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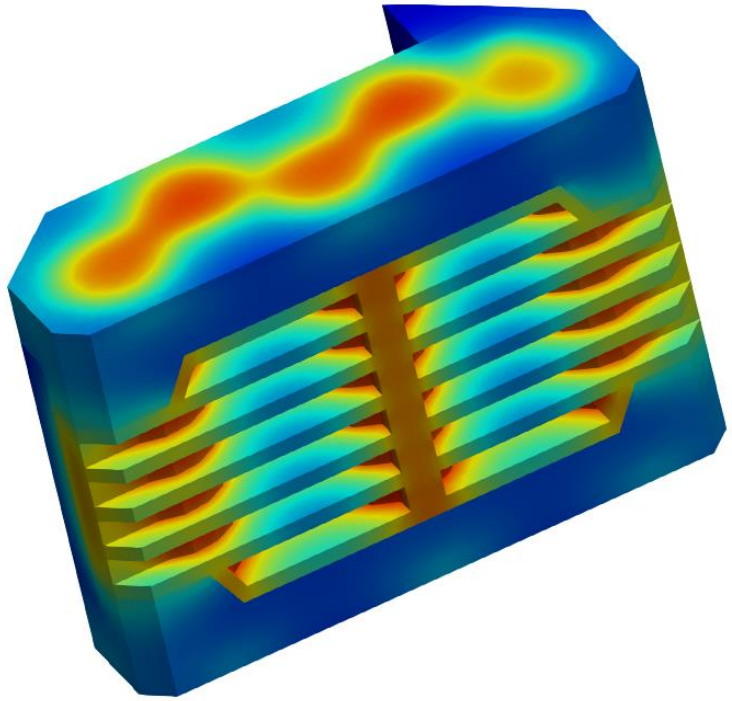
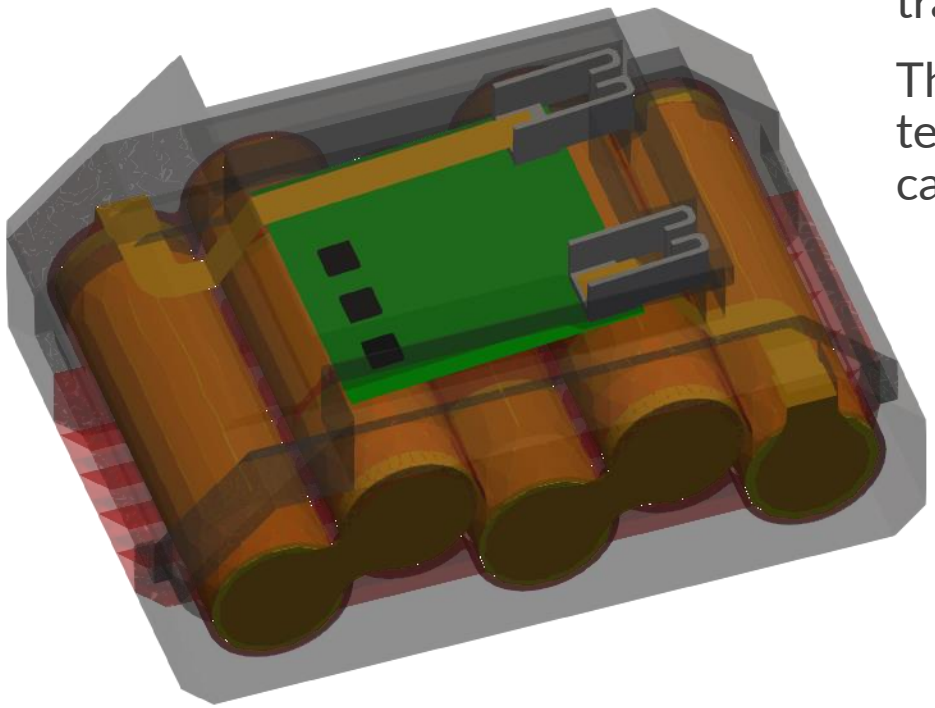


