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Extended Abstract of:

Data Driven Model for a Fuel Cell stack development in a complex Multi-source Hybrid Renewable Energy System

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Fuel cells based on polymer electrolyte membrane are considered as the most hopeful clean power technology. The operating principles of polymer electrolyte membrane fuel cells (PEMFC) system involve electrochemistry, thermodynamics and hydrodynamics theory for which it is difficult to establish a mathematical model. In this paper a nonlinear data driven model of a PEMFC stack is developed using Neural Networks (NNs). The model presented is a black-box model, based on a set of measurable exogenous inputs and is able to predict the output voltage and cathode temperature of a high power module working at the CNR- ITAE. The device in this study was a 5 kW NUVERA PEM fuel cell stack consisting of 50 cells with 500 cm^2 of geometric area each (Fig. 1). The stack works with a Cathode Water Injection system that dissipate heat and humidifies the cathode side by mixing air stream and water. In this work the stack was operated in a test station that includes an electronic load, gas mass flow controllers and pressure sensors and actuators, and a control and monitor software. The station has allowed to modify a number of process variables and to obtain an experimental database about the PEMFC stack under different operating conditions. To obtain a significant stack voltage dynamic the load current was changed from 30 to 110 A, the air mass flow from 35 to 184 slpm, the hydrogen mass flow from 19 to 104 slpm and nitrogen mass flow from 7 to 39 slpm in a number of different combinations. To train the different neural models, a set of patterns with sampling time T=10 sec., covering different process working points, was considered. A trial and error approach was used to select the best model among possible candidates. All the networks were trained using the Levemberg-Marquardt algorithm, with the early stopping approach to prevent overfitting. A trial and error approach was used to select the best model among possible candidates. Several sub-optimal neural models were been obtained, corresponding to a different number of hidden neurons and/or different set of learning pattern. The neural model with the higher correlation coefficients has 12 hidden neurons and correlation coefficients (Acquired / Simulated Data) for the output voltage and cathode temperature are *99%* and *98%* respectively. The data driven obtained model performed quite satisfactory and stack voltage and cathode temperature dynamics were simulated with accuracy. In Fig.2 and Fig.3 the comparison of stack voltage and ccathode temperature acquired data and corresponding model estimation for a Test data subset are shown.The trained NN model is computationally fast and easy to use, especially in the case where physical models are not readily available.

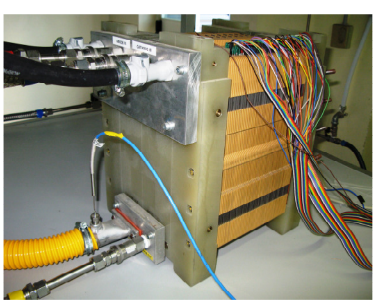

Fig.1 Nuvera 5Kw PEM Stack

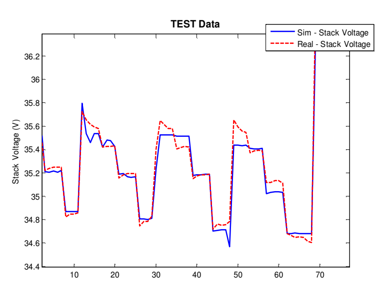

Fig.2 Comparison of Stack Voltage acquired data and corresponding model estimation for a Test data subset.

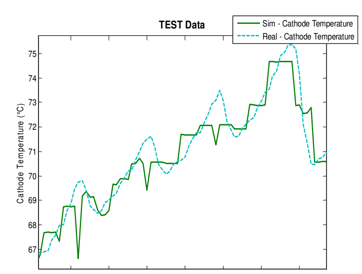

Fig.3 Comparison of Cathode Temperature acquired data and corresponding model estimation for a Test data subset.