ABSTRACT QUESTIONNAIRE

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EXPECTED CLASSIFICATION: (please, mark all the options that better define your abstract)

**MAIN SESSION**
- PEM fuel cells
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- Numerical simulation
- New materials
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- Standards and regulations
Analysis of conventionally controlled PEMFC based on a distributed parameter model

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1 Introduction

The proton exchange membrane fuel cells (PEMFC) have been incorporated to a wide range of portable, stationary and automotive applications. However, PEMFC are still not accepted as a practical power generator. The key challenge is to reduce the cost and achieve a high performance and long life of the cells. Variations in the concentrations of reactants, as well as current density or temperature, have significant effects on the performance and durability of PEMFC. All these variables exhibit spatial dependence along the channel, which needs to be taken into account in order to progress towards a PEMFC operation that is efficient and mitigates degradation. To this end, a controlled PEM fuel cell study is done through a distributed parameter simulation model. A conventional stoichiometry control objective is considered in order to analyze the behavior of spatial profiles of some important variables and, therefore, point out the importance of considering distributed parameter models in control design.

2 System, model and control description

The system is a single cell of one channel that includes all the functional parts of the PEMFC: bipolar plates, gas channels, gas diffusion layers, catalyst electrode layers, a proton exchange membrane and a cooling system. The case study selected in the work is a 0.4 m along-the-channel single cell (active area 0.4 x 10⁻³ m) with Nafion 117 membrane. The model equations are based on the work by Mangold et al. [1]. The model is 1+1D with approximation of gradients by a fixed number of points in y-direction and partial differential equations along the channel (implementation details are presented in [2]).

A simple proportional feedback control is chosen in order to obtain a closed-loop system. The control objective is to maintain oxygen stoichiometry at a certain reference value. In this conventional scheme, the control variable is oxygen inlet flow, whereas voltage is taken as a perturbation to the system.

3 Simulation results

Different operating conditions are studied. In the example shown here, oxygen stoichiometry reference is set at 9. Voltage is set at 0.8 V and, at time t = 10 s, this variable undergoes a change down to 0.7 V, which causes an increase in current density and thus a decrease in oxygen stoichiometry. Fig. 1 shows the results for this variable. The horizontal dimension corresponds to gas channel length.

![Fig. 1. Membrane current density along the channel](image)

4 Conclusions

As seen in Figure 1, current density has an important variation along the channel. This profile needs to be taken into account regarding membrane humidity. For example, extremely high or low humidity values are not desired at any membrane point. Therefore, control design considering spatial profiles of relevant variables is a sensible approach.

5 Acknowledgements

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6 References