Q-Bat use case

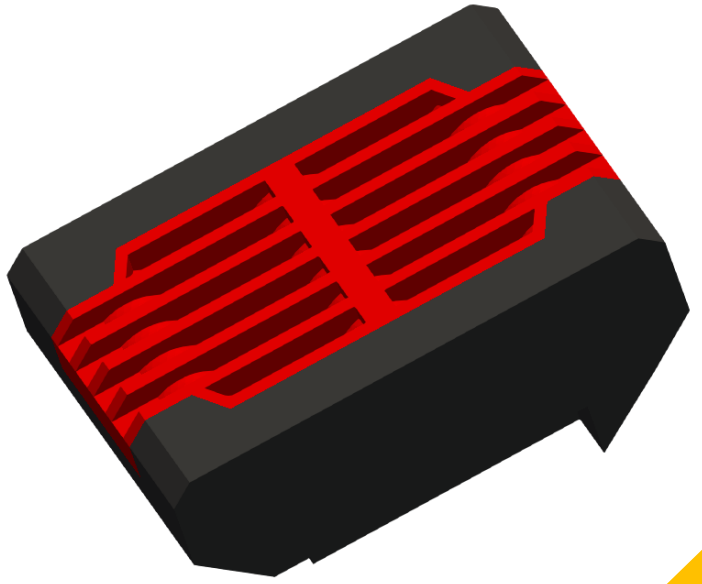
Power tool’s battery pack

Overview of model



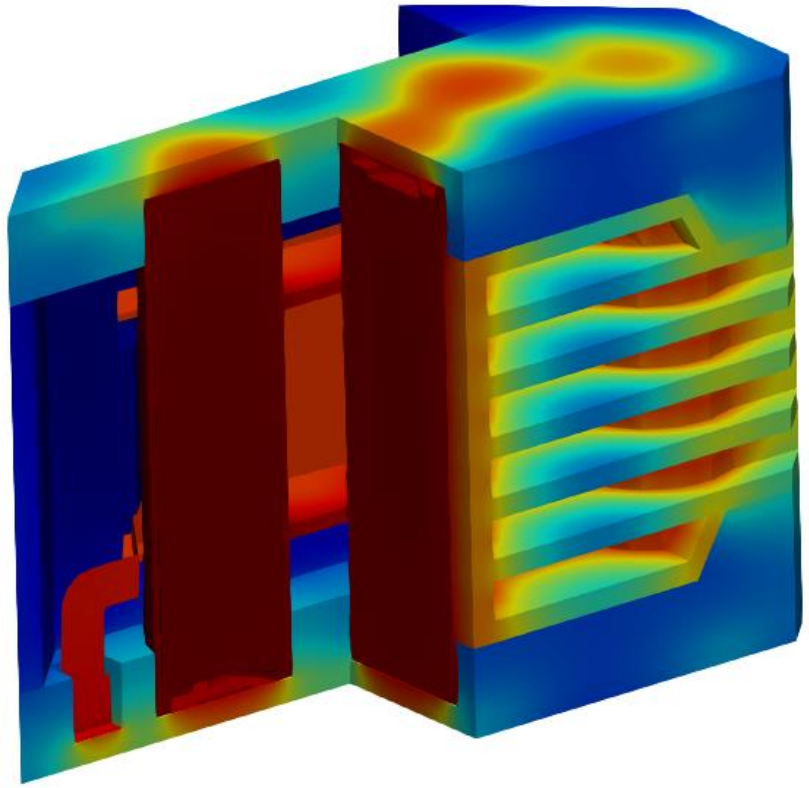
This use case presents how to perform simulation of heat transfer in a power tool's battery pack in Q-Bat software.

The model consists 5 groups of 21700 Li-ion cells (5s1p), terminals, connectors, bus burs, transistors, circuit board and casing.

