11th World Congress on Structural and Multidisciplinary Optimisation
07th -12th, June 2015, Sydney Australia

Parameter estimation of the electrochemical model in Li-ion battery with polynomial-based surrogate model

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Abstract

In the battery health management, capacity estimation during the use is of great importance because it is considered failure when it fades by 30%. Several diagnostic techniques have been suggested to this end, such as open circuit voltage and electrochemical impedance spectrometry (EIS), which is however limited in terms of practicality. In this study, an efficient method for capacity fade of Li-ion battery is addressed, which employs pseudo-2D electrochemical model that simulates voltage response under the current profile by solving nonlinear PDE. As the model parameters such as electrodes diffusivity undergo degradation over time, they are inversely estimated based on the measured voltage at charge station, which is easily obtained at no cost. The estimation is carried out in a probabilistic way using Markov Chain Monte Carlo (MCMC) approach to account for the uncertainty. Then the capacity fade is estimated by the P-2D model using the estimated parameters with its 95% confidence bounds. In order to apply the method into the on-board electric vehicle, surrogate model with 4th order polynomial is built that replaces the original complex P-2D model. The estimation result is compared with that by the P-2D model. As a result, the surrogate model enables reduction of the computation time remarkably from 12 hours to a few minutes.