

ABSTRACT QUESTIONNAIRE

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Title:	Dynamic modeling of a thermal system for a high-temperature PEM fuel cell				
Presenting author:	Vicente Roda	Under 30 years old	X	Presentation in English	YES POSTER

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Dynamic modeling of a thermal system for a high-temperature PEM fuel cell

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High-temperature PEM fuel cells (HT-PEMFCs) operation differs from that of conventional ones, because the working temperature has to be controlled between 120°C and 180°C. The proton conducting membrane that functions as electrolyte is made of a PBI polymer doped with phosphoric acid and is highly hygroscopic [1]. On the one hand, if its working temperature decreases below 120°C it absorbs water and the acid is pushed out, reducing the overall proton conductivity. On the other, if the device is forced to work at temperatures above 180°C, the evaporation of phosphoric acid is accelerated, and the stack lifetime can be dramatically shortened. Therefore, the control system must incorporate specific operational strategies, different to the ones used in low-temperature PEMFCs.

In such framework, the objective of this research is to provide a dynamic model of the thermal subsystem of a HT-PEMFC, aiming to develop a proficient temperature controller for a small stack manufactured at LIFTEC. As a first stage, the set of full-order differential equation is obtained assuming concentrate parameters and following a heat flow balance approach [2]. Next, resorting to physical consideration, it is worked into a reduced-order state-space model, suitable for control design purposes. Moreover, taking advantage of electrical analogies, a modular equivalent circuit is proposed for the thermal model of each cell. Lumping such modules allows to straightforwardly obtain, not only the whole dynamic model of the stack under consideration, but also of a large stack that will be tackled in a future stage of this project.

In particular, the thermal dynamic model presented in this work corresponds to a device comprising five MEAs Celtec[®]-P1100W manufactured by BASF Fuel Cells, with an active area of 605 cm². The bipolar plates are machined in aluminum, and coated with a thin ceramic layer of CrN of 2.5 μm thick to prevent corrosion, but preserving a high electric conductivity. As independent thermal actuators, the stack incorporates flexible electrical resistance wires surrounding each MEA in every

individual cell. It is also equipped with electrical resistance cartridges placed in the main gas collectors. Thus, by increasing the temperature of the reactant gases, they are able to transfer heat to the bipolar plates and the MEAs, providing a more uniform and rapid heating of the whole stack.

In addition, the fuel cell has been thermally insulated, in order to reduce the heating power demand and to benefit of the heat generated by the stack. In this way, at certain operation conditions, the reaction thermal energy could be large enough to keep the temperature within the range recommended by the MEAs' manufacturer. However, when the stack operates at high current densities, the excess heat must be extracted, in order to maintain the temperature of the stack in the working range. To this end, the insulation device has a ventilation system equipped with axial fans [3]. Note that the heat extracted can be utilize in heating systems if the HT-PEMFC stack is used as a combined heat and power unit (CHP).

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