Optimal Experimental Design for Parameter Identification of PEM Fuel Cell Models
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Modeling has been an invaluable tool in analyzing and optimizing polymer electrolyte membrane (PEM) fuel cells for improved performance and durability. Moreover, computationally efficient models may be used as software sensors and provide critical information about the internal states of an operating fuel cell. While the utility of fuel cell models has been shown in a myriad of modeling works in the literature, model parameterization remains a relatively understudied subject. The fact that all fuel cell models rely on some level of empiricism, such as the uptake isotherms used for membrane water uptake, makes the problem of proper model parameterization even more significant for fuel cell models. To date, most of the models in the literature have been parameterized using extensive material characterization obtained from the literature\(^1\). There are several drawbacks to such an approach. First, it requires extensive resources to be able to characterize individual cell components. Second, such characterization is often invasive and requires taking the cell apart. Finally, parameterizing a model using ex-situ characterization data may reduce the model’s prediction capabilities when it is applied to operating fuel cells.

Optimization-based approaches offer some remedy to many of these problems by enabling direct parameterization of the models using non-invasive measurements obtained on an operating fuel cell\(^2\). Although these techniques have been used occasionally to identify a few model parameters\(^3\),\(^4\), their application is rare, which is most likely due to the significant computational cost of many of the fuel cell models available in the literature. Nevertheless, recent progress in the battery research community highlights several opportunities for effective parameterization of electrochemical energy systems\(^5\)–\(^7\). Building up on this literature, in this talk we present some results on optimal design of experiments for identifying the parameters of a recently developed model of PEM fuel cells\(^8\),\(^9\). The optimal experiments help improve identifiability of the parameters of interest using non-invasive performance measurements. Furthermore, we present a methodology for systematic parameterization of such models. The results indicate the importance of optimally designing experiments for the purpose of parameter identification and highlight the utility of the systematic approach in effective model parameterization. We also discuss some issues regarding structural identifiability of fuel cell models and how additional measurements may help alleviate some of these issues.

Acknowledgement:
Financial support for this work was provided by Ford Motor Company.


