Trigger Method Development-Self-Heating

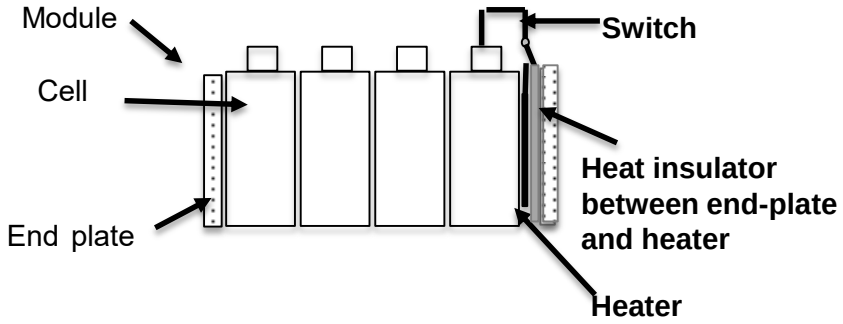
CATL

Introduction

- The remarkable feature of this method is that there is no additional energy compared to a fully charged cell
- The purpose of this method is to use the energy discharged by the battery itself, heating a physical resistance to trigger the battery go to thermal runaway
- Easy for assembling
- Possible for automatic control
- …

Test Set Up：Self-Heating Method

- Test procedure(brief，see the attachment for details)：
  - Assembly
  - Switch on, start self-heating
  - Switch off once thermal runaway



The resistor we used in this

Type	Dimension	Rated capacity	Suitable cell
Metal insulated	130*90*3mm	300~600w (approx. 5 w/cm^2)	Pouch & Prismatic

Heater under development

Proposed heater selection rule

- The resistance sealed without “heated and flushed metal” exposure
- Resistor selection: wouldn’t melt cell can/pouch package, and heating power should smaller than the continuous current interrupter that the cell can bear, but enough for thermal runaway initiation
- The heater should parallel to the cell surface, and similar area with the contacted cell surface is preferred, which wouldn’t lead additional gap between cell-cell or cell-end plate.
- …

Test Set Up：Self-Heating Method(Detailed Draft)

Pre-condition	• Temperature: 25±5℃ • Humidity: 15%~90% • Air condition: ≤10m/s • Voltage acquisition accuracy: ±0.5mV • Atmospheric pressure : 86kpa~106kpa • Resistance acquisition accuracy:±2mΩ
Process	• Connect the self-heating resistance with the initiation cell, which is from the positive electrode (or negative electrode) to the heating resistance, see Figure 1 • Any external wires need be acquired, which provides the way to charge the disperse units of the modified module. • Heating area of the self-heater is directly contacting the cell surface and it is not larger than the surface of that. • The heater position is correlated with the temperature sensor position, which is described in Figure 2. • The state of charge (SOC) shall be adjusted. • After installation, the self-heater should be reached to its fixed power, which depends on the energy of the battery pack. • Turn off the switch, when thermal runaway occurs. The temperature and voltage should be observed in period.. • The test shall be conducted at an indoor test facility or in a shelter to prevent the influence of wind.

