DATA ANALYSIS

The dataset is from NASA Ames Prognostics Center of Excellence . To simulate the dynamic operation conditions in real applications, 18650 LiCoO2 batteries (2.1 Ah) were cycled under a series of random currents rather than the constant discharge currents. Each loading period lasted for 5 minutes. A 2 A charging and discharging test was performed after every 1500 periods (about 5 days) to measure the battery capacity. For our study, we used the data from B0005,B0006,B0007 and B0018 batteries. The failure thresholds for those batteries are considered as the capacities at the end of the test. The capacities are plotted against the test time (days). The capacity curve is highly dynamic and nonlinear.

Data Description

- **Number Of Battery Samples : 4**
- **No. of charge,discharge,impedance cycles for each battery : 616**
- **Parameters considered for charge cycle :**
  Voltage, current,temperature,current charge,voltage charge and time
- **Parameters considered for discharge cycle :**
  Voltage, current, temperature, current load,voltage load ,capacity and time

Parameters considered for impedance cycle :
Voltage_measured,Current_measured,Temperature_measured,Current_charge, Voltage_charge, Time,Capacity

Ambient Temperature considered for collecting data : 24℃

Parameter Description:

Data Structure:

cycle: top level structure array containing the charge, discharge and impedance operations

type: operation type, can be charge, discharge or impedance

ambient_temperature: ambient temperature (degree C)

time: the date and time of the start of the cycle, in MATLAB date vector format

data: data structure containing the measurements

For charge the fields are:

1. **Voltage_measured:** Battery terminal voltage (Volts)
2. **Current_measured:** Battery output current (Amps)
3. **Temperature_measured:** Battery temperature (degree C)
4. **Current_charge:** Current measured at charger (Amps)
5. **Voltage_charge:** Voltage measured at charger (Volts)
6. **Time:** Time vector for the cycle (secs)

For discharge the fields are:

1. **Voltage_measured:** Battery terminal voltage (Volts)
2. **Current_measured:** Battery output current (Amps)
3. **Temperature_measured:** Battery temperature (degree C)
4. **Current_charge:** Current measured at load (Amps)
5. **Voltage_charge:** Voltage measured at load (Volts)
6. **Time:** Time vector for the cycle (secs)
7. **Capacity:** Battery capacity (Ahr) for discharge till 2.7V

For impedance the fields are:

1. **Sense_current:** Current in sense branch (Amps)
2. **Battery_current:** Current in battery branch (Amps)
3. **Current_ratio:** Ratio of the above currents
4. **Battery_impedance:** Battery impedance (Ohms) computed from raw data
5. **Rectified_impedance:** Calibrated and smoothed battery impedance (Ohms)
6. **Re:** Estimated electrolyte resistance (Ohms)

Procedure:

1. Run through 3 different operational profiles (**charge, discharge and impedance**) at room temperature.

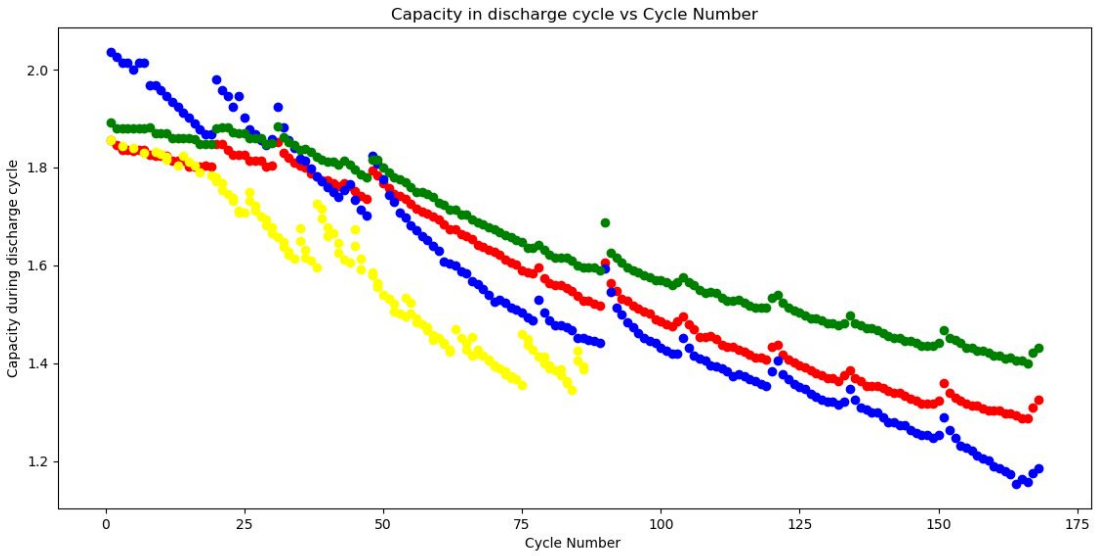
2. Charging is carried out in a constant current (CC) mode at 1.5A until the battery voltage reached 4.2V.

3. And then continued in a constant voltage (CV) mode until the charge current dropped to 20mA.

4. Discharge was carried out at a constant current (CC) level of 2A until the battery voltage fell to 2.7V, 2.5V, 2.2V and 2.5V for batteries 5 6 7 and 18 respectively.

5. Impedance measurement was carried out through an electrochemical impedance spectroscopy (EIS) frequency sweep from 0.1Hz to 5kHz. 6. Repeated charge and discharge cycles result in accelerated aging of the batteries while impedance measurements provide insight into the internal battery parameters that change as aging progresses.

6. The experiments is stopped when the batteries reached end-of-life (EOL) criteria, which was a 30% fade in rated capacity (from 2Ahr to 1.4Ahr).



Red:B0005 (168 cycles)
Blue:B0006 (168 cycles)
Green:B0007 (168 cycles)
Yellow:B0018 (132 cycles)
The above graph shows change in capacity w.r.t cycle number for all the four batteries. As the cycles number increases, the capacity of the batteries decreases and after 70% consumption of battery, the battery can no longer be used. The main parameter for prediction of RUL is the capacity of batteries.

The graph above is of cycle number and capacity.It shows the prediction of RUL with threshold value 1.25. The predicted RUL value is more than 6 days.