Modelling of High Temperature PEM Fuel Cell Start-Up Process By Using COMSOL Multiphysics

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Abstract

High temperature PEM (proton exchange membrane/polymer electrolyte membrane) fuel cells have been considered the next generation fuel cell. The electrochemical kinetics for electrode reactions are enhanced by using PBI (Polybenzimidazol) membrane at an operation temperature between 160 °C and 180 °C comparing to low temperature PEM fuel cell. Besides this by using PBI membrane gases do not need to be humidified and the water produced by the reaction has only one phase. Therefore water management is unnecessary. This simplifies the HT PEM fuel cell system. In addition, higher CO tolerance makes it possible to simplify the fuel processing system by integrating the fuel cell with a fuel processing unit (e.g. reformer).

But starting HT PEM fuel cell from room temperature to a proper operation temperature is a challenge. There are different methods to start HT PEM fuel cells. Electrical heating by using extra heating plate assembled on the fuel cell endplate or embedded within the graphite plates is an option as well as using preheated reaction gas (only air on cathode side) or coolant to head up the fuel cell through the gas channels or cooling channels. Combinations of the mentioned methods including self-heating (or ohmic heating) from the fuel cell process are possible as well.

In this work, different start-up processes or combinations of different start-up processes have been simulated by using Comsol Multiphysics for a single HT PEM fuel cell with serpentine gas channels and straight cooling channels. These start-up processes are analyzed by comparing the start-up time and thermal behaviors inside the fuel cell. At the same time, different flow rates and flow directions of reactant and coolant are also analyzed for the gas heat-up processes. Based on the Comsol HT PEM fuel cell model, optimal start-up methods can be found according to the setup parameters for different applications.