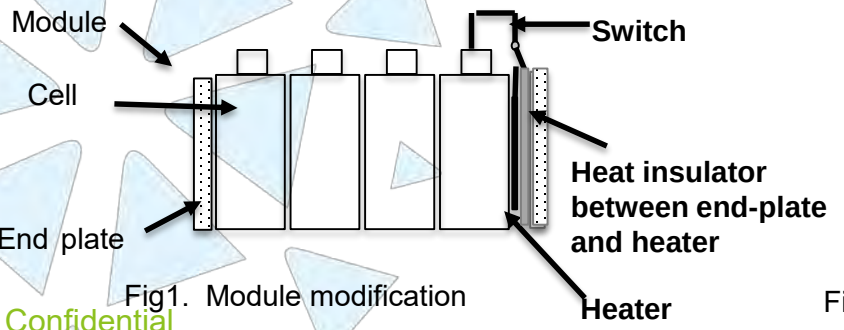


Fig1. Module modification

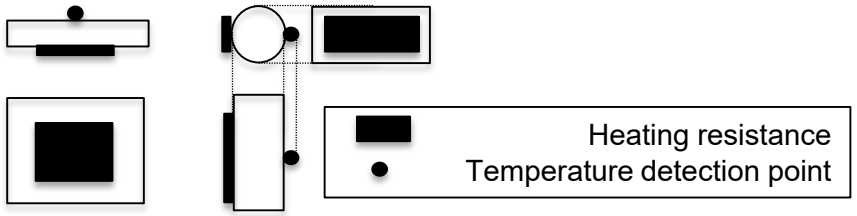
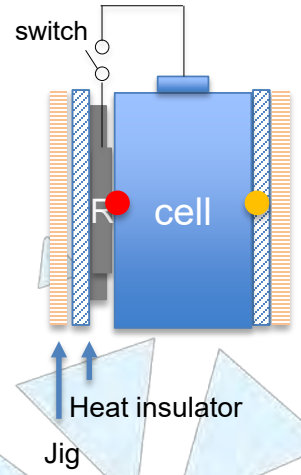
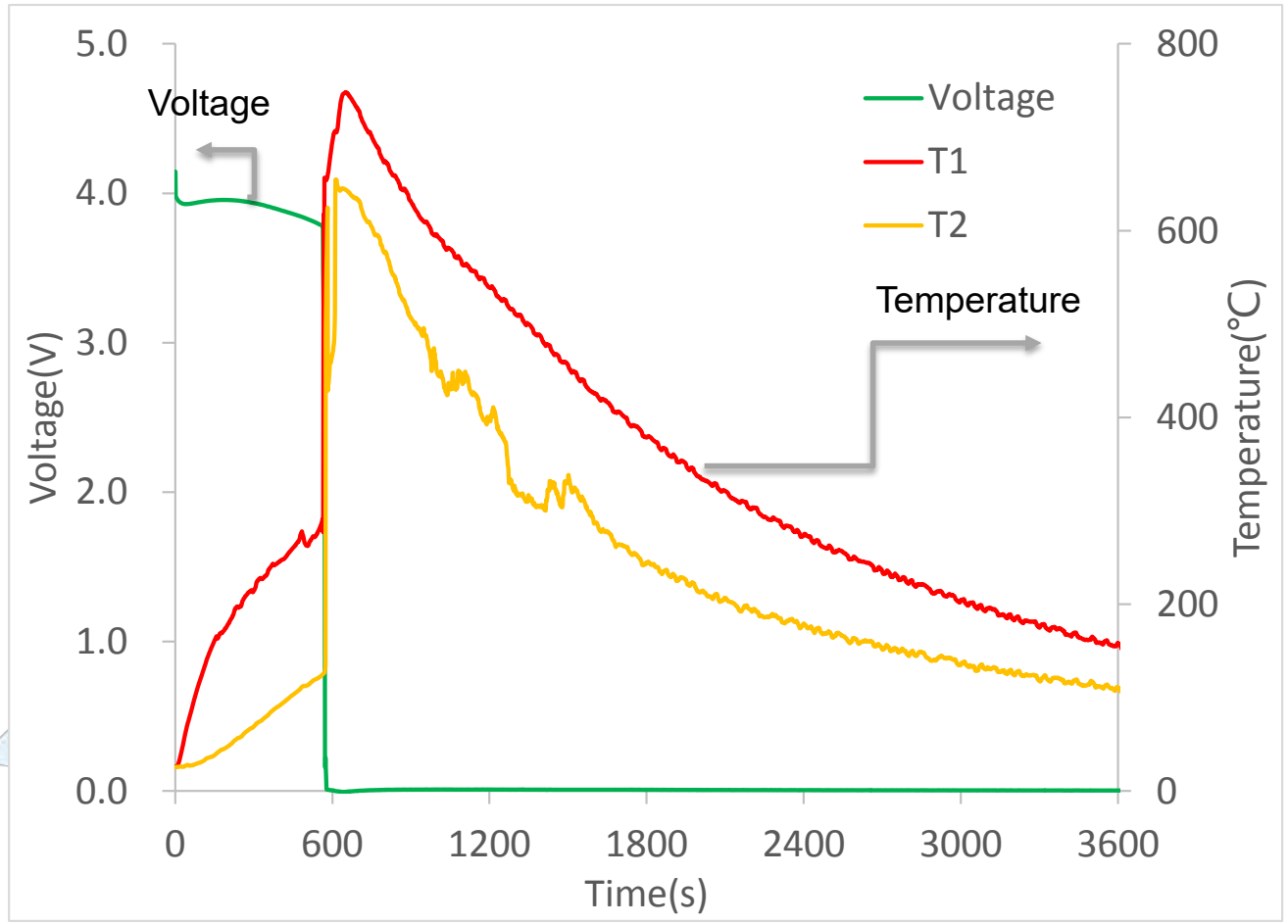


