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MAGNETIC BUOYANCY-BASED WATER ELECTROLYSIS IN ZERO-GRAVITY

Abstract

Water electrolysis has been regarded as a safe and convenient technology for oxygen and hydrogen production in space since the early 1960s. It is a key process in modern environmental control and life support systems, such as the Oxygen Generation Assembly or the Sabatier reactor at the International Space Station. Oxygen and hydrogen are also employed in a wide range of propulsion technologies and for high-density energy storage. In addition, liquid water is also a potential In-Situ-Resource-Utilization propellant for future interplanetary missions.

Major technical challenges are associated with the operation of electrolytic cells in zero-gravity environments. A layer of gas bubbles tend to apper over the electrodes due to the weak buoyancy force, shielding the active surface area and increasing the ohmic resistance. Forced water convection is usually employed in anode and cathode feed systems to overcome this effect, but it requires complex, heavy and noisy liquid management devices to induce the movement and separate the phases. Static feed configurations remove those components but present lower efficiencies.

The natural detachment of gas bubbles in zero gravity may be induced by making use of *magnetic buoyancy*. This phenomenon follows from the application of a sufficiently strong magnetic volume force to the fluid. Since liquid water is a weak diamagnetic material, enhanced susceptibilities could be achieved by making use of colloidal suspensions of magnetic nanoparticles (ferrofluids). This would lead to fuel cells with minimum or no moving parts. The efficiency of the reaction may be also improved due to water ionization. As a counterpart, the stability of the ferrofluid solution may be compromised by high temperatures, ionization, or space radiation, among others.

This paper introduces the magnetic buoyancy-based water electrolysis concept and presents its theoretical foundations and preliminary feasibility analysis. Potential space applications are identified and major technological challenges are described.