



LI-ION BATTERY THERMAL RUNAWAY TOPIC

GUIDELINES



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A NEW ECN TOPIC

- From last ECN
 - New research topic for the combustion community
 - New scientific challenges for transportation sector
 - Apply Spray A approach for Li-Ion batteries research
- Thermal Runaway is a urgent safety issue for the large-scale deployment of electric vehicles



Feng et Al, Energy Storage Materials 10, (2018) 246-267

A NEW ECN TOPIC

● Objective:

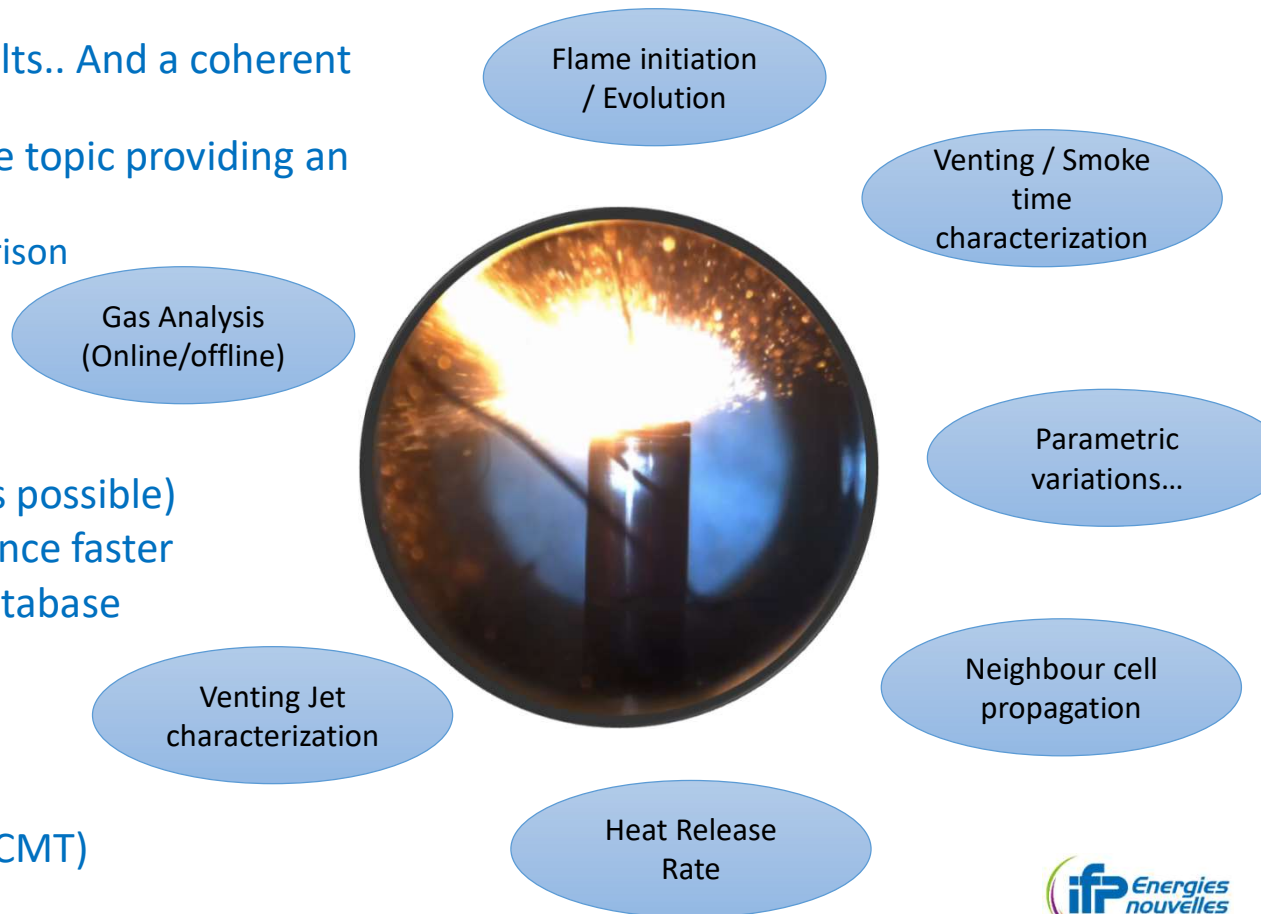
- Move towards a coherent database of results.. And a coherent understanding
- Put together the modelers interested in the topic providing an interactive reference database
 - Open discussion for data analysis / comparison

