TU Clausthal
Clausthal University of Technology

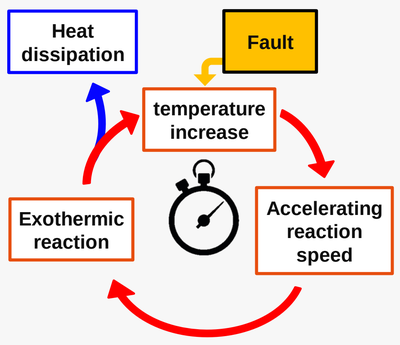
EST
Forschungszentrum Energiespeichertechnologien

Early Thermal Runaway detection in lithium ion batteries by using of a coupled electrical - thermal plausibility model

Jens Grabow*, Jacob Klink, Nury Orazov, Ralf Benger
Clausthal University of Technology, Research Center Energy Storage Technologies, D-38640 Goslar

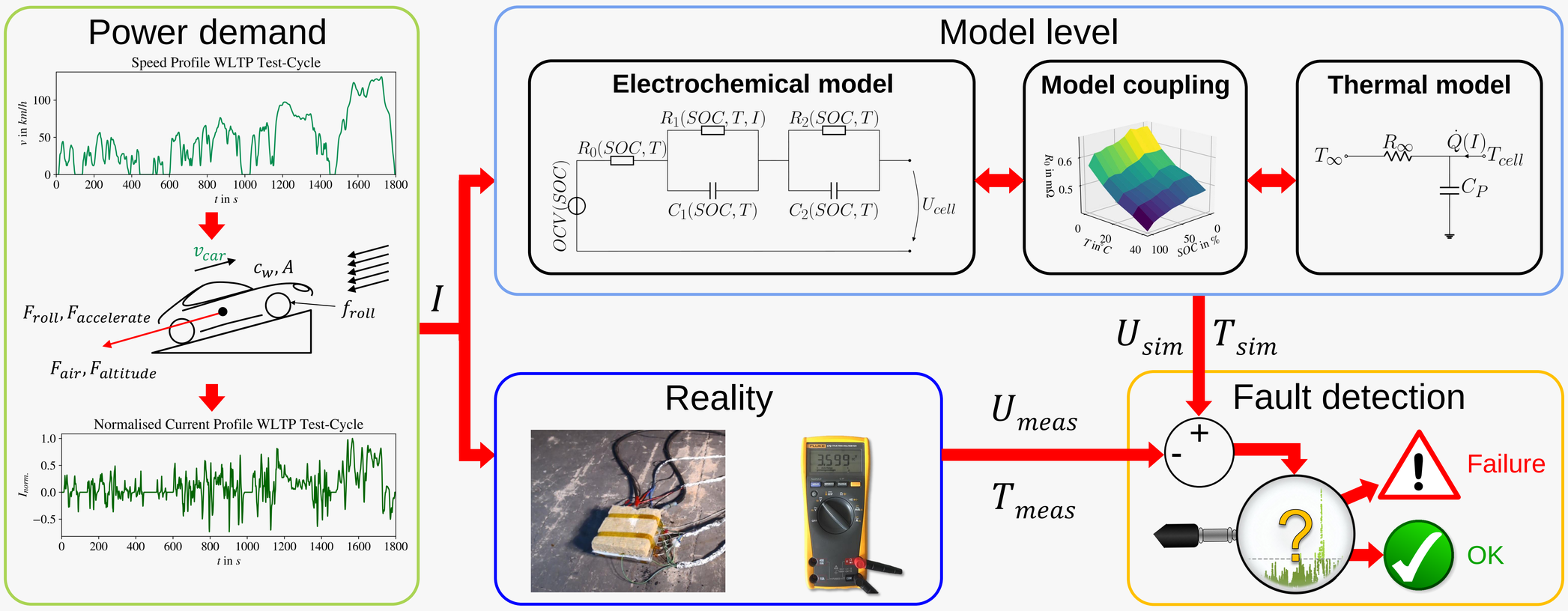
1. Introduction

- In addition to the high usable electrical energy, a large amount of chemical energy is stored in the cell components, which can lead to safety-critical states in the case of incorrect handling or production defects [1]
- As a result of exothermic side reactions and insufficient heat removal in the worst case, the self-accelerating temperature increase can lead to thermal runaway, which can release toxic substances and large amounts of heat [1,2]
- This Safety-critical faults occur in practice (although scarcely), so that it is necessary to warn of an upcoming thermal runaway as early as possible to minimize the risks for users and the environment
- This work investigates the effect of the change in voltage caused by the temperature variation by using a parallel running model as an indicator for an implausible cell state to detect a ongoing Thermal Runaway

