PHYSICAL MODELING OF THE ELECTROCHEMICAL IMPEDANCE OF A PEMFC

S. CHEVALIER(1),(2), C. JOSSET(1), J-C OLIVIER(2), D. TRICHET(2), B. AUVITY(1) and M. MACHMOUM(2)

(1) Laboratoire de Thermocinétique de Nantes (CNRS UMR 6607), Polytech'Nantes, Nantes, France

(2) IREENA, University of Nantes, Nantes, France

Stephane.chevalier@univ-nantes.fr

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Abstract

To diagnose the state of health of a Polymer Electrolyte Membrane Fuel Cell (PEMFC) [1], Electrochemical Impedance Spectroscopy (E.I.S.) tends to be widely used for some years now. However, the interpretation of the PEMFC frequency response is often only qualitative, and a quantitative analysis of PEMFC spectra remains the key to get a relevant diagnosis. In particular, the water management is a key issue to get stable and high PEMFC performances, and a deeper understanding of the relationship between drying or flooding conditions in the Membrane Electrode Assembly (MEA) and the impedance spectra is needed.

A PEMFC's numerical model based on a physical approach [2] was developed. Mass transport, charge transport and electrochemical reactions were solved in a two dimensional geometry to obtain the steady state conditions. Then, using the Laplace transform, the PEMFC harmonic behaviour was computed to obtain the so-called fuel cell electrochemical impedance.

Recent numerical and experimental studies reported in the literature [3,4], have revealed the impact of flooding conditions on the diffusion layer's pores filling and the decreasing of the platinum active area available through the catalyst layer. Artificial defaults simulating these various types of flooding were introduced in our model to analyse the impact of the default size and location (anode or cathode side) on PEMFC performances and impedance spectra.

In the communication, the simulation results will be presented. It will be shown how a GDL clogging or a catalysis layer alteration on the anode side of the MEA affects the electrochemical behaviour on the cathode side, and inversely. The impact of this kind of default on the impedance spectra will be also shown. Moreover, the current density, the potential distribution as well as the concentration distribution over the whole MEA can be extracted from the numerical model.

These data provide new insights into the physical phenomena that occur in a MEA when localized defaults appear, and the typical "signature" of these degradations on the fuel cell impedance spectrum can be determined.

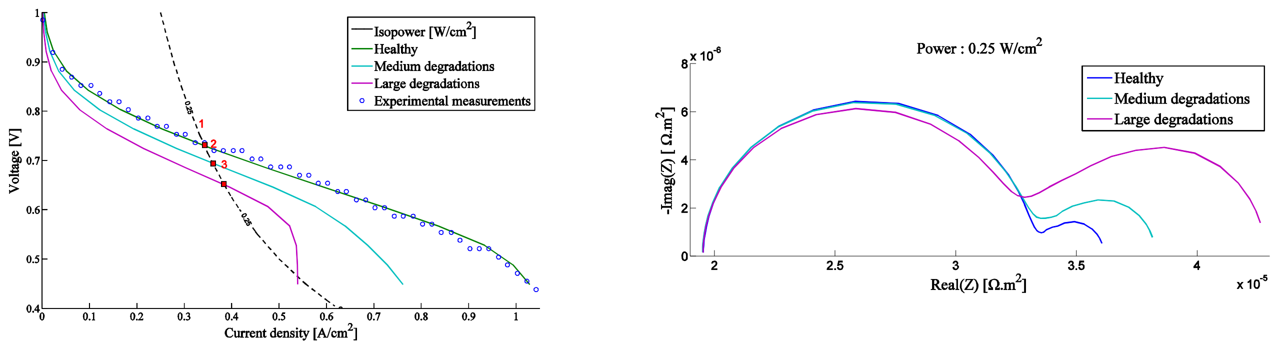

Figure 1 -- (a) Healthy and defective's PEMFC polarization curves. (b) Impedance responses obtain from operating load 1, 2 and 3 depicted on figure 1.a.

References

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