A system model of proton exchange membrane electrode fuel cell for the study of the water/thermal management

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ABSTRACT

In this study, a systematic approach for the investigation of the water/thermal management on the performance of the proton exchange membrane fuel cell (PEMFC) is presented. This work includes two simulation models which are a comprehensive multi-dimensional thermal model for the study of the unit fuel cell and a dynamic fuel cell stack and balance of plant (BOP) components model for the study of system performance.

The comprehensive multi-dimensional thermal model is developed to study the performance of the large active area unit PEMFC with a water-cooled thermal management system. A lumped transient system model is developed for the system level study. Even though the multi-dimensional model is capable of analysis of various parametric effects, the computational efficiency confined the application area of the multi-dimensional model to system level study. Also, the dynamic system model is developed to investigate the system performance of the PEMFC with high computational efficiency and it is required to simplify the complicated model. A systematic approach is suggested to boost the analysis capability via combination of two simulation models. Under systematic approach, the model of unit PEMFC provides the study results to the system model to be used them as control policy. Once the control policy is determined, the dynamic system model is used it for the optimization of operating conditions. After the one cyclic iteration of the systematic approach, the result of system level study can be delivered back to unit PEMFC study for further improvement.

The systematic approach is applied to a case study of the optimization of the thermal management system. The results show that the efficiency of the PEMFC system can improved 2% of the net power when the thermal management system is properly controlled by the result of the control policy. Currently, our team at KIMM applies the systematic approach to the design optimization of the BOP components for the SOFC (Solid Oxide Fuel Cell) and the MCFC (Molten Carbonate Fuel Cell) as well as the optimization of operating conditions for the water management of the PEMFC.