Dynamics and Control of PEM Fuel Cell Systems

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ABSTRACT

This work aims at developing a proton exchange membrane (PEM) fuel cell integrated system, accompanying with air compressor, air cooler, humidifier, supply manifold and return manifold. To recirculate the unreacted hydrogen fuel, an ejector-based recirculation system is included. Further, water cooled heat exchanger is employed to stabilize the fuel cell operating temperature. These auxiliary process units make the PEM fuel cell reversible one. The PEM fuel cell converts the chemical energy into electrical energy. For this, it receives oxygen from supplied air (or pure oxygen) and for hydrogen generation, there are two process units additionally developed. They include the methanol reformer and water electrolyzer. Verifying the PEM fuel cell model, it is further used for closed-loop performance study. To improve the fuel cell performance and lifetime, it is indeed required to maintain proper water management and avoid reactant starvation against load cycling. For this, a high-quality control of the nonlinear PEM fuel cell integrated system is inevitable. In this light, the nonlinear multivariable estimator based globally linearizing control (GLC) and sliding mode control (SMC) are synthesized. Finally these control schemes are compared hybridizing with various state estimators, namely adaptive state observer, extended Kalman filter and sliding mode observer, in terms of servo and regulatory response to find a best option for the PEM fuel cell integrated system.

Keywords: PEM fuel cell (PEMFC); methanol reformer; PEM water electrolyzer; PEMFC integrated system; modeling, simulation and verification; nonlinear observer-based controllers