Battery Pack Life Estimation through Cell Degradation Data and Pack Thermal Modeling for BAS+ Li-Ion Batteries

Cooperative Research and Development Final Report

CRADA Number: CRD-12-489

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CRADA Report
NREL/TP-5400-66171
March 2016

Contract No. DE-AC36-08GO28308

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In accordance with Requirements set forth in Article XI, A(3) of the CRADA document, this document is the final CRADA report, including a list of Subject Inventions, to be forwarded to the Office of Science and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

Parties to the Agreement: General Motors, LLC

CRADA Number: CRD-12-489

CRADA Title: Battery Pack Life Estimation through Cell Degradation Data and Pack Thermal Modeling for BAS+ Li-Ion Batteries

Joint Work Statement Funding Table Showing DOE Commitment:

Estimated Costs	NREL Shared Resources
Year 1	$ 75,000.00
TOTALS	$ 75,000.00

Abstract of CRADA Work:

Battery life estimation is one of the key inputs required for Hybrid applications for all GM Hybrid / EV/ EREV / PHEV programs. For each Hybrid vehicle program, GM has instituted multi-parameter design of experiments generating test data at cell level, and also pack level, on a reduced basis. Based on experience, generating test data on a pack level is found to be very expensive, resource intensive, and sometimes less reliable. The proposed collaborative project will focus on a methodology to estimate battery life based on cell degradation data combined with pack thermal modeling. NREL has previously developed cell-level battery aging models and pack-level thermal/electrical network models, though these models are currently not integrated. When coupled together, the models are expected to describe pack-level thermal and aging response of individual cells. GM and NREL will use data collected for GM's BAS + battery system for evaluation of the proposed methodology and assess to what degree these models can replace pack-level aging experiments in the future.

Summary of Research Results:

In addition to cell-level aging effects, lifetime of electric-drive vehicle (EDV) batteries is also impacted by pack-level effects. For accurate life prediction, it is important to capture factors that contribute to non-uniform aging of cells in a multi-cell pack. These include the effect of temperature gradients within the pack and cell non-uniform aging processes.

In FY13, NREL combined previously developed cell and pack models to create a pack-level life prediction tool. The tool was validated using proprietary data shared by GM under a CRADA. First, a cell-level life model was regressed to aging data for a Nickel-Manganese-Cobalt (NMC)

chemistry Li-ion cell. Next, a cell electrical circuit model was regressed to HPPC data for the same cell and linked to the life model to describe cell performance changes with aging. A pack thermal model was regressed to pack thermal characterization experiments, capturing cell heat generation with drive cycle and heat dissipation through passive and active cooling paths.

The cell life and electrical models were linked with the pack-level thermal/electrical model to create a predictive tool for pack-level lifetime. The model-based process greatly reduces the need to run pack-level aging experiments, saving substantial cost from the battery engineering development process. The proprietary NMC pack life models are being implemented in NREL's Battery Ownership model to enhance the fidelity of future technoeconomic analysis of EDV batteries.

Subject Inventions Listing:

None

Report Date:

21 January 2016

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