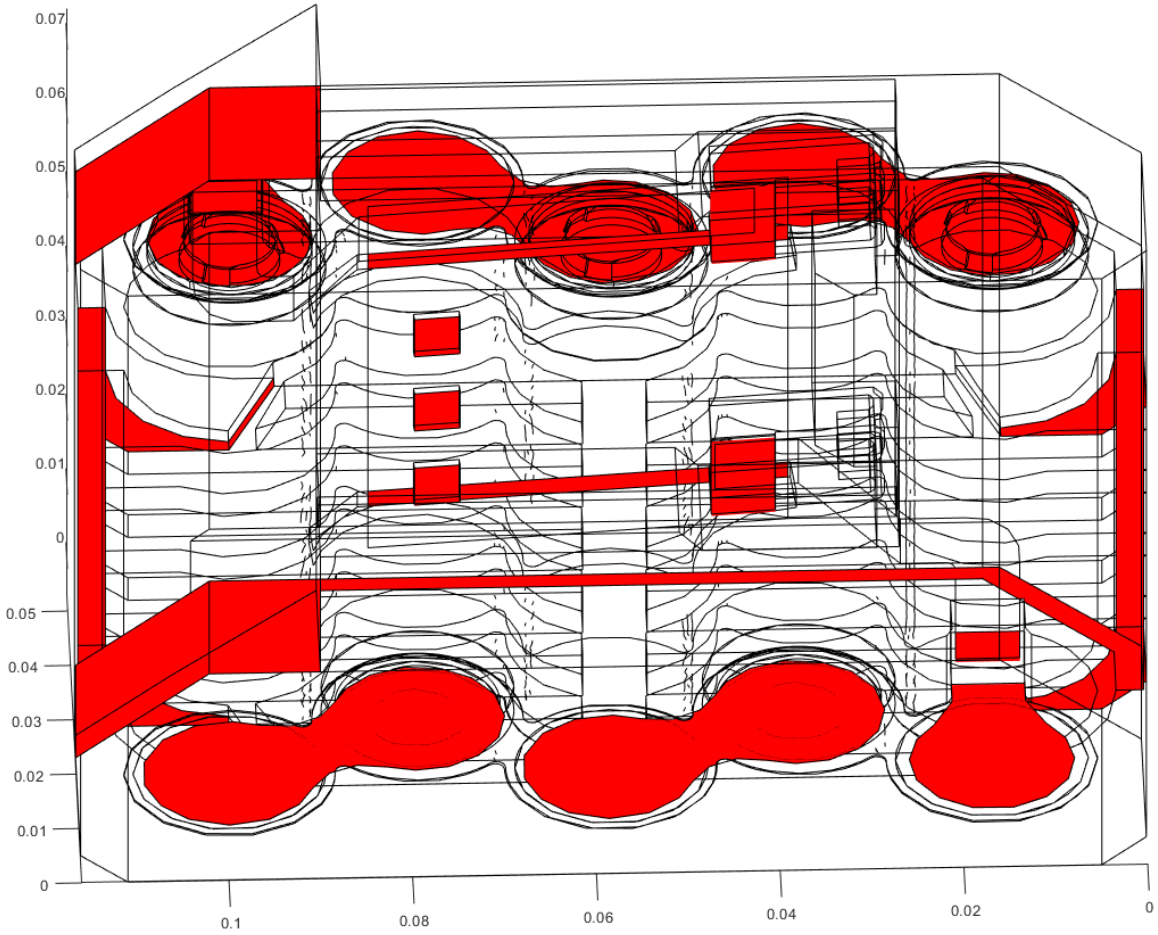


Thermal model

- Heat generated uniformly across cell volume
- Thermal contacts set to transfer heat between chosen surfaces
- Additional heat generation in due to losses
- Robin boundary condition is assigned to the casing outer boundaries.
- Ambient temperature of 25 °C

