Model Reformulation for Lithium-ion Battery Simulation

Paul W. C. Northrop[*, 1] BharatKumar Suthar[*, 1] Venkat R. Subramanian[**,1,z]

[1]Department of Energy, Environmental and Chemical Engineering, Washington University, St. Louis, MO 63130

A simple transformation of coordinates is demonstated that facilitates the efficient simulation of the non-isothermal lithium-ion pseudo 2-D (P2D) battery model. [1-5] The transformed model is then conveniently discretized using orthogonal collocation with the collocation points in the spatial direction. The resulting system of differential algebraic equations (DAEs) is solved using efficient adaptive solvers in time. A series of mathematical operations are performed to reformulate the model to enhance computational efficiency as well as for programming convenience.[3] This is done to maintain accuracy even when non-linear temperature dependent parameters are used. Additionally, this methodology can be applied to the model as more physical phenomena, and therefore greater computational complexity and increased nonlinearities, are considered. The transformed coordinate allows for efficient simulation and allows for a logical extension from a single cell sandwich to multi-cell stack models. In order to demonstrate this, the transformation and reformulation techniques are used to simulate operation of a multi cell battery stack subject to varying heat transfer coefficients as well as specified temperature boundary conditions.

A strong physics based battery model can play a significant role in the model based design of battery architecture and optimal control of batteries for improved performance. [6] However, the computational cost of high level models has limited the utility of the same in many applications, driving the development of various mathematical techniques to reduce the computational cost. [7-11] Improved computational efficiency of the reformulated models is essential to increase the viability of using such models in environments of limited computing power. This is implemented into model based Battery Management System (BMS) for vehicular applications. This talk will review the recent developments in efficient simulation of battery models, and in particular the improvements in the algorithms for inverse calculations encountered in state estimation, parameter estimation and model predictive control.

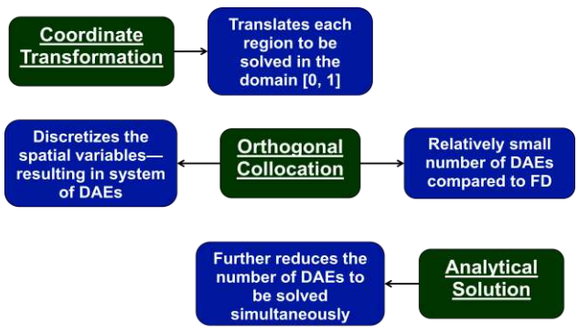

Figure 1: Steps used in the model reformulation of lithium-ion batteries to improve computational efficiency

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* Electrochemical Society Student Member
** Electrochemical Society Active Member
z vsubramanian@seas.wustl.edu