SECOND-LIFE ASSESSMENT OF AUTOMOTIVE BATTERIES AT THE UNIVERSITY OF SZEGED

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Abstract

The growing number of electric vehicles has led to an increasing amount of end-of-life batteries that no longer satisfy user requirements, while efficient recycling practices are still in their early development stages. At the University of Szeged, we established a standardized analytical protocol based on the UL 1974 framework, enabling objective evaluation of various large-capacity battery types. In addition, we built the necessary laboratory infrastructure to safely disassemble cells and conduct post-mortem analyses. To date, more than ten batteries have been systematically tested using the developed methodology, and several dozen cells have been dismantled and examined in detail. This approach not only provides a reliable pathway for assessing second-life potential but also lays the foundation for future recycling strategies.

Introduction

The management of used lithium-ion batteries poses significant environmental and industrial challenges. Although some cells remain partially functional, their performance no longer meats the required characteristic and safety requirements for transportation. Nevertheless, their secondary use potential and the recovery of valuable raw materials are highly relevant. Based on international standards (e.g., ANSI/CAN/UL 1974), we set out to develop a laboratory-feasible, standardized protocol for the systematic characterization of second-life batteries.

Experimental

The following procedures were applied:

- physical inspection,
- insulation resistance
- open-circuit voltage measurements,
- charge–discharge cycling,
- state-of-health (SOH) estimation,
- self-discharge tests and internal resistance determination,
- micro CT-scan
- disassembly of the bad cells,
- postmortem analysis of the cell materials.

Before disassembly, the cells were first examined using micro-CT imaging to identify apparent structural issues. Following this non-destructive screening, defective cells, primarily $LiFePO_4$ cathode-based, were dismantled under safe conditions, either in a glovebox or under a fume hood with humidity monitoring. The cell casing was opened by scoring and cutting, followed by electrolyte removal through puncturing and draining. After unrolling the jelly roll, electrodes and separators were inspected for typical failures such as separator perforation, black spots, discontinuities, and graphite detachment from the copper foil.

Results and discussion

We successfully developed and applied a systematic battery analysis method at the university. Open-circuit voltage and insulation values were adequate in several cells, while others fell below acceptable limits. Charge–discharge tests revealed stable performance within the operational voltage range in many analyzed cells, without significant temperature rise. Autolab measurements indicated SOH values of ~98% for new cells, and as low as 60% for used ones. Degraded cells exhibited a threefold increase in internal resistance and self-discharge rates of ~0.5–0.7% per month.

Prior to disassembly, micro-CT imaging was carried out to identify hidden structural anomalies. This technique revealed, in one case, the presence of iron filings inside a cell, likely introduced during the manufacturing process. Subsequent post-mortem analysis of faulty cells confirmed typical structural damages, including separator punctures, ceramic coating detachment, and graphite loss. These combined results demonstrate the complementary value of non-destructive imaging and destructive inspection in identifying both operational degradation and assembly-related defects.

Conclusion

The proposed methodology allows for an objective assessment of used battery cells and facilitates the distinction between units suitable for reuse and those requiring disposal and recycling. Our results may support the standardization of battery recycling processes in Hungary and provide a foundation for future second-life applications.

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