Temperature Regulation for Li-ion Cells

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Thermal Management Challenges in Large, Thick Cells

Thermal management of bigger and thicker cells, high capacity cells, at higher C-rates requires new design: Additional thermal tabs are used for heat transfer!

A 4.3 Ahr NMC Cell Equivalent to NMC 25 Ah Cells

6 mm 4.3 Ahr

13 mm 10 Ahr
Cooling from Pouch Surface is Very Ineffective!

**Ice Block Cooling Through the Pouch**

- Cooling from the surface is only effective few layers deep
- Confirms the need for alternative cooling
Side Cooling of a New Cell with Thermal Tabs Using a Water Chiller

- 9.5 Ah NMC cell with thermal tabs
- Cooling temperature can be changed 20-24°C
- Resolution: 0.1°C
- For demonstration only and the designs can be further refined

Modeling Results
Side Cooling Results: Experiment and Modeling

2.5C Experiment

5C Discharge Modeling

- Experiments have additional resistance due to uneven contact that is not included in the simulations
- Idealized boundary conditions can be achieved through engineering and thus improved cooling
Future Work and Test Matrix

2014 Plan:
- High C-rate cooling tests
- Cycling comparison:
  a. Baseline cell
  b. Thick cell (no cooling)
  c. Thick cell (surface cool)
  d. Thick cell (side cool)
- Modeling work:
  1. Form factors
  2. Various cell design
  3. Cooling options
- Technology-to-market

Benefits:
Side cooling should improve lifetime/safety in current designs and allow for a new generation of bigger cells with acceptable thermal behavior.

Test Matrix

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Protocol</th>
<th>Cell Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thin</td>
<td>1-Cycle (1C to 5C discharge)</td>
<td>A</td>
</tr>
<tr>
<td>Thick</td>
<td>1-Cycle (1C to 5C discharge)</td>
<td>B</td>
</tr>
<tr>
<td>Thick with side cooling</td>
<td>1-Cycle (1C to 5C discharge)</td>
<td>C</td>
</tr>
<tr>
<td>Thin with no cooling</td>
<td>Cycling (1C charge, 5C discharge till 80%)</td>
<td>A</td>
</tr>
<tr>
<td>Thick with no cooling</td>
<td>Cycling (1C charge, 5C discharge till 80%)</td>
<td>B</td>
</tr>
<tr>
<td>Thick with standard surface cooling</td>
<td>Cycling (1C charge, 5C discharge till 80%)</td>
<td>B</td>
</tr>
<tr>
<td>Thick with side cooling</td>
<td>Cycling (1C charge, 5C discharge till 80%)</td>
<td>C</td>
</tr>
</tbody>
</table>

Three Types of Cells:

A. Thin cells: Thin
B. Thick cells: Thick
C. Thick cells with side-cooling layers: Thick with Side-cooling