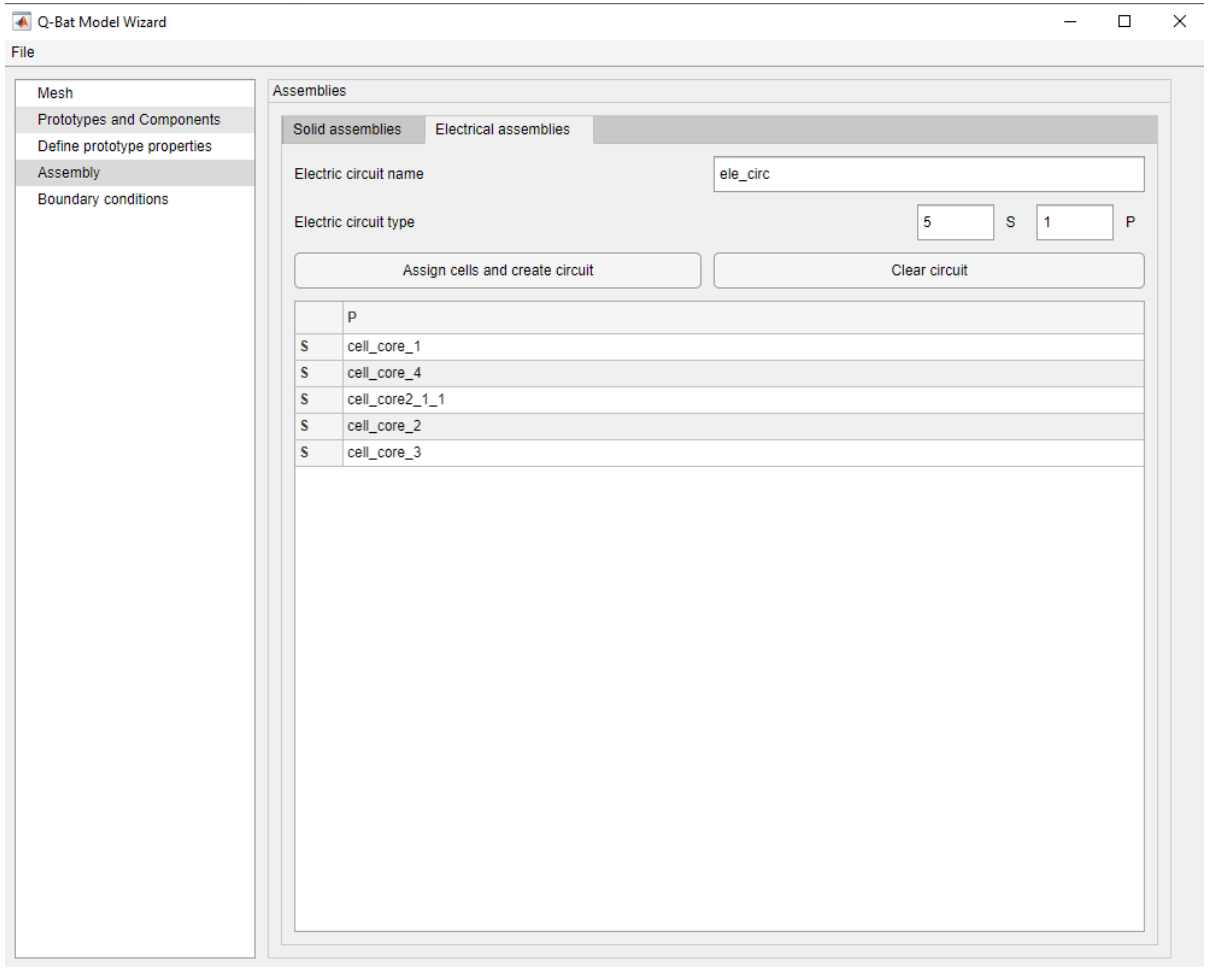


Model assembly



- All components are aggregated in multiple assemblies and contact regions between them are created.
- Different contact conductivities are set.
- Overall 64 contact regions.

