A PEM Fuel Cell Distributed Parameters Model Aiming at Studying the Production of Liquid Water Within the Cell During its Normal Operation: Model Description, Implementation and Validation

SAE International
Date:
Tuesday, April 12, 2011
DOI:
http://dx.doi.org/10.4271/2011-01-1176

One of the major issues coming out from low temperature fuel cells concerns the production of water vapor as a chemical reaction (between hydrogen and oxygen) by-product and its consequent condensation (at certain operating conditions), determining the presence of an amount of liquid water affecting the performance of the fuel cell stack: the production and the quantity of liquid water are strictly influenced by boundaries and power output conditions. Starting from this point, this work focuses on collecting all the required information available in literature and defining a suitable CFD model able to predict the production of liquid water within the fuel cell, while at the same time localizing it and determining the consequences on the PEM cell performances. This virtual test bench must be able to simulate a representative portion of a single PEM cell in order to determine the most likely operating conditions causing formation of liquid water: the objective lies in managing adequately the liquid water in order to reduce to the minimum its impact on the cell's operations, aiming at identifying liquid water accumulation mitigation strategies, such as bipolar plate shapes optimization through a Multidisciplinary Design Optimization (MDO) loop, which will be covered in future works. The hereinafter presented model has been developed in CD-adapco STAR-CCM+ CFD environment and interfaced directly to MATLAB routines, while choosing iSight as the overall framework and optimizer tool. It deals with stationary, three-dimensional, non-isotherm fluid-dynamics, encompassing and improving most of the previous CFD PEMFC models already available in literature; at the same time, MATLAB routines are responsible for studying and defining all the electro-chemical aspects, this giving to the user a friendly and flexible way to cover and consider thoroughly all the events involved during the operation of a fuel cell supplying any kind of electrical load. In order to validate the overall model, a first comparison with other fluid-dynamics model has been carried out, in terms of analytical results, as well as a crossed check with some experimental results available from experiences gained over the years by the research group.

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