Pressure Vessel Design Concepts for Planetary Probe Missions

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Materials and systems for extreme environments have been identified by the Outer Planets Assessment Group (OPAG) as technology needs for future planetary probe missions [1-2]. One critical element of this system is the lightweight pressure vessel component suitable for missions in extreme environments, and this element is considered the highest priority for *in situ* exploration [2].

Mass of traditional pressure vessels is directly proportional to the vessel volume, differential pressure, and material density and is inversely proportional to material strength. There are two potential mass saving opportunities for pressure vessels: material selection and structural layout. Pauken et al. [3] provide an excellent overview of metallic and advanced composite material selections. They conclude that there is a potential for reducing the mass of a titanium baseline pressure vessel for a mission to a high pressure/temperature environment by 30-50%. Stackpoole and et al. [4] propose a nano-reinforced titanium concept as candidate material for pressure vessels. Samples processed by Stackpoole indicate that there is a potential for a lower mass alternative for pressure vessel materials with 10% mass reduction and more than 200% increase in higher specific modulus.

This report explores lightweight layout design concepts for pressure vessels that use externally stiffened elements. Most stiffened layouts are based on stiffened-ring concepts that are effective in reducing the overall structural mass [5]. An alternative to stiffened-ring concept is a spherical polyhedron layout that uses a tiling approach for spheres. There are many possible polyhedron layouts. This study will explore several promising concepts such as truncated icosahedron (soccer ball), hosohedron (beach ball), and a Icosahedron (20 curved triangular faces). This report will present an overview of pressure vessel design for planetary probe missions, various structural layout concepts, and simplified parametric mass sizing models that are suitable for a system analysis application.

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