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Incremental Capacity Analysis of a Lithium-ion Battery Pack for Different Charging Rates

Theodoros Kalogiannis a, Daniel-Ioan Stroe a, Jonas Nyborg b, Kjeld Nørregaard b
Andreas Elkjær Christensen c and Erik Schaltz a

a Department of Energy Technology, Aalborg University, Denmark
b Danish Technological Institute, Aarhus 8000, Denmark
c Lithium Balance A/S, Hassellund 13, Sømrum, 2765 Denmark

Email: thk@et.aau.dk

Motivation

Incremental Capacity Analysis (ICA) is a method used to investigate the capacity State-of-Health (SoH) of battery cells [1]. The aim of this poster is to present the challenges for implementing the ICA technique for battery packs, here consisted of 14 cells, by means of different C-rates (C/10, C/6 and C/5) and for several temperatures. LFP chemistry based cells are connected in series to build the packs, for either 60Ah and 160Ah.

Experimental Setup

14*Winston 160Ah LiFeYPO4 cells at C/6 between 5\(^\circ\) and 30\(^\circ\)C
14*CALB 60Ah LiFePo4 cells at C/5 and C/10 charge current rate

Direct & Terminal ICA

- **Charge Voltages:** at C/10 & C/5
- **Charge Voltages:** at C/10 for Charger & BMS
- **Terminal ICA:** at C/6
- **Terminal ICA:** at C/5

ICA Method

- **Incremental Capacity Analysis:**
  \[ IC = \frac{dQ}{dV} \]
  At a chosen \( \Delta V \) (5~25mV) [2]
- Several approaches in literature for wide range of chemistries, capacities and cell designs [3]
- For many different C-rates and temperatures [4]
- Significance at a battery pack level not yet established
- Smoothing of raw data and filtering of charge/discharge capacity curves, to achieve an identifiable and unique IC peak

Results

- **Direct ICA:** Less than 1mV deviation to the averaged cells ICA
- **Terminal ICA:** Approx. 10mV deviation to the averaged ICA
- **Terminal ICA** sees a higher impedance path compared to direct
- **Variable temperatures for C/6:** For the 160Ah battery pack. The peak moves to the lower voltage levels due to lower resistance, which is caused by a higher temperature
- **160Ah battery pack charged with C/6 at 5\(^\circ\)C:** spread of the individual cells’ peaks due to inactivity of balancing during charging. Charge is stopped when a cell reaches cut-off limit.

ICAs influenced from temperature variations on the pack level

References


Conclusion & Future Work

- The additional Z path, the temperature variations and the C-rates must be considered for ICA on a battery pack.
- **Terminal ICA** is not deriving the actual capacity SoH of the cells.
- **Outlook:** Lifetime experiments at pack level under certain conditions.

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