● Approach:

- Define a common commercial cell
- Define common test conditions (as close as possible)
- Build-up a common understanding to advance faster
- Create a complementary and consistent database

● Topic organization

- Michele BARDI (IFPEN)/ Antonio GARCÌA (CMT)



EXPECTED EXPERIMENTAL CONTRIBUTIONS

- A reference thermal runaway case (described in the presentation) is defined (see following slides)
 - Commercial NMC 811 battery
 - Controlled abuse test (controlled heating ramp 1.5 , 0.5 and 0.2 °C/min)
 - State of charge variation (100%, 50%, 25%)
- 2 laboratories contributing at the moment (IFPEN and CMT) with complementary diagnostics
- If other labs wants to join the experimental effort, please contact the topic leaders
- The topic discussion at the workshop will be focused on:
 - Comparison of experimental approach
 - Building complementarities among the different results
 - Investigating experimental uncertainties

EXPECTED NUMERICAL CONTRIBUTIONS

- The experiments on thermal runaway case is operated to provide validation data for modeling
 - The database can be shared on demand (please contact the topic leaders ASAP)
- ANY numerical approach is of interest for the topic (0D, 3D, empirical or physical models.. Etc)
- The topic discussion at the workshop will be focused on:
 - Comparison of different numerical approach Vs Experiments based on some main parameters:
 - Venting and Runaway gas temperature (temperature just before the two events)
 - Venting and Runaway cell skin temperature (temperature just before the two events)
 - Venting and runaway pressure increase (optional)
 - Venting/Runaway jet/flame propagation in the chamber (optional)
 - Sensitivity of these parameters to parametric variations
 - State of charge
 - Heating ramp
- Other aspects of thermal runaway could be discussed, and further experimental analysis could be realized (more details could be found in the following slides)
- Please join the discussion contacting the topic leaders as soon as possible, workshop is very soon!

DETAILS OF THE EXPERIMENTAL SETUP BOUNDARY CONDITIONS

- Focus on Battery Cell (BC):
 - Battery cell definition:
 - Battery cell type: LG M50
 - Format 21700
 - Positive electrode type: NMC 811
 - Standard Running-in / charge
 - 120 BC purchased by IFPEN
 - from the same batch → to limit variability in the manufacturing procedure
 - shared between IFPEN and CMT (available for other contributors!!)

DETAILS OF THE EXPERIMENTAL SETUP BOUNDARY CONDITIONS

- Reference Running-in
 - 3 charge / discharge cycles
 - CC/CV ref cycle from manufacturer
 - EIS measurement for battery health characterization

- Test Definition:
 - Thermal Abuse
 - “Slow cooking mode”
 - Heating with a controlled heating ramp at constant gradient
 - Reference case : 1.5 °C/min
 - Parametric Variation: 0.5 °C/min ; 0.2 °C/min

- BC state of charge (SOC):
 - Ref Case: 100%
 - Parametric variations: 50% ; 25% ; 75%

- Temperature ramps data and experimental configuration (e.g. vessel geometry) are available for modeling

