735ar - A Systematic Model-Based Estimation of State of Health and State of Charge for Second-Life Li-Ion Batteries

Wednesday, October 30, 2024

3:30 PM - 5:00 PM

Exhibit Hall GH (Ground Level, San Diego Convention Center)

Abstract

Electric vehicles (EVs) are now being widely used as environmentally friendly alternatives to traditional combustion-engine vehicles. Lithium-ion (Li-ion) batteries are widely adopted as the main power source for EV’s. Their popularity stems from their high energy density, environmental friendliness, and long-life cycle, making them the preferred choice in the EV industry [1]. However, the energy storage capacity of these batteries decreases over the battery lifetime because of aging. Therefore, the state of battery aging is assessed for safe and smooth driving experience [2]. Once an appropriate aging indicator reaches the predetermined limit, the battery is to be replaced [3]. As a result, there is a surge in battery or electro-chemical waste, necessitating the development of technologies to handle these batteries once they reach the end of their original application. Creating new technologies for the safe and useful repurposing of batteries is crucial to mitigate severe environmental and economic consequences and for maximum utilization of these batteries. This study considers second-life use of these batteries for stationary applications such as for storing renewable energy. Even for those applications, a used battery’s state of health (SOH) and state of charge (SOC) should be accurately estimated for reliability of the energy storage systems. Furthermore, it is desired that their remaining useful life (RUL) be predicted so that replacement/maintenance planning can be undertaken without compromising system integrity and reliability. Existing approaches to the monitoring of SOH and SOC and prediction of RUL of Li-ion batteries can be broadly classified into

three main approaches: (1) heuristics-based methods, (2) model-based techniques, and (3) data-driven approaches [4,5]. This work proposes a hybrid approach where a detailed first-principles electrochemical model is developed and integrated with real-time data to optimally adapt model parameters and update state estimates. The current estimates of state and model parameters are then utilized to estimate the current SOH and SOC and predict RUL by projecting current states and parameters into the future. In this hybrid approach, the electrochemical model computes the spatial distribution of electrolyte concentration based on the concentrated solution theory, along with the potential distribution in the solid and liquid phases across the anode, cathode, and separator. Several approaches are developed in this study, including model reformulation, coordinate transformation, orthogonal collocation, and recursive Bayesian estimation for computational tractability of the optimal estimation problem for this spatially distributed large-scale partial differential algebraic equation system. The approach is evaluated by applying to the retired batteries collected from EVs.

References:

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Presenting Author

H

Md Emdadul Haque
West Virginia University

Authors

C

Auggie Chico
Parthian Battery Solutions

L

Greg Lusk
Parthian Battery Solutions

K

John Kolar
Parthian Battery Solutions

B

Paramarshi Banerjee
West Virginia University

S

Anurag Srivastava
West Virginia University

B

Debangsu Bhattacharyya
West Virginia University

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