



High temperature polymer electrolyte membrane fuel cells – Modeling, simulation, and segmented measurements

Christian Siegel

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A three-dimensional computational fluid dynamics model of a high temperature polymer electrolyte membrane fuel cell, employing a high temperature stable polybenzimidazole membrane electrode assembly doped with phosphoric acid, was developed and implemented using a commercially available finite element software. Three types of flow-fields were modeled and simulated. Selected simulation results at reference operating conditions were compared to the performance curves and to segmented solid-phase temperature and current density measurements. For the segmented measurements, an inhouse developed prototype cell was designed and manufactured. The segmented cell was successfully operated and the solid-phase temperature and the current density distribution were recorded, evaluated, and discussed. Sequentially scanned segmented electrochemical impedance spectroscopy measurements were performed to qualitatively support the observed trends. These measurements were used to identify and determine the causes of the inhomogeneous current density distributions. An equivalent circuit model was developed, the obtained spectra were analyzed, and the model parameters discussed. This work helps to provide a better understanding of the internal behaviour of a running high temperature polymer electrolyte membrane fuel cell and presents valuable data for modeling and simulation. For large fuel cells and complete fuel cell stacks in particular, well designed anode and cathode inlet and outlet sections are expected to aid in achieving flatter quantities distributions and in preventing hot spots over the membrane electrode assembly area, and to develop proper start-up, shut-down, and tempering concepts.

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