Advanced Modeling in Fuel Cell Systems: A Review of Modeling Approaches

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Abstract

A review of fuel cell modeling approaches across various length scales is given, with special focus on low-temperature hydrogen-fed polymer electrolyte fuel cell (PEFC) systems. The overall scope of fuel cell modeling is incredibly broad, and ranges from fundamental atomistic modeling of catalytic processes and transport to nearly completely empirically based online system control models. In the first part an overview of the various scales of modeling is given, with some examples from the literature, along with a summary of the common limitations and requirements for successful predictive capabilities. In the second part, a critical analysis of the present state of polymer electrolyte fuel cell performance and water management models is given, and the inability of the existing framework of models to accurately predict the liquid water distribution and transport in the PEFC is demonstrated and discussed. Based on the discussion of the various modeling approaches and the limitations in the current framework, the needs of future research to provide precise fundamental and engineering models are discussed.