Experimental validation of an identification procedure for degraded PEM fuel cell state using EIS combined with a physical impedance modelling

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An original modelling of PEM fuel cell impedance is developed in our laboratory [1].It is based on the resolution in the frequency domain of the physical equations taken into account the main phenomena encountered in PEM fuel cell: electrochemical reactions, ionic and electronic transport, charge and mass transfer in GDL and channel [2]. The impedance model has been validated on experimental impedance measurements of the literature [3]. We show that this model can be used to detect various flooding scenarios. Actually, depending on the location of the flooding inside the cell, either in the catalyst layer or in the GDL, and either on the anode or the cathode side, the cell impedance is sufficiently modified from its reference state to allow the identification of the degraded cell parameters. The feasibility of the default detection has been proved by numerical simulations. We are now currently applying the detection procedure that we have implemented and validated numerically to experimental tests conducted in the laboratory. A 500 W stack is connected to a test station allowing the investigation of the influence of operating conditions (mass flow rate, inlet temperature and relative humidity of gases) on stack performances. The 30 stack cell impedances are simultaneously measured using an Electrochemical Impedance Spectrometer. The heterogeneous responses of stack cells to different operating conditions are interpreted using the physical developed modelling.
In the communication, we will present the identification procedure we have developed as well as its first validation on experimental results with a 30 cells PEMFC stack.

References:

[1] S. Chevalier, D. Trichet, B. Auvity, JC Olivier, C. Josset and M. Machmoum « PEM fuel cell impedance modelling for the detection of degraded cell parameters", Int. J. hydrogen Energy, submitted, October 2012.
[2]T. E. Springer, Characterization of Polymer Electrolyte Fuel Cells Using AC Impedance Spectroscopy, Journal of The Electrochemical Society 143 (2), 1996.
[3] M. Ciureanu, R. Roberge, Electrochemical Impedance Study of PEM Fuel Cells . Experimental Diagnostics and Modeling of Air Cathodes, Journal of Physical Chemistry B (2001) 3531–3539