Computational Multiphysics to Optimize Humidification Chamber for a Novel PEM Fuel Cell Power System Used in Automobile Application

M. Raja [1]

[1]Tata Motors, Bengaluru, Karnataka, India

Abstract

Proton Exchange Membrane (PEM) fuel cells are quickly becoming an attractive technology due to their ability to meet increasing energy demands in a cleaner, more efficient way compared to existing methods.
A fuel cell is an electrochemical device which converts the chemical energy of a fuel and an oxidant directly into electricity without the intermediate step of classical, chemical combustion used in the normal process.
In this regard, humidification of air will play a very big role in PEM fuel cell like
- The membrane must be suitably hydrated to maintain good proton conductivity
- Excess water may flood the electrodes preventing the H2 gas from reaching the catalyst sites
- The performance of the PEM fuel cell is decisively dependent on the humidity of the electrolyte membrane
- The fuel cell system requires humid air to facilitate the chemical reaction
- The reactants in the fuel cell are humidified to keep polymer membrane wet and saturated with the water for sustained ionic conductivity
In order to validate, the above computational model of a humidification chamber for a PEM fuel cell was built and solved in COMSOL Multiphysics®. This model takes into account species, momentum and heat transport phenomena within porous glass matrix zone, and thermal analysis in the heater core area. The purpose of the model is to evaluate the effect of humidification for the various scenarios of the operation of a fuel cell power system. The results of the model give a better understanding of important considerations such as water and heat management.
Improvements in the design and operation of the fuel cell humidification chamber are suggested based on model results.
It has been demonstrated here, how effectively transport species, porous media flow and heat transfer can be coupled in COMSOL Multiphysics®.
We at Tata Motors use Structural Mechanics, Computation Fluid Dynamics, and Batteries and Fuel Cells Modules in COMSOL Multiphysics® to solve simple as well as complex problems.