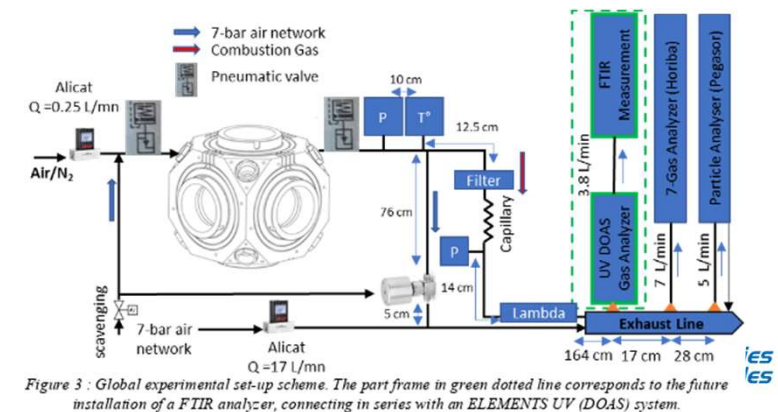
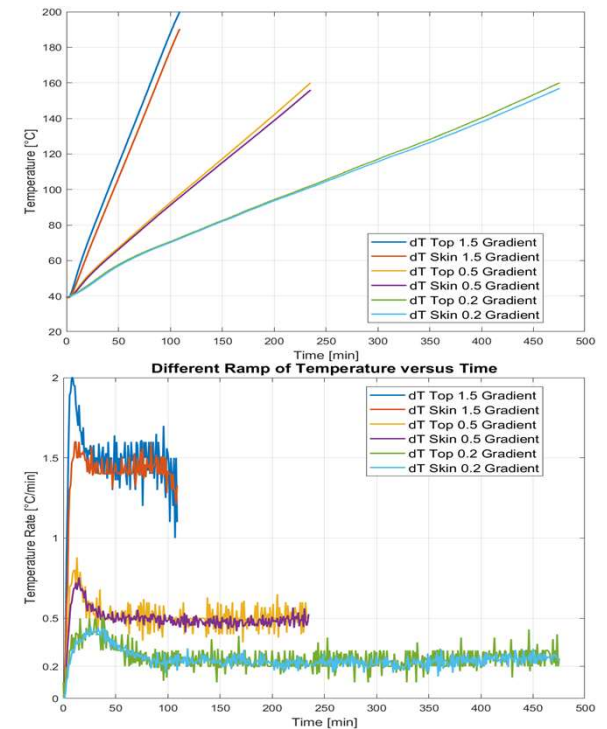


Figure 3 : Global experimental set-up scheme. The part frame in green dotted line corresponds to the future installation of a FTIR analyzer, connecting in series with an ELEMENTS UV (DOAS) system.

