Novel methodology to diagnose fuel cell air channel velocities based on EIS measurements

S. Chevalier[1], C. Josset[1], A. Bazylak[2], and B. Auvity[1]

[1]*Laboratoire de Thermique et Énergie de Nantes (CNRS UMR 6607), Polytech Nantes, Université de Nantes, Nantes, France*
[2]*Thermofluids for Energy and Advanced Materials Laboratory, Dept. of Mechanical & Industrial Engineering, University of Toronto, Toronto, Ontario, Canada*

Polymer Electrolyte Membrane (PEM) fuel cells are considered as promising clean sources for automotive applications. A key challenge to reduce the cost of this technology is to increase the power density by operating PEM fuel cells at high current densities without significantly increasing the electrical consumption of the auxiliaries, such as the air feeding system. The energetic cost of these auxiliaries can represent up to 20% of the energy consumed by a fuel cell system, therefore air flow rates are usually kept as low as possible, i.e. air stoichiometric ratios ranging between 1.5 and 3. In a stack configuration, such low stoichiometric ratios may induce air flow maldistribution between each single cell of the stack and cause fuel cell channel clogging. Therefore, the knowledge of the air velocity that flows through each cell would be a valuable criterion to diagnose and prevent the channel clogging.

When a PEM fuel cell operates in low air stoichiometry during electrochemical impedance spectroscopy measurements, several studies have reported the presence of the channel impedance at very low frequency (ranging from 5 to 0.1 Hz) [1,2]. In this communication, we will present how the air velocity can be obtained from the measurement of the channel impedance. Our methodology is based on an analytical criterion derived from the equation of oxygen transport in a straight channel and in the gas diffusion layer. This criterion is a function of channel air velocity, channel geometry and operating conditions (inlet pressure, cell temperature, and cell current density). Finally, air velocities are obtained by fitting this criterion to the experimental measurements of the fuel cell impedance. The validation of this novel methodology using a commercial single cell will be presented.

References:
[1] I. A. Schneider, S. A. Freunberger, D. Kramer, A. Wokaun, and G. G. Scherer, J. Electrochem. Soc., 154, B383–B388 (2007)
[2] S. Chevalier, C. Josset, A. Bazylak, B. Auvity, J. Electrochem. Soc. 163 (2016) F816–F823