Testing And Analysis Of Li-Ion Battery For Electric Vehicles Application

Dr. P. S. Raghavendran, T. Abinaya, P. Karthikeyan

Abstract: Lithium-ion batteries are ordinarily used for moveable physics and electrical vehicles and are growing in quality for military and part applications. Over the past many decades, the quantity of electric vehicles has continued to extend. Projections estimate that worldwide quite a hundred twenty-five million electrical vehicles are going to be on the road by our future generations. At the guts of those advanced vehicle is that the lithium-particle [Li-ion] battery that provides to needed energy storage. This project gift Li-ion batteries and their associated battery management systems, similarly as approaches to enhance overall battery potency, state of charge, voltage and current analysis, life span. The planned work helps to analysis the battery that aims to develop the Li-ion battery performs higher in action. Additionally, the interior resistance of the battery is going to be analyzed for the longer-term scope for increasing the generation, similarly as opportunities to repurpose and recycle the batteries.

Index Terms: Current, Life Span, State Of Charge (SOC), Voltage

1 INTRODUCTION
Batteries give the most supply of electricity before the event of electrical grids around the finish of the nineteenth century. Most of the vehicles, during these times still exploitation fuel. High usage of fuel, produce the matter atmospheric phenomenon and additionally shortage of fossil energy. So most of the country inspired the realize the new renewable power energy automotive company for substitution. One of the choices of energy for the work unit is a battery. Batteries are classified into 2 varieties. They are primary battery and secondary battery. The first battery is additionally known as a non-reversible battery and therefore and the secondary battery is also called a rechargeable battery.

2 LITHIUM-ION BATTERY FAILURE
This section describes the Lithium-ion battery failure. This will be mainly happened due to overvoltage, improper lithium plating, overheating, under-voltage/over-discharge, temperature effects[4]

COMMON REASONS FOR BATTERY SULFATION
1. Batteries sit excessively long between charges. As little as 24 hours in hot climate and few days in a cooler climate. Sulfations develop on the battery plates.
2. The battery is put away without some kind of energy input.
3. Incorrect charging levels and settings. For example, the undercharging of a battery to just 90% of limit will permit sulfation of the battery utilizing the 10% battery not reactivated and not finishing the charging cycle.
4. Low electrolyte level battery plates laid open to air will promptly sulfate.

3 OPERATION OF LITHIUM-ION BATTERY
During charging lithium ions (yellow circles) flow from the positive electrode (red) to the negative electrode (blue) through the electrolyte (gray). Electrons also flow from the positive electrode to the negative electrode and deposit lithium there. When no more ions will flow the battery is fully charged and ready to use. When all the ions have moved back, the battery is fully discharged and needs charging up again[4].

4 CHARGING PROFILE
The charging profile based on four different stages
1. Trickle-charge
2. Constant current charge
3. Constant voltage
4. Charge termination

TRICKLE CHARGE
The cell voltage is approximately 3V. The cell is charged with a constant current of a maximum 0.1C.

CONSTANT CHARGING CURRENT
The range is between 0.2C to 0.1C. Constant current rates above 1C.

CONSTANT VOLTAGE
The voltage regulation tolerance should be better than +1%. Voltage state is invoked and cell voltage reaches 4.2V.

CHARGE TERMINATION
The minimum current senses the charging current during the constant voltage stage diminishes in the range of 0.002c to 0.007c. It will depleted in 2.5 hours to 3 hours.
5 PROCEDURE FOR CHARGING LITHIUM-ION BATTERY
1. Charge the battery when the temperature is 50-86°F (10-30°C).
2. Lithium-ion batteries run the most effective within the recommended temperature range.
3. However, lithium-ion batteries can be charged at temperature between 32-113°F (0-45°C) if necessary.
4. Lithium-ion does not need to be fully charged: a partial charge is better.
5. Over discharged batteries can be “boosted” to life again. Discard pack if the voltage does not rise to a normal level within a minute while on boost.

6 BATTERY STATE OF CHARGE
SOC is the level of charge of an electric battery relative to its capacity. The units SOC are percentage points (0% = empty; 100% = full). SOC is normally used when discussing the current state of a battery in use. The battery desires to be charged and discharged at a constant rate such as coulomb-counting.[6]
In general, there are five methods to determine SOC indirectly:
1. Chemical
2. Voltage integration
3. Kalman filtering
4. Pressure

7 DEPTH OF DISCHARGE
For example, if you have a 100amp hour battery and use 50amp hours you have discharged the battery 50%. The same battery discharged it only 20amp hours or 20% of the battery, your depth of discharge will be 20 %, 50% can result in less than 300 total cycles. 100% DOD and there is no long term effect. You can expect to get 3000 cycles or more at this depth of discharge.

