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Impact of Alternative Fuel Feeding on Fuel Cell Performance and Durability

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Abstract : With the expansion of the hydrogen economy, Proton Exchange Membrane Fuel Cell (PEMFC) systems are often presented as promising energy converters suitable for transport applications. However, reaching a durability of 5000 h recommended by the U.S. Department of Energy and decreasing system cost are still major hurdles to their development. In order to increase the system efficiency and simplify the system without affecting the fuel cell lifetime, an architecture called alternative fuel feeding has been developed. It consists in a fuel cell stack divided into two parts, alternatively fed, implemented on a 5-kW system for real scale testing. The operation strategy can be considered close to Dead End Anode (DEA) with specific modifications to avoid water and nitrogen accumulation in the cells. The two half-stacks are connected in series to enable each stack to be alternatively fed. Water and nitrogen accumulated can be shifted from one half-stack to the other one according to the alternative feeding frequency. Thanks to the homogenization of water vapor along the stack, water management was improved. The operating conditions obtained at system scale are close to recirculation without the need of a pump or an ejector. In a first part, a performance comparison with the DEA strategy has been performed. At high temperature and low pressure (80°C, 1.2 bar), performance of alternative fuel feeding was higher, and the system efficiency increased. In a second part, in order to highlight the benefits of the architecture on the fuel cell lifetime, two durability tests, lasting up to 1000h, have been conducted. A test on the 5-kW system has been compared to a reference test performed on a test bench with a shorter stack, conducted with well-controlled operating parameters and flow-through hydrogen strategy. The durability test is based upon the Fuel Cell Dynamic Load Cycle (FC-DLC) protocol but adapted to the system limitations: without OCV steps and a maximum current density of 0.4 A/cm^2. In situ local measurements with a segmented S++® plate performed all along the tests, showed a more homogeneous distribution of the current density with alternative fuel feeding than in flow-through strategy. Tests performed in this work enabled the understanding of this architecture advantages and drawbacks. Alternative fuel feeding architecture appeared to be a promising solution to ensure the humidification function at the anode side with a simplified fuel cell system.

Keywords : automotive conditions, durability, fuel cell system, proton exchange membrane fuel cell, stack architecture
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