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电池与储能

基于分层电化学热耦合模型的锂电池放电过程研究

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Research on Discharging Process of Lithium Battery Based on Layered Electrochemical Thermal Coupling Model

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History

摘要

软包锂离子电池由许多电池单元叠压形成,其中电池单元的电和热行为对电池的整体安全性有很大的影响。为了研究电池单元与单体之间的关系,采用多孔电极理论建立了大容量软包锂电池的分层多维模型,并考虑了瞬态温度变化与电化学反应间的相互作用关系。利用该分层模型研究不同温度下电池放电过程中的电化学和热特性,得到更为真实的电池温度场分布。此外,介绍了表征电池单体内不同电池单元荷电状态分布的均匀指数。仿真表明,电池单体内的温度梯度差异加剧了不同电池单元间的过电位不一致和电流密度不一致程度,有利于进一步研究单体电池的衰退演化轨迹。

Abstract

A pouch-type lithium-ion battery is formed by stacking many cell units, in which the electrical and thermal behaviors of cell units have a great impact on the battery's overall safety. To study the relationship between cell units and the battery, a layered multi-dimensional model of a large-capacity pouch-type lithium battery was established by using the porous electrode theory, and the interaction between transient temperature changes and electrochemical reactions was considered. This layered model was used to study the electrochemical and thermal characteristics of the battery during discharging at different temperatures, and a more realistic battery temperature field distribution was obtained. In addition, the uniformity index that characterizes the distribution of the state of charge between different cell units was introduced. Simulation results show that the temperature gradient difference within the battery aggravates the inconsistency of overpotential and current density between different cell units, which is beneficial for further studying the battery's decay evolution trajectory.

关键词

软包锂离子电池 / 电化学热耦合模型 / 电池单元 / 电化学特性分析 / 热分析

Key words

pouch-type lithium-ion battery / electrochemical thermal coupling model / cell unit / analysis of electrochemical characteristics / thermal analysis

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参考文献

[1] Kang Jianqiang, Yan Fuwu, Zhang Pei, et al.Comparison of comprehensive properties of Ni-MH(nickel-metal hydride) and Li-ion(lithium-ion) batteries in terms of energy efficiency[J]. Energy, 2014, 70: 618-625.
[2] Fathabadi H.High thermal performance lithium-ion battery pack including hybrid active-passive thermal management system for using in hybrid/electric vehicles[J]. Energy, 2014, 70: 529-538.
[3] Doyle M, Fuller T F, Newman J.Modeling of galvanostatic charge and discharge of the lithium/polymer/insertion cell[J]. Journal of the Electrochemical Society, 1993, 140(6): 1526-1533.
[4] Fuller T F, Doyle M, Newman J.Simulation and optimization of the dual lithium ion insertion cell[J]. Journal of the Electrochemical Society, 1994, 141(1): 1-10.
[5] Gu W B, Wang C Y.Thermal-electrochemical modeling of battery systems[J]. Journal of the Electrochemical Society, 2000, 147(8): 2910.
[6] Zhang Xiaokun, Chang Xiaohuan, Shen Yingdong, et al.Electrochemical-electrical-thermal modeling of a pouch-type lithium ion battery: an application to optimize tem-perature distribution[J]. Journal of Energy Storage, 2017, 11: 249-257.
[7] Li Jie, Cheng Yun, Ai Lihua, et al.3D simulation on the in-ternal distributed properties of lithium-ion battery with pla-nar tabbed configuration[J]. Journal of Power Sources, 2015, 293: 993-1005.
[8] Xu Meng, Zhang Zhuqian, Wang Xia, et al.Two-dimensional electrochemical-thermal coupled modeling of cylindrical $LiFePO_4$ batteries[J]. Journal of Power Sources, 2014, 256: 233-243.
[9] Xu Meng, Zhang Zhuqian, Wang Xia, et al.A pseudo three-dimensional electrochemical-thermal model of a prismatic $LiFePO_4$ battery during discharge process[J]. Energy, 2015, 80: 303-317.
[10] Li Jie, Cheng Yun, Jia Ming, et al.An electrochemical-thermal model based on dynamic responses for lithium iron phosphate battery[J]. Journal of Power Sources, 2014, 255: 130-143.
[11] Chen Jingwei,Jiaqiang E,Kang Siyi,et al.Modeling and characterization of the mass transfer and thermal mechanics of the power lithium manganate battery under charging process[J]. Energy, 2019, 187: 115924.
[12] Ghalkhani M, Bahiraei F, Nzari G A, et al.Electrochemical-thermal model of pouch-type lithium-ion batteries[J]. Electrochimica Acta, 2017, 247: 569-587.
[13] Chen Mingbiao, Bai Fanfei, Song Wenji, et al.A multilayer electro-thermal model of pouch battery during normal dis-charge and internal short circuit process[J]. Applied Ther-mal Engineering, 2017, 120: 506-516.
[14] Wu Bin, Li Zhe, Zhang Jianbo.Thermal design for the pouch-type large-format lithium-ion batteries[J]. Journal of the Electrochemical Society, 2014, 162(1): A181-A191.
[15] Yi J, Kim U S, Shin C B, et al.Three-dimensional thermal modeling of a lithium-ion battery considering the combined effects of the electrical and thermal contact resistances be-tween current collecting tab and lead wire[J]. Journal of the Electrochemical Society, 2013, 160(3): A437-A443.
[16] Choa H M, Choia W S, Gob J Y, et al.A study on time-dependent low temperature power performance of a lithi-um-ion battery[J]. Journal of Power Sources, 2012, 198: 273-280.

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