State of Charge Estimation for Lithium-Ion Battery Models Based on a Thermoelectric Coupling Model

Huanhuan Li^{1,3}, Xiaoyu Wang¹, Ashwani Saini¹, Yuqiang Zhu¹, Ya-Ping Wang^{2,3,*}

¹ Automotive Engineering Research Institute, Jiangsu University, 301 Xuefu Road, Zhenjiang 212013, P. R. China

² School of Materials Science & Engineering, Jiangsu University, Zhenjiang 212013, P. R. China

³ Key Laboratory of Advanced Energy Materials Chemistry (Ministry of Education), College of Chemistry, Nankai University, 94 Weijing road, Tianjin, 300071, PR China

*E-mail: wangyaping@ujcs.edu.cn

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Conventional equivalent circuit models of lithium-ion batteries (LIBs) ignore the influence of temperature changes caused by heat generated inside the battery; unfortunately, the above leads to mismatched model parameters, which decreases the precision of the model. In this paper, a thermoelectric battery model based on thermoelectric coupling is proposed by coupling an equivalent circuit model with a thermal model, which considers the temperature increase in the battery. Performance tests for the hybrid pulse power characteristic (HPPC), charge-discharge capacity-voltage curve, time-temperature curve and direct current (DC) internal resistance were performed to calibrate 30 Ah ternary prismatic LIBs; furthermore, the model parameters were identified by a least squares method. The accuracy and effectiveness of the model were then validated by steady-state experiments and dynamic tests. In the steady state experiment, the maximum voltage error was 24.36 mV, and the maximum temperature simulation error was 0.93 °C at 1C, whereas the absolute voltage error was under 20 mV and the error of a high current pulse reached 60 mV in a dynamic test under the New European Driving Cycle (NEDC) condition. The above results confirm that the simulation can consistently and properly model the experimental results, which illustrates that the developed model has high accuracy and can reflect the characteristics of LIBs during a charge/discharge process in real time. Finally, an SOC estimation method for an LIB is developed by using an extended Kalman filter algorithm and is verified by experiments under the NEDC condition. The results show that the model has a high estimation accuracy, and the SOC error, maximum error and average error values are approximately 3%, 2.96% and 0.81%, respectively; additionally, an initial value dependence or a cumulative error in an ampere-time integration method is not generated, which demonstrates that the algorithm has a strong self-correcting ability with initial SOC errors and strong convergence.

Keywords: Lithium-ion battery; Thermoelectric coupling model; Equivalent circuit; Parameter identification; SOC Estimation

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