Research of Battery Durability Performance

• Based on Lithium Ferrous Phosphate Battery

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BYD all research on Lithium Ferrous Phosphate Battery, implemented on vehicles as bus K9 (pure EV), passenger car e6 (pure EV)
Six aspects are considered regarding parameter of battery durability performance:
Durability cycle testing shall be carried out based on five aspects below:

- temperature
- rate
- cycle
- charging/discharging depth
- vibration

Different factors could influence each feature of battery durability performance and different batteries will also have different performance. In order to explain the researching method, following BYD research achievements will be presented for battery durability performance.
 Battery durability performance—capacity

Room temperature (20°C ± 5°C), testing cycle:
1. Refer to Standard QC / T 743 Lithium battery for EV;
2. Testing cycle: charge to 100% SOC with 0.5c constant current, and then implement cycle standard discharging till reaching cut-off voltage;
3. With ratio of total output energy during cycles and initial energy, convert into the cycles times in the graph.
4. Compare the influence to battery capacity fading under different cycle conditions with the same output energy.

Battery cycle capacity fading is slightly slower than constant current cycle.
• Battery durability performance—storage

**Result analysis:**
1. Under certain condition, battery capacity decreases regularly with storage time increase;
2. Under same storage temperature, capacity fading is faster when battery SOC is higher after storage;
3. Under same SOC, capacity fading is faster when storage temperature is higher.
• Battery durability performance—DC internal resistance (DCIR)

DCIR: when SOC is below 50%, voltage (produced when battery is discharging with 1.5C constant current for 30s) is divided by discharging current

With battery capacity fading caused by cycles, battery DCIR changes regularly, also with big fluctuation.
• Battery durability performance—power

Room temperature (20°C ± 5°C), testing cycle
1. Refer to Standard QC / T 743 Lithium battery for EV;
2. Testing cycle: charge to 100% SOC with 0.5c constant current, and then implement cycle standard discharging till reaching cut-off voltage;
3. Power: SOC below 50%, it is the power produced when battery is discharging with 1.5C (300A) constant current for 30s.

With cycle condition at room temperature, SOC below 50%, battery power does not change with battery capacity decrease.
• Battery durability performance—temperature

Ratio of charging/discharging capacity at different temp. and capacity at room temp. changes with fading of battery capacity result analysis
1. Low temp. discharging capacity ratio gradually increase with fading of battery capacity, high temp. discharging ratio increase slightly with fading of battery capacity but not obvious.
2. Low temp. charging capacity ratio gradually decrease with fading of battery capacity, high temp. charging ratio gradually increase with fading of battery capacity.
• Battery durability performance—rate

**Different rate discharging:** fully charged at room temp., then discharge with different rate

**Different rate charging:** fully discharged at room temp., then charge with different rate

Ratio of different rate charging/discharging capacity and 0.5C capacity change with battery capacity fading result analysis:
1. With battery capacity fading, battery capacity ratio almost remains the same.
2. With battery capacity fading, battery capacity ratio decrease with rate increase when high rate charging.
Analysis:
After investigating charging /discharging current data of five BYD buses from Shenzhen area for three months, charging/discharging current diagram above was derived. Data above was categorized into several levels below:

<table>
<thead>
<tr>
<th>Charging rate</th>
<th>Ratio</th>
<th>Discharging rate</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/3C</td>
<td>18%</td>
<td>1/3C</td>
<td>11%</td>
</tr>
<tr>
<td>1/6C</td>
<td>9%</td>
<td>1/6C</td>
<td>11%</td>
</tr>
<tr>
<td>1/15C</td>
<td>9%</td>
<td>1/15C</td>
<td>42%</td>
</tr>
</tbody>
</table>
After investigating charging /discharging current data of five BYD passenger vehicles (Taxi) from Shenzhen area for three months, charging/discharging current diagram above was derived. Data above was categorized into several levels below (200AH cell):

<table>
<thead>
<tr>
<th>Charging rate</th>
<th>Ratio</th>
<th>Discharging rate</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/5C</td>
<td>15%</td>
<td>1/5C</td>
<td>52%</td>
</tr>
<tr>
<td>1/2C</td>
<td>19%</td>
<td>1/2C</td>
<td>12%</td>
</tr>
<tr>
<td>1C</td>
<td>/</td>
<td>1C</td>
<td>2%</td>
</tr>
</tbody>
</table>
Thank You!

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