8 BATTERY DISCHARGE CYCLE
Batteries are seldom fully discharged and often use the 80 percent DOD formula to rate a battery. The 80% of available energy is delivered and 20% remains in reverse.

BATTERY SPECIFICATION
Voltage : 60V
Capacity : 32Ah
Nominal drop voltage : 3.7V
Maximum voltage : 4.2V
Minimum drop voltage : 3V
Full charge voltage : 67.2V

8.1 PRACTICALLY TESTED
In table 1 the battery 1 is discharged. The discharging current is 35 amps. It is tested for four cycles with the same battery. It is analyzed that the battery having a different capacity.

Table.1 Battery 1 discharge cycle

<table>
<thead>
<tr>
<th>CYCLE</th>
<th>SPEC</th>
<th>I</th>
<th>FCV</th>
<th>CV</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.67</td>
<td>52.89</td>
<td>29.03</td>
</tr>
<tr>
<td>2</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.85</td>
<td>51.73</td>
<td>30.03</td>
</tr>
<tr>
<td>3</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.67</td>
<td>50.89</td>
<td>28.63</td>
</tr>
<tr>
<td>4</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.67</td>
<td>51.49</td>
<td>27.65</td>
</tr>
</tbody>
</table>

In the table2 the battery 2 is discharged. The discharging current is 35 amps. It is tested for four cycles with the same battery. It is analyzed that the battery having a different capacity.

Table.2 Battery 2 discharge cycle

<table>
<thead>
<tr>
<th>CYCLE</th>
<th>SPEC</th>
<th>I</th>
<th>FCV</th>
<th>CV</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.36</td>
<td>47.28</td>
<td>30.16</td>
</tr>
<tr>
<td>2</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.77</td>
<td>47.17</td>
<td>30.83</td>
</tr>
<tr>
<td>3</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.53</td>
<td>52.57</td>
<td>27.68</td>
</tr>
<tr>
<td>4</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.86</td>
<td>51.48</td>
<td>29.92</td>
</tr>
</tbody>
</table>

In the table2 the battery 2 is discharged. The discharging current is 35 amps. It is tested for four cycles with the same battery. It is analyzed that the battery having a different capacity.
In table 3 the battery 3 is discharged. The discharging current is 35 amps. It is tested for four cycles with the same battery. It is analyzed that the battery having a different capacity.

**Table 3** Battery 3 discharge cycle

<table>
<thead>
<tr>
<th>CYCLE</th>
<th>SPEC</th>
<th>I</th>
<th>FCV</th>
<th>CV</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.36</td>
<td>47.28</td>
<td>30.16</td>
</tr>
<tr>
<td>2</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.77</td>
<td>47.17</td>
<td>30.83</td>
</tr>
<tr>
<td>3</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.53</td>
<td>52.57</td>
<td>27.68</td>
</tr>
<tr>
<td>4</td>
<td>60V/30Ah</td>
<td>35</td>
<td>66.86</td>
<td>51.48</td>
<td>29.92</td>
</tr>
</tbody>
</table>

BAT- Battery, SPEC-Specification, I-Current, FCV- Full charge voltage, CV- Cut-off voltage, Ah- Capacity

In table 4 the battery 1, battery 2, battery 3, battery 4, battery 5 is discharged. The discharging current is 25 amps. It is tested for five cycles with different batteries. It is analyzed that the battery having a different capacity.

**Table 4** Different Battery discharge cycle

<table>
<thead>
<tr>
<th>CYCLE</th>
<th>BAT</th>
<th>SPEC</th>
<th>I</th>
<th>FCV</th>
<th>CV</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BAT 1</td>
<td>60V/30Ah</td>
<td>25</td>
<td>66.81</td>
<td>46.87</td>
<td>31.24</td>
</tr>
<tr>
<td>2</td>
<td>BAT 2</td>
<td>60V/30Ah</td>
<td>25</td>
<td>66.74</td>
<td>47.23</td>
<td>31.48</td>
</tr>
<tr>
<td>3</td>
<td>BAT 3</td>
<td>60V/30Ah</td>
<td>25</td>
<td>66.85</td>
<td>46.81</td>
<td>31.71</td>
</tr>
<tr>
<td>4</td>
<td>BAT 4</td>
<td>60V/30Ah</td>
<td>25</td>
<td>66.74</td>
<td>48.00</td>
<td>30.73</td>
</tr>
</tbody>
</table>