Fig2. Schematic diagram of temperature sensor layout during heating

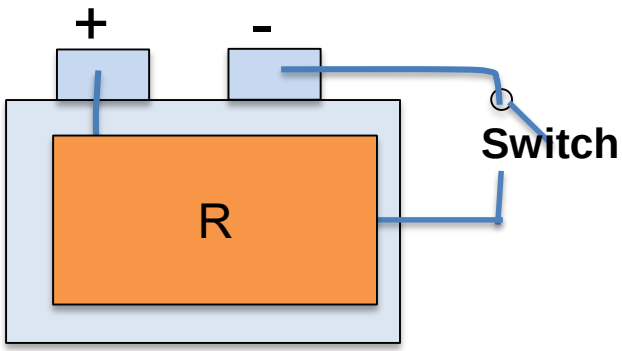
Single Cell Test Result_ An Example

- Prismatic





Energy Transformation

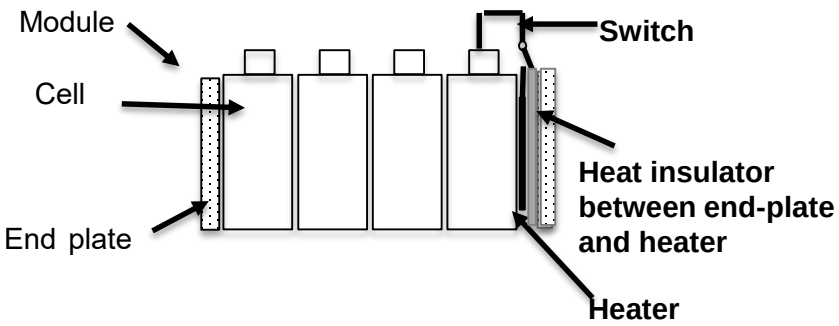


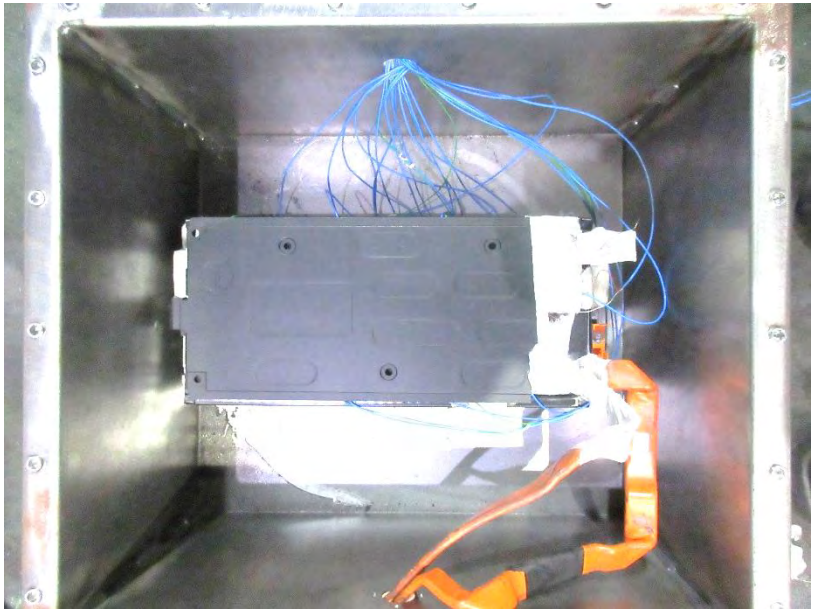
- **Q : Energy release before cell thermal runaway**, $Q = \int_0^{t1} idt$
- **Q_b : Total Energy absorbed by the heating resistance,** $Q_b = \int_{T0}^{T1} C_{p\_h} * m_h * dT$
- **Q_c : Dissipated heat with the environment,** $Q_c = \int_{T0}^{T1} h * AdT$, h=5 W/(m^2*K)
- **Q_d: Radiant Energy,** $Q_d = \varepsilon * A * \sigma * (T_1^4 - T_2^4)$, $\sigma = 5.67 * 10^{-8} W/(m^2 * K^4)$

Sample	Q(kJ)	Q_b(kJ)	Q_c(kJ)	Q_d(kJ)	$(Q_b+Q_c+Q_d)/Q$
Example	~198.4	~5.1	~2.3	~1.9	~4.7%