A NEW ECN TOPIC: DATA ANALYSIS AND OUTPUT PARAMETERS

● Measurement data: Richardet et al, ECM 2023

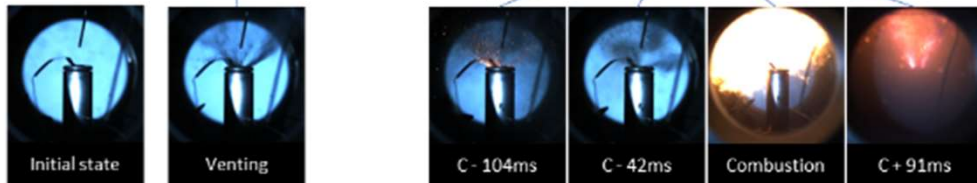
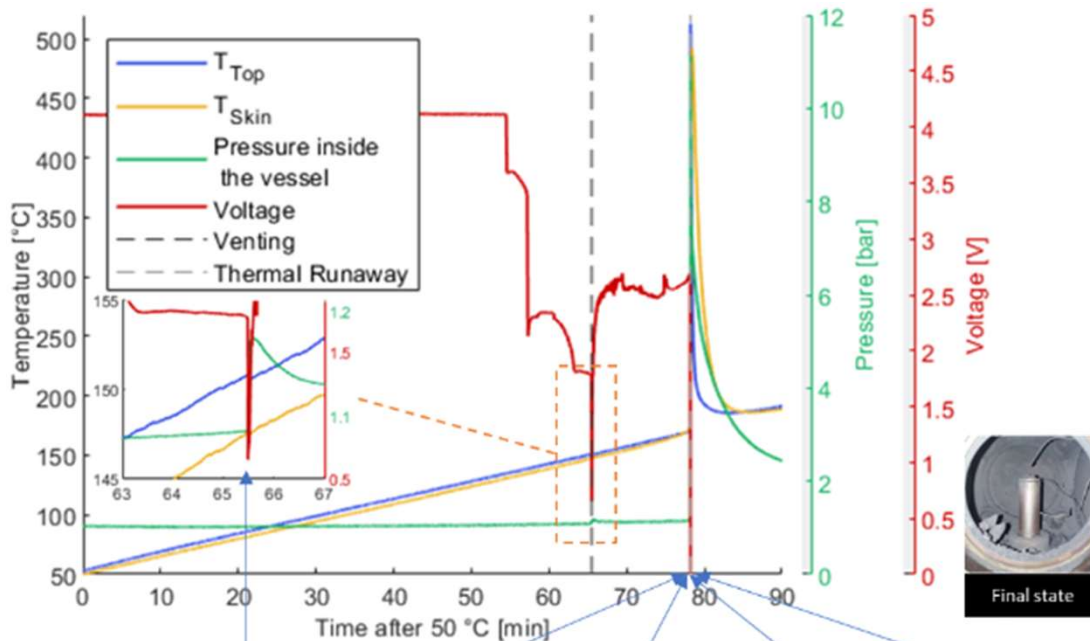


Figure 4 : Evolution of Temperature of BC skin (yellow) T_{Skin} and above the BC (blue) T_{Top} , BC Voltage (red), Pressure inside the HP/HT vessel (green); Close up to the time of Venting; Visualization of state of the BC at different time, compared to Combustion time (C).

● Output Parameters already extracted:

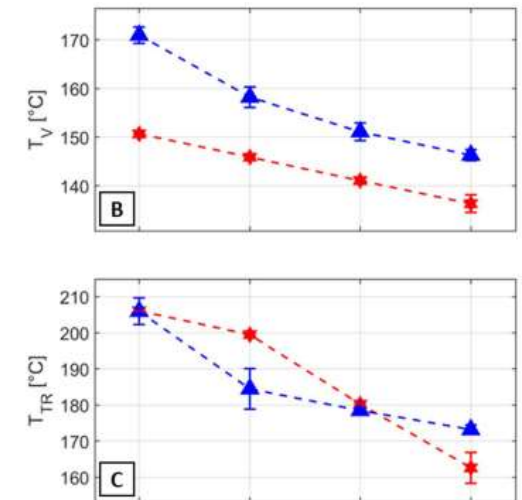
- Venting time/ temperature
- Runaway Time/ temperature
- Voltage drop time / temperature
- Mass Loss
- Exothermic reaction onset (obtained in ARC)
- Temperature rate at onset
- Temperature at 100 °C/min
- Temperature at 10 °C/min
- Time from onset temperature to maximum temperature
- ΔT from onset temperature to maximum temperature
- Pressure increase (venting / thermal runaway)

● Output parameter under investigation

- Vented Gas Mass
- Venting jet characterization
- Ignition characterization
- Flame characterization
- Gas analysis (venting and runaway)
- Other are open to discussion

FIRST DATA AVAILABLE

- IFPEN test campaign already started on the reference battery
- Experimental data analyzed characterized, and several characteristics parameters are available (see some examples on the plots blue dots for LG M50)
- All the data concerning the experiments could be shared and discussed
- CMT experiments starts at beginning of July and data will be shared soon



[Richardet et al, SAE 2023-24-0165 \(not published yet\)](#)



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