World Academy of Science, Engineering and Technology
International Journal of Chemical and Materials Engineering
Vol:17, No:07, 2023

Improved Operating Strategies for the Optimization of Proton Exchange Membrane Fuel Cell System Performance

Authors : Guillaume Soubeyran, Fabrice Micoud, Benoit Morin, Jean-Philippe Poirot-Crouvezier, Magali Reytier

Abstract : Proton Exchange Membrane Fuel Cell (PEMFC) technology is considered as a solution for the reduction of CO2 emissions. However, this technology still meets several challenges for high-scale industrialization. In this context, the increase of durability remains a critical aspect for competitiveness of this technology. Fortunately, performance degradations in nominal operating conditions is partially reversible, meaning that if specific conditions are applied, a partial recovery of fuel cell performance can be achieved, while irreversible degradations can only be mitigated. Thus, it is worth studying the optimal conditions to rejuvenate these reversible degradations and assessing the long-term impact of such procedures on the performance of the cell. Reversible degradations consist mainly of anode Pt active sites poisoning by carbon monoxide at the anode, heterogeneities in water management during use, and oxidation/deactivation of Pt active sites at the cathode. The latter is identified as a major source of reversible performance loss caused by the presence oxygen, high temperature and high cathode potential that favor platinum oxidation, especially in high efficiency operating points. Hence, we studied here a recovery procedure aiming at reducing the platinum oxides by decreasing cathode potential during operation. Indeed, the application of short air starvation phase leads to a drop of cathode potential. Cell performances are temporarily increased afterwards. Nevertheless, local temperature and current heterogeneities within the cells are favored and shall be minimized. The consumption of fuel during the recovery phase shall also be considered to evaluate the global efficiency. Consequently, the purpose of this work is to find an optimal compromise between the recovery of reversible degradations by air starvation, the increase of global cell efficiency and the mitigation of irreversible degradations effects. Different operating parameters have first been studied such as cell voltage, temperature and humidity in single cell set-up. Considering the global PEMFC system efficiency, tests showed that reducing duration of recovery phase and reducing cell voltage was the key to ensure an efficient recovery. Recovery phase frequency was a major factor as well. A specific method was established to find the optimal frequency depending on the duration and voltage of the recovery phase. Then, long-term degradations have also been studied by applying FC-DLC cycles based on NEDC cycles on a 4-cell short stack by alternating test sequences with and without recovery phases. Depending on recovery phase timing, cell efficiency during the cycle was increased up to 2% thanks to a mean voltage increase of 10 mV during test sequences with recovery phases. However, cyclic voltammetry tests results suggest that the implementation of recovery phases causes an acceleration of the decrease of platinum active areas that could be due to the high potential variations applied to the cathode electrode during operation.

Keywords : durability, PEMFC,recovery procedure, reversible degradation
Conference Title : ICFCP 2023 : International Conference on Fuel Cells and Processing
Conference Location : Copenhagen, Denmark
Conference Dates : July 10-11, 2023

Open Science Index, Chemical and Materials Engineering Vol:17, No:07, 2023 publications.waset.org/abstracts/156669.pdf