

SOH and Cell Balance Estimation Using Non-Destructive Diagnostics During Cycle Aging of a Battery Pack Emulating Repurposed Use

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This study aims to establish safety assessment and non-destructive diagnostic methodologies for electric vehicle (EV) lithium-ion batteries following cycle-induced degradation, with a particular focus on diagnostic indicators based on the State of Health (SOH) and the State of Safety (SOS). In our previous work, we investigated non-destructive diagnostic techniques for battery packs comprising multiple series-connected cells. Using Charging curve analysis (CCA), we evaluated a ternary-chemistry battery pack configured as seven series-connected blocks, each consisting of six parallel cells, throughout its cycle degradation process. The capacities and cell balance variations of individual cell blocks were estimated, enabling highly accurate calculation of the total pack capacity. Furthermore, we observed that differences in cell balance between blocks with distinct degradation levels increased rapidly as cycling progressed.

Repurposed EV batteries represent a typical case in which battery packs are assembled from cells exhibiting heterogeneous degradation states. To analyze cell balance behavior under such conditions, we constructed a battery pack using cells with equivalent capacities sourced from modules previously subjected to independent high- and low-temperature cycling tests. Cycle degradation tests for battery packs emulating repurposed use (BP1 and BP2) were conducted under high and low temperature conditions. In addition to the CCA method, the State of Health (SOH) of the battery pack was evaluated using conventional methods, namely SOC estimation based on reference OCV–SOC characteristics and a capacity determination technique that integrates the current between two defined SOC points (the two-point SOC capacity method)

The estimated cell capacities and cell balance values were used to calculate the total pack capacity, which showed strong agreement with measured capacities. These results validate the proposed SOH estimation and cell balance diagnostic approaches for battery packs composed of cells with differing degradation histories.

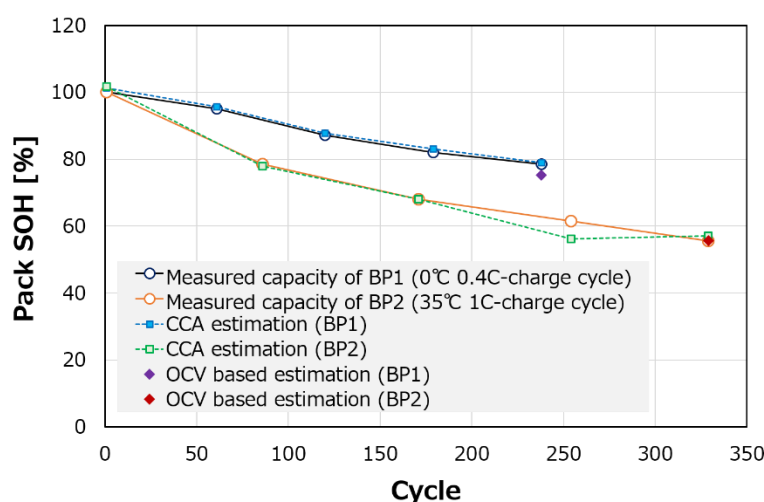


Fig.1 Measured and estimated battery pack capacities

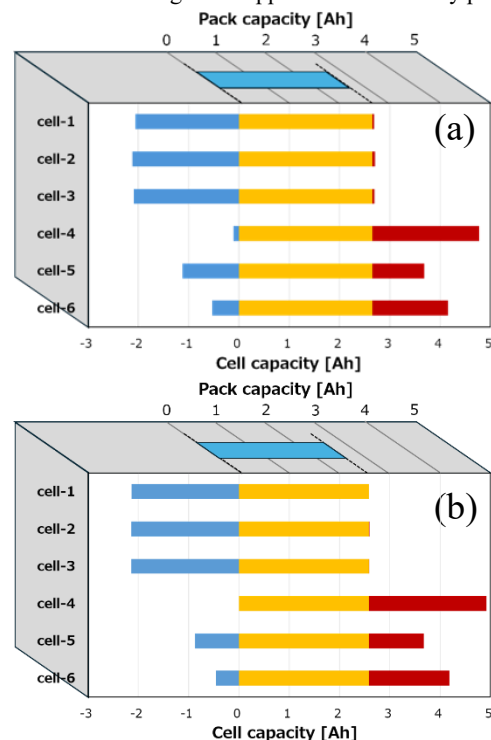


Fig.2 Estimation of individual cell capacity and cell balance for BP2 at the end of cycle test
(a) CCA method, (b) two-point SOC capacity method