**REGENERATIVE FUEL CELL SYSTEM AS ENERGY STORAGE SOLUTION FOR SPACE APPLICATIONS**

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**ABSTRACT**

Regenerative fuel cell systems (RFCS) are considered a promising technology for space applications requiring high power levels or for missions with long eclipse duration, hence high energy demand, due to their theoretical high energy density. For example, the European large logistic lander (EL3) mission will require a lunar night survival capability, meaning that a very large amount of electric energy is required to be stored. These specific requirements can be met with RFCS, while current batteries technologies are expected to have at least twice the mass of an RFCS with the same energy stored (depending on the system size). The RFCS concept consists of a storage system for reactants (H2, O2 and H2O), a fuel cell, and an electrolyser. During charging, the electrolyser converts water to hydrogen and oxygen by supply of solar power. During discharge the fuel cell converts hydrogen and oxygen to water and generates electrical power and heat.

A complete RFCS was designed and constructed, comprising a High Temperature PEM fuel cell stack and a High-Pressure PEM electrolyser stack. A 500W fuel cell stack was designed and manufactured incorporating a water-cooling loop designed specifically for space applications environment. The fuel cell stack operating window was between 155⁰C and 170⁰C. The electrolyser stack was designed to meet the requirements of balanced pressurized operation up to 80 bar and lightweight construction. The final electrolyser stack assembled, comprising 17 MEAs accounting for 0.7-1 kW, operates at 70⁰C.

The RFC system was tested against a three Lunar day cycles profile, and in closed-loop mode simulating selected eclipses of a GEO satellite profile. The performance metrics of the stacks are remarkable considering the test conditions and strategies applied. Both stacks performed without significant performance degradation; the fuel cell stack survived start-stop without inert gas purging, while 80 bar operation of electrolyser was achieved. The successful completion of the testing presents a major milestone for the RPEMFC technology as the results obtained are pioneering in the field in many aspects (high temperature fuel cell operation on pure oxygen, simultaneous storage of hydrogen and oxygen, closed loop operation, steep start-up/shut-downs, autothermal electrolyser operation). The developments exceed TRL 4 for the RFCS technology.

**KEYWORDS:** Regenerative Fuel Cell System - RFCS, High pressure PEM electrolyser, High temperature PEM fuel cell, Energy storage, Space power technologies

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