **86% reduction in mass and a 66% reduction in volume** while meeting structural factor of safety. Sample pieces were 3-D printed.

**Next Steps:**

- Smooth surfaces and remove a few artifacts from the topology optimization process
- Integrate heat pipes into structure for improved thermal characteristics
- Finalize a full stack design with integrated parts, lower contact resistances
- Address increased deflection toward the center of the stack

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