**Fig 5. Battery 2 Discharge cycle**

**Fig 6. Battery 3 Discharge cycle**

8.2 **BATTERY SOC Vs CAPACITY ANALYSIS**

<table>
<thead>
<tr>
<th>STATE OF CHARGE</th>
<th>CAPACITY(AH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>32</td>
</tr>
<tr>
<td>90</td>
<td>28.8</td>
</tr>
<tr>
<td>80</td>
<td>25.6</td>
</tr>
<tr>
<td>70</td>
<td>22.4</td>
</tr>
<tr>
<td>60</td>
<td>19.2</td>
</tr>
<tr>
<td>50</td>
<td>16</td>
</tr>
<tr>
<td>40</td>
<td>12.8</td>
</tr>
<tr>
<td>30</td>
<td>9.6</td>
</tr>
<tr>
<td>20</td>
<td>6.4</td>
</tr>
<tr>
<td>10</td>
<td>3.2</td>
</tr>
</tbody>
</table>

**Fig 7. Battery 3 different batteries with the same discharge current ratings.**

**Fig 8. BATTERY SOC VS Ah**

**BATTERY SPECIFICATION**

Voltage: 48V  
Capacity: 24Ah  
Full charge: 54.6V  
Output Current: 6A  
Input current: max 4A  
Maximum voltage: 4-2V
Nominal voltage : 3.7V

**COMPARISON OF TWO BATTERIES**
Current ratings: 15Amps, Full charge voltage: 54.6 V, Battery 1 and battery 2 voltage: 48V, Capacity: 24Ah
In the table 5 the battery is discharged. The discharging current is 15 amps...
It is analyzed that the battery having a different capacity.

*Table 5 COMPARISON OF TWO BATTERIES*

<table>
<thead>
<tr>
<th>BAT</th>
<th>SPEC</th>
<th>I</th>
<th>FCV</th>
<th>CV</th>
<th>Ah</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>48V/24Ah</td>
<td>15</td>
<td>54.6</td>
<td>44.04</td>
<td>22.63</td>
</tr>
<tr>
<td>2</td>
<td>48V/24Ah</td>
<td>15</td>
<td>54.6</td>
<td>41.05</td>
<td>22.89</td>
</tr>
</tbody>
</table>

BAT- Battery, SPEC-Specification, I-Current, FCV- Full charge voltage, CV- Cut-off voltage, Ah- Capacity

**9 SIMULATION MODEL OF BATTERY CIRCUIT**

**RC CIRCUIT**
An RC circuit is a circuit with both a resistor (R) and capacitor (C). RC circuits are a frequent element in electronic devices. The crucial parameters that describe the time dependence are the time constant RC.[10]

**CONSTANT CURRENT**
A constant current(steady-state current, time-independent current, stationary current) is a type of direct current(DC) that does not change in its intensity with time.

**CONSTANT VOLTAGE**
Constant voltage refers to the ability to fluctuate output current to maintain a set voltage.

**SIMULATION CIRCUIT PARAMETER VALUES**
Resistor (R) = 1000 ohm
Capacitor (C) = 0.2 mf
Amplitude = 20
Frequency = 500

**10 RC CHARGING CIRCUIT**
When a voltage source is applied to an RC circuit, the capacitor, C charges up through the resistance, R. When an increasing DC voltage is applied to a discharged capacitor the capacitor draws a charging current and charges up and when
the voltage is reduced, the capacitor discharges in the opposite direction.[4]

SIMULATION
PARAMETER VALUES
Resistor = 1k
Capacitor = 9mf
Dc voltage source = 9V

OUTPUT
The output of the RC charging circuit the output voltage increases.

The output of the RC charging circuit the output current decreased.

REFERENCES

RESULT AND CONCLUSION
From the above analysis, it is concluded that Li-ion battery is used in many electric vehicle applications. Because of their charging and discharging characteristics. In this paper, the different parameters are analyzed. The parameters are a state of charge, voltage, a current, capacity that is used to improve the performance and life span of the battery. The improvement in analysis gives the eco-friendly usage of lithium batteries.