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Modeling Tool Development for Optimal Design

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Description

Today, it is acknowledged that the development of clean energy systems is necessary to meet well-known environmental and regulatory standards for emissions and energy conversion efficiency in both stationary and automobile applications. Fuel cell systems are regarded as the most appealing alternative by the automotive and power generation industries as well as by many research and academic groups due to their high efficiency and absence of hazardous emissions. Solid oxide fuel cells are particularly appealing in these situations because of their high efficiency, modularity, and fuel flexibility on the one hand, and low emissions and noise on the other. Additionally, the SOFC may be used in extremely efficient cogeneration applications thanks to the high working temperatures. The fuel can also be internally reformatted using SOFCs [1,2].

Due to the inherent characteristics of this fuel cell type, SOFC application to residential plants is currently undergoing rapid development. Slow dynamic reaction and high-temperature wasted heat are two key drivers of this tendency in high operating temperatures. Due to the highly variable power demands, the former decreases interest in vehicle propulsion purposes. In particular, allowing SOFC to operate at lower temperatures will undoubtedly increase technological viability, but at the cost of decreasing efficiency. In order to achieve the best balance between material requirements and operational efficiencies, the ideal temperature range must be identified. Either developing electrode supported cells or utilizing novel electrolyte materials can result in lower temperature operations [3].

At both the supervisory and low-control levels, optimal control procedures are defined. Dynamic simulations are not always necessary to define the best functioning set points, which compete to higher control levels. On the other hand, low-level controls are frequently implemented through feedback techniques, necessitating the consideration of the primary system dynamics. Both situations require optimization analyses, which suggest combining the use of steady and dynamic gray/black-box models. An enlarged data set was made available, allowing for the development of a control-oriented model with little computational overhead and acceptable precision. According to indications from very computationally complex, multi-dimensional models, the model is especially good at capturing the voltage undershoot that occurs after such a load change [4].

A scarcity of suitable transient experiments is observed even though various steady-state experiments are publicly available. Such data are crucial for both identifying control-oriented models based on lumped techniques and enabling further validation of model-based intuitions. As a result, developing aim-oriented modelling approaches is necessary for the creation of dependable and affordable SOFC-based energy systems. In order to conduct SOFC transient tests, specialized experimental facilities must be put up as well as strategies for the design of the experiments. The modelling, scaling, and control of the SOFC stack and its ancillaries have also received some contributions. With the use of this model, they were able to mimic the dynamic behaviour of SOFC during a load transient and examine the heat-up phase, offering some helpful suggestions for thermal control.

The papers discussed modelling techniques for creating control-/diagnostic-oriented models of SOFC cells and stacks. After providing, a general overview of the key difficulties that must be resolved in order to advance SOFC technology, a thorough presentation and discussion of the hierarchical modelling that underpins model development followed. Control-oriented modelling of SOFC systems in particular has the potential to improve design phases at both the cell and stack levels, while also considerably assisting in the formulation of suitable control and diagnostics strategies and architecture, as well as the ideal BoP [5].

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Conflict of Interest

The authors reported no potential conflict of interest.

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