Numerical Modelling of Solid Oxide Fuel Cells: Role of Various Cell Parameters on Performance

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Abstract

Solid oxide fuel cells (SOFCs) are expected to play a major role in future energy systems due to their wide range of applications, high energy efficiency, environmental friendliness and good fuel flexibility. While conventional high temperature SOFCs operate at about 1000C, there is growing interest in intermediate temperature SOFCs which operates between 600C and 800C allowing for wider range of materials, stability and reduced cost of production. A fully coupled computational fluid dynamics (CFD) model predicting the performance of a planar solid oxide fuel cell (SOFC) at intermediate temperature has been developed using the finite element based package COMSOL Multiphysics®. The model solves governing equations for mass, momentum and charge transport as well as the kinetics of the electrochemical reaction, the effect of Knudsen diffusion is accounted for in the electrochemical reaction layer. Varying structural designs and operating conditions, is used in predicting the performance of the cell. The cell is modelled with yttria-stabilized zirconia (YSZ) electrolyte, Ni-YSZ anode support layer, Ni-YSZ anode reaction layer, strontium doped lanthanum manganite (LSM)-YSZ cathode reaction layer and LSM current electrolyte layer with hydrogen as fuel and air as oxidant. The predicted performance of the cell is validated with measured data found in literature. Sensitivity analysis on the effect of some cell parameters on cell performance was carried out. Results shows that decreasing the electrolyte and anode thickness improves cell performance, also reduction in cell temperature lowers cell performance due to increased activation and ohmic losses while increased operating pressure enhances cell performance due to reduced concentration losses.