High pressure PEM electrolysis stack as part of a Regenerative Fuel Cell System

F. Zaravelis[1,2#], D.K. Niakolas[1*], S. Neophytides[1], F. Paloukis[1], C.G. Vayenas[2], A. Katsaounis[2], M. Schautz[3], B. Buergler[3]

[1] Foundation for Research and Technology, Institute of Chemical Engineering Sciences (FORTH/ICE-HT), Patras, GR-26504, Greece

[2] Department of Chemical Engineering, University of Patras, GR-56504, Greece

[3] European Space Research and Technology Centre (ESTEC), The Netherlands

Presenting author: Fotis Zaravelis, email: fotis.zaravelis1@gmail.com

* Corresponding author: Dimitris Niakolas, email: niakolas@iceht.forth.gr

ABSTRACT

Regenerative fuel cells offer significant advantages over rechargeable batteries as energy storage devices, especially in applications where high specific energy density is required as in the case of telecommunication satellites. A closed loop regenerative PEM fuel cell system (RPEMFCS) operates as a high-pressure PEM electrolyser when excess power is available from the solar array (charging mode/reactant regeneration) and as a PEM fuel cell when the solar array does not generate power i.e. when the satellite is in eclipse (discharge mode). Regenerative fuel cells, of a discrete or a unitized design, have been considered as potential energy storage solution for future space missions [1], as well as for terrestrial applications.

The objective of this research is the development of a stack assembly, working under electrolysis mode and high pressure (High Pressure PEM Electrolyser), as part of a regenerative fuel cell system for energy production. The system is destined for large telecommunication platforms in geostationary orbit GEO (Commercial application) in collaboration with the European Space Agency (ESA). Based on the materials research and development, which has been carried out up to now, two stacks (a high-pressure PEM electrolyser and a high-temperature PEM fuel cell) are under manufacturing and preliminary testing, aiming to be incorporated in a regenerative fuel cell test bench for further evaluation [2].

The electrolysis stack assembly (1.5 kW) will comprise low temperature (T≤80°C) Nafion® membranes made by FumaTech. The membrane, the electrodes and the other components put together a single electrolysis assembly (Membrane Electrode Assembly: MEA). Research on the optimization of the materials used in the stack (electrocatalysts, gas/water diffusion layers, bipolar plates, sealing materials, design of the reactor etc.), as well as pressurized experiments on a single MEA with an active area of 5x5 cm^2 have already been published [3]. The presented study deals with the experimental results of a 3-MEA and a 5-MEA stack with 7x7 cm^2 active area, operating under elevated pressure (1 – 80 bar). Quantitative analysis of the produced gases (H_2, O_2) took also place, using a mass spectrometer. Moreover, there was determination of the H_2 crossover amount, which can be attributed either to sealing issues or to diffusion/crossover processes through the Nafion membrane/electrolyte. The main objective is to clarify the reasons that cause the possible diffusion/crossover of H_2 and to reduce them to minimum, in order to meet the safety regulations. Last but not least, stability measurements were conducted under high operating pressure. It is worth mentioned that, so far, there is no publication in the literature of a similar electrolysis stack (low weight and volume with Technology Readiness Level, TRL = 4.5), which operates at the same time as a (H_2 and O_2) compressor in the pressure range between 1 – 80 bar.

REFERENCES

[1] ESA Electrochemical Energy Storage Roadmap, 2011.

[2] Executive Summary Report from activity GTF2065: “Regenerative PEM Fuel Cells” (ESA Contract 22329/09/NL/CBI).

[3] D.K. Niakolas, S. Neophytides, C.G. Vayenas, A. Katsaounis, N. Athanasopoulos, S. Balomenou, K.M. Papazisi, D. Tsiplakides, M. Schautz, 11th European Space Power Conference (ESPC-2016), Vol: B03-Electrochemical components.