World Academy of Science, Engineering and Technology
International Journal of Energy and Power Engineering
Vol:18, No:04, 2024

Modeling and Temperature Control of Water-cooled PEMFC System Using Intelligent Algorithm

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Abstract : Proton exchange membrane fuel cell (PEMFC) is the most promising future energy source owing to its low operating temperature, high energy efficiency, high power density, and environmental friendliness. In this paper, a comprehensive PEMFC system control-oriented model is developed in the Matlab/Simulink environment, which includes the hydrogen supply subsystem, air supply subsystem, and thermal management subsystem. Besides, Improved Artificial Bee Colony (IABC) is used in the parameter identification of PEMFC semi-empirical equations, making the maximum relative error between simulation data and the experimental data less than 0.4%. Operation temperature is essential for PEMFC, both high and low temperatures are disadvantageous. In the thermal management subsystem, water pump and fan are both controlled with the PID controller to maintain the appreciate operation temperature of PEMFC for the requirements of safe and efficient operation. To improve the control effect further, fuzzy control is introduced to optimize the PID controller of the pump, and the Radial Basis Function (RBF) neural network is introduced to optimize the PID controller of the fan. The results demonstrate that Fuzzy-PID and RBF-PID can achieve a better control effect with 22.66% decrease in Integral Absolute Error Criterion (IAE) of T_st (Temperature of PEMFC) and 77.56% decrease in IAE of T_in (Temperature of inlet cooling water) compared with traditional PID. In the end, a novel thermal management structure is proposed, which uses the cooling air passing through the main radiator to continue cooling the secondary radiator. In this thermal management structure, the parasitic power dissipation can be reduced by 69.94%, and the control effect can be improved with a 52.88% decrease in IAE of T_in under the same controller.

Keywords : PEMFC system, parameter identification, temperature control, Fuzzy-PID, RBF-PID, parasitic power
Conference Title : ICAE 2024 : International Conference on Applied Energy
Conference Location : Tokyo, Japan
Conference Dates : April 22-23, 2024