Module Level Test Result_ An Example

- Prismatic module-1
  - 1P4S



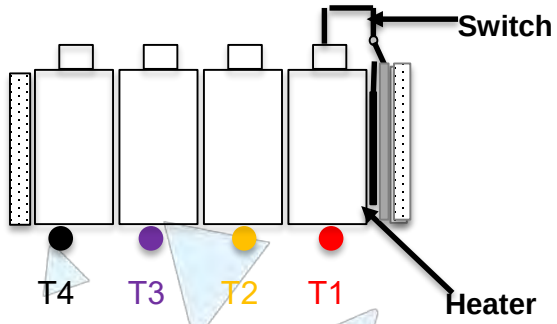


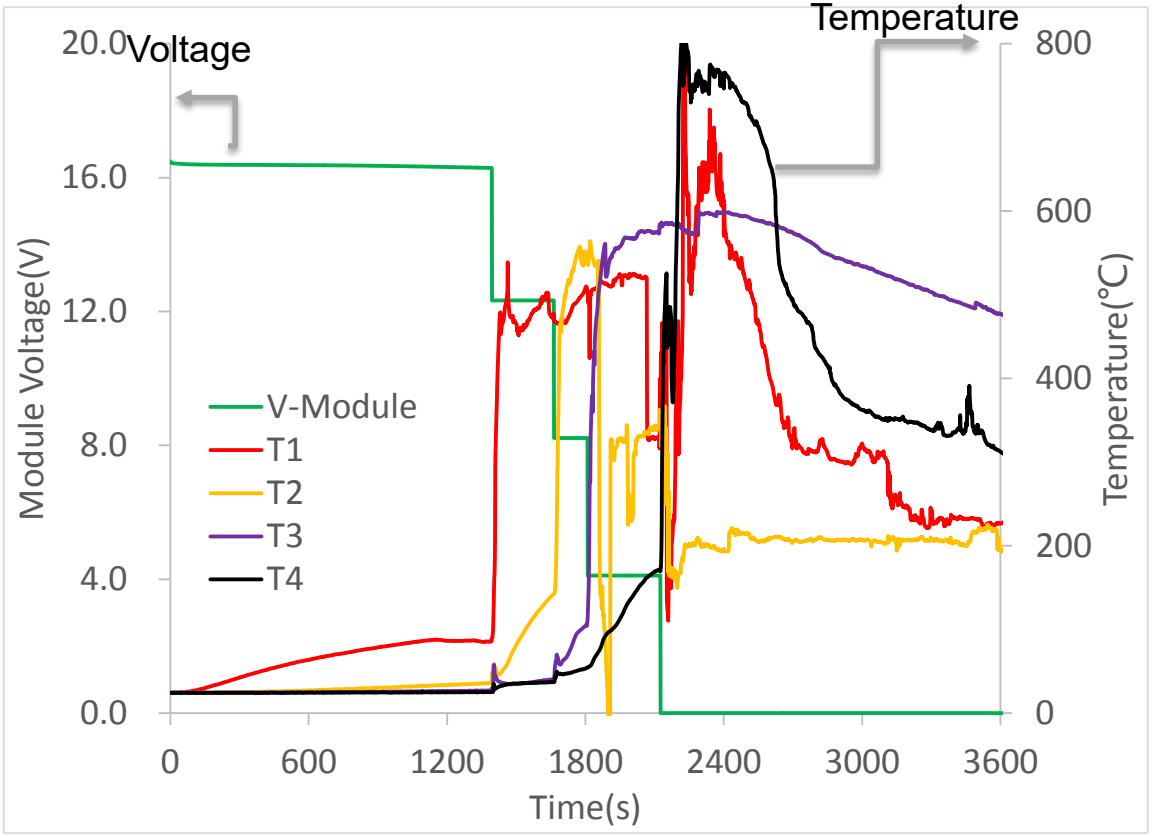
- Triggered cell：
  - ~95%SOC

- Measured data include：
  - Cell and module voltage
  - Bottom temperature of the cell
  - Photographs before，during and after the test

Demo Pack Test Result_ An Example

- Thermal runaway propagated to the other cells.





Summary

- Draft heater selection rules have been proposed
- No additional energy during the Self-Heating test , and most of the energy(normally <5% heat capacity effect and heat dispersant) is re-entered into the battery by Self-Heating;
- We will continue to study the method, including heater development, procedure standardize and automatic control switcher etc.

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感谢聆听

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