Electrochemical study of durability aspects in large vehicle batteries

Abdilbari Shifa Mussa, Matilda Klett, Göran Lindbergh, Rakel Wreland Lindström

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Title: Electrochemical study of durability aspects in large vehicle batteries

Period: 2015-01-01 - 2017-12-31 (3 months extension 2018)

PL: Rakel Wreland Lindström, Applied Electrochemistry, KTH

Program: Energy effective vehicles

Budget: 2 311 000 SEK

Associated to:
- Swedish Electromobility Centre
- Fast charging of large energy optimized Li-ion cells for electrical drivelines (Batterifonden project)
Batteries age with time and use. It is a performance, cost, and safety issue!

→ The goal is to increase the lifetime of batteries by optimizing the usage conditions for better performance and minimized ageing.
→ Improving battery lifetime decrease safety risks!

Our objectives:
• Understand how fast-charging affects battery lifetime
• Identify and quantify internal battery state-of-health using non-destructive electrochemical techniques
• Understand non-uniform ageing in large format cells
• Identify the conditions that cause the non-uniform ageing
Li-ion battery

Matal oxides (NMC, LCO...)
Metal phosphates (LFP)

Graphite

Adapted from: https://casatech6.wikispaces.com/Rechargeable+Batteries
Li-ion battery

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Li-ion battery ageing mechanisms

http://epg.eng.ox.ac.uk/content/degradation-lithium-ion-batteries
Why lower ageing during fast charging?

Temperature? - No
0.5 C => 26.5 °C
1.5 C => 30 °C

Charing current? - No

State-of-Charge range? - Yes!

Full charging aged the battery more than the fast charging!
What happens inside?

A voltage fitting non-destructive analysis

- Cell capacity loss completely dominated by loss of cyclable lithium!
- Negligible graphite active mass loss
- Significant NMC/LMO active mass loss that doesn’t affect cell capacity loss

What happens inside?

Post-mortem analysis

NMC/LMO capacity

Non-uniform ageing in graphite electrode

Graphite capacity

- Post-mortem analysis confirmed the non-destructive analysis
- The electrode jelly-roll aged non-uniformly

What cause non-uniform ageing

- Pressure distribution
- Temperature distribution
- Current distribution
Pressure cell

- Battery tabs
- Heating element
- Pressure spring
- Thermocouple hole
Effect of pressure on performance

- Higher pressure $\rightarrow$ higher impedance
- Differences lead to current distribution

Impedance in a fresh cell

Parallel cells

[Graph showing impedance vs. ohm*cm² for different pressures]
Effect of pressure on single cell ageing

- There is optimal pressure that extends the battery life
- The optimal pressure reduces cyclable lithium loss
No significant increase in ageing is found at the low pressure (0.66 MPa) cell coupled to the cell with the optimal pressure (1.32 MPa).

Pressure distribution causes current distribution but does not affect ageing rate.
Effect of temperature on ageing

- Cell impedance decreases with temperature
- Ageing increases with temperature
- Temperature distribution lead to current distribution
- No non-uniform ageing due to temperature distribution in parallel connected cells (32-40°C)
Thank you for your attention!

Mussa
KTH, Applied electrochemistry
asmussa@kth.se