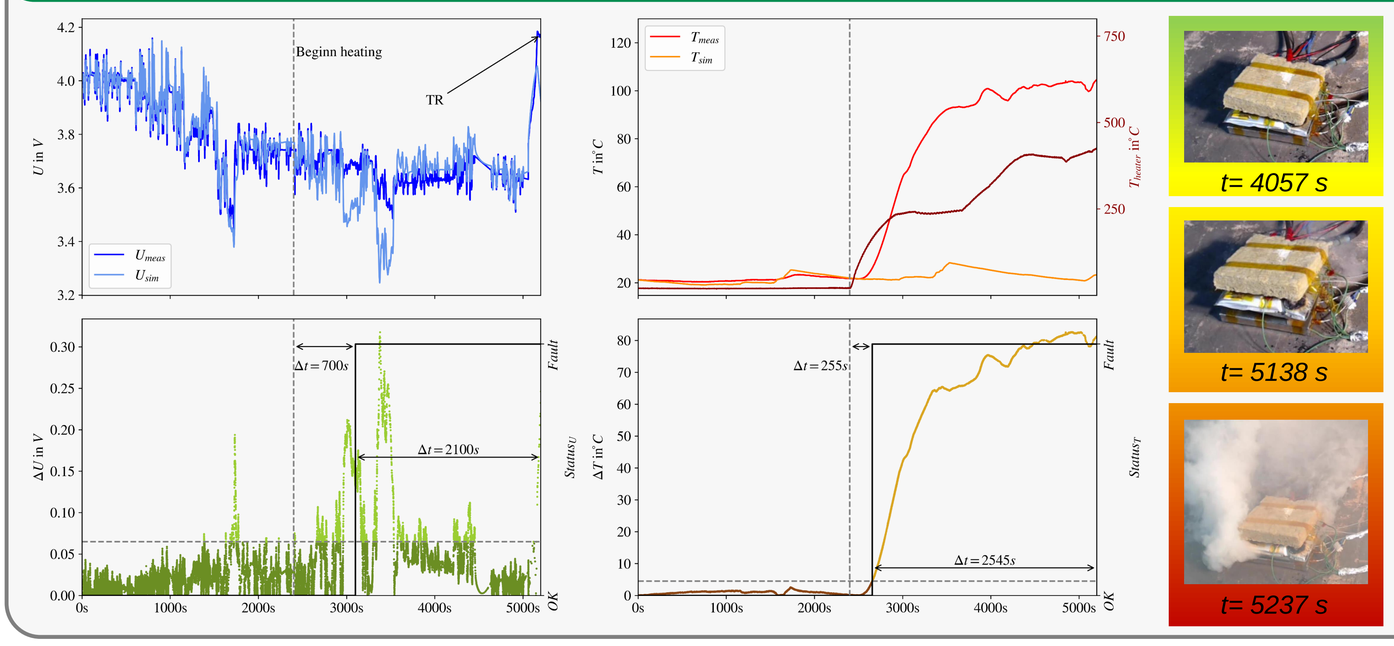


2. Method

- The cell states temperature T and voltage U are estimated based on a coupled cell model (Model level) and compared against the measured data (Reality). When these differences exceed a defined threshold the integrated Fault Detection will suspect a cell failure. Both model validation and thermal fault induction are performed during highly dynamic cell load by the power demand of the WLTP



3. Findings



- About 255s after the cell has been heated externally, the error is detected by a temperature deviation of 4.5°C averaged over 2 minutes
- About 700s after the cell has been heated externally, the fault is detected by a voltage deviation of more than 0.065V over a period of at least 4 minutes
- Fault detection by temperature comparison 2545s (42 min) and by voltage comparison 2100s (35 min) before the first venting of the Thermal Runway

3. Conclusion

- Early detection of a safety critical status through the plausibility comparison of both voltage and temperature values
- The temperature comparison shows an earlier and more robust response, but requires temperature sensors
- The voltage comparison is in principle more sensible to interference and false detections, but it can theoretically detect various realistic faults and does not require any additional sensors
- The coupling of both signals is useful when developing a detection method for practical applications

4. Future work

- Transfer of this approach to module level
- Verifying the sensitivity for other trigger conditions, which lead to faster Thermal Runaway conditions
- Inspect the stability of the detection method during long-term monitoring with changing cell properties
- Identify and develop necessary model adaptations

References:
[1] X. Feng et al., Energy Storage Materials (2018), doi: 10.1016/j.ensm.2017.05.013.
[2] Q. Wang et al., Progress in Energy and Combustion Science (2019), doi: 10.1016/j.pecs.2019.03.002.

Acknowledgement:
"ReserveBatt - Systemdienstleistungen für den sicheren Betrieb des Energieversorgungssystems: Momentanreserve mit Hochleistungsbatterien" FKZ: 03ET6123A

Gefördert durch: Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages
ACEA European Automobile Manufacturers Association

Contact:
Jens Grabow, M. Sc.
Am Stollen 19A, D-38640 Goslar
jens.grabow@tu-clausthal.de