Special Issue on “Modelling and Process Control of Fuel Cell Systems”

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Editorial

Special Issue on "Modelling and Process Control of Fuel Cell Systems"

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The ever increasing energy consumption, rising public awareness for environmental protection, and higher prices of fossil fuels have motivated many to look for alternative and renewable energy sources. The world fossil fluid fuel demand will soon exceed the world fossil fluid fuel production, which is expected to lead to an energy shortage crisis unless a sustainable alternative fuel is available soon. Among the many alternative fuel sources, fuel cells have received a major share of the attention, while they can also act as cogeneration systems.

The complicated reaction, heat, and mass transfer mechanisms in the fuel cells introduce extreme nonlinearities in the dynamcis of the fuel cell. The fundamental modeling and control problem in the fuel cells is further complicated by the existence of strong interaction between the input and output parameters; conventional modeling approaches and control strategies are incapable of coping with these difficulties. The conventional models do not consider all these the phenomena in their model. Therefore, a comprehensive analysis of the models and effects of various parameters are needed to provide a more realistic understanding of the phenomena encountered in fuel cells and improve the quantitative understanding of the actual process.

Since fuel cells are severely nonlinear and typically have several operational constraints, a single linear controller may not provide satisfactory performance over a wide range of operating conditions. Therefore, advanced process control schemes are needed to be implemented to cater the process dynamic nonlinearities and difficulties involved in the robust control of fuel cells. Efficient management and operation of such hybrid fuel cell grids are hence also needed along with better control methods. Since the simulation results of modeling is only a prediction and estimation of real system, an important step in the development of modeling and control is online validation. Unfortunately, there is a lack of experimental validation of the dynamic models of fuel cells in the open literature at present. Environmental assesment of systems closely related to fuel cell operations such as the Lithium-Ion battery is also necessary in these further studies.

In this special issue, we have seven papers related to the above issues i.e., of Fuel-Cell based Cogeneration System (1 paper), Management and Control of Fuel Cell Systems (2 papers), Analysis, Simulation and Operations of different types of fuel cells (1 paper), Modelling and Online experiment validation (2 papers), and environment assessment of Cathode Materials in Lithium-Ion battery energy generation systems (1 paper).

The paper by Ramadhani, F. et al. [1] gives a comprehensive review with technical guidelines for the design and operation of fuel-cell especially in cogeneration system setup. This review can be an important source of reference for the optimal design and operation of various type of fuel cells in cogeneration systems.

The paper by Atawi, I.E. et al. [2] discusses the modelling, management, and control of an autonomous hybrid microgrid system which incorporates fuel cells. This work utilizes an optimal control algorithm called the Mine Blast Algorithm, where the fuel cell compensates for extra load in the power demands of the system. The paper by Chatrattanawet, N. et al. [3] involves the design and implementation of off line robust model predictive control for solid oxide fuel cells. This work relates to the control of the temperature and fuel in a direct internal reforming solid oxide fuel cell through an ellipsoidal invariant set. For the analysis part, the paper by Ahmed et al. [4] touches on the simulation of solid oxide fuel cell anode using Aspen HYSYS Software. This paper mainly focus on the study of the effect of reforming activity on distributed performance profiles, carbon formation and anode oxidation risks.

At the same time, the paper by Govindarasu, R.; Somasundaram, S. [5] involves the mathematical modelling and simulation to identify the most influencing process variable affecting the fuel cell operation. Real time experiments were carried out to validate and obtain the optimum temperature for maximun power density. Furthermore, the paper by Burkic, D. et al. [6] discusses on the effects of induced friction in open cathode conduits with virtual roughness in the air-forced flow of a proton exchange membrane fuel cell. The regression model obtained correlates air flow and pressure drop as a function of the variable flow friction factor.

Finally, the work of Wang, L. et al. [7] presents the environmental sustainability assessment of typical cathode materials of Lithium-Ion battery based on three life cycle assessment approaches that are applicable to the other cathode-based set up such as the fuel cell systems.

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