Electric circuit



- 5 cells connected in series
- Heat generation is set by specifying the electrical properties of the cell (capacity, voltage, resistance) and applied current load, that varies in time
- Cells are modelled using RC equivalent circuit model

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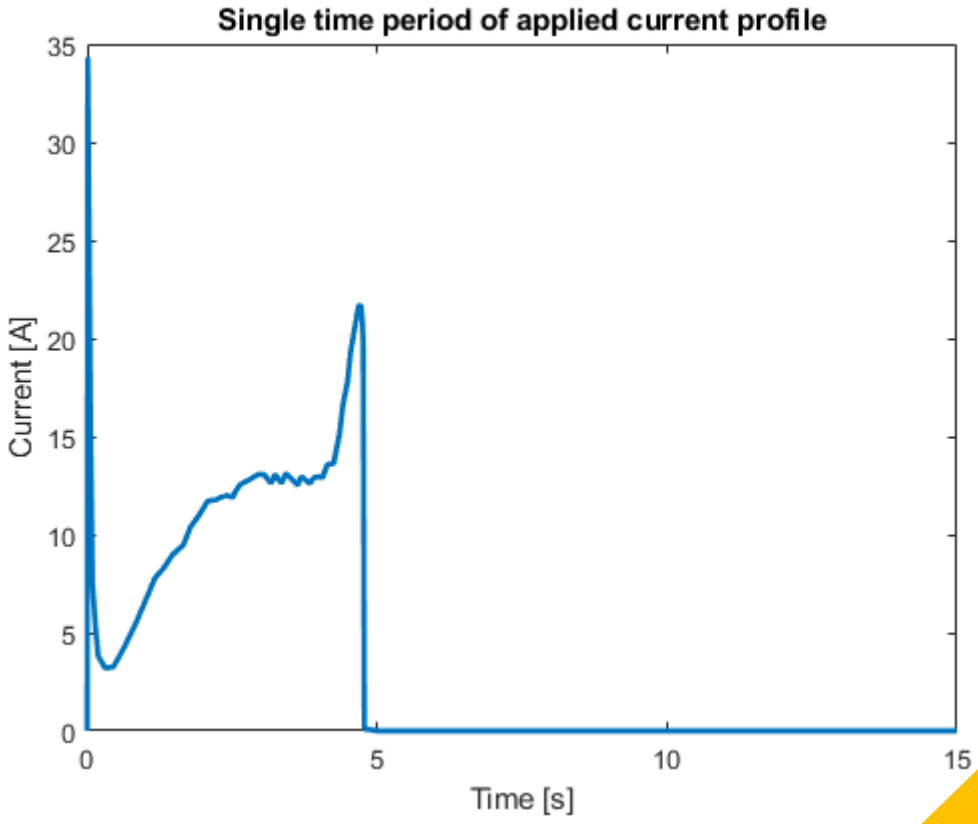
Prototype properties

- Material properties of the cells and heat comoponents are defined in the Excel spreadsheet

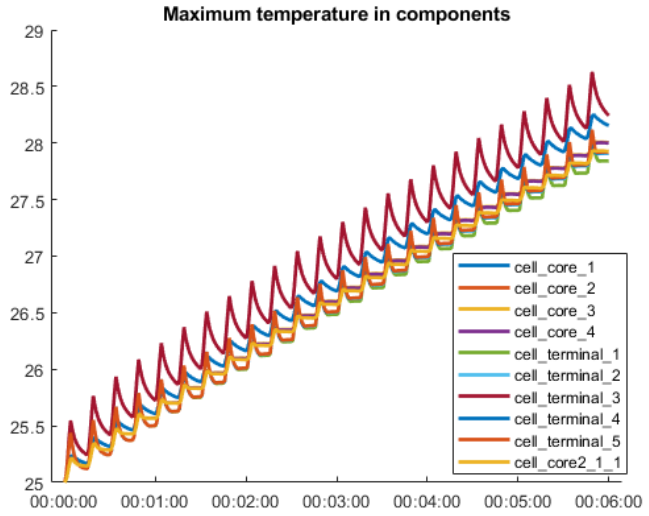
Part	rho	cp	λ_ϕ	λ_r	λ_z
Cell	2650	1250	28	1.3	28
			λ_x	λ_y	λ_z
Casing	1200	1200	0.2	0.2	0.2
Connectors	8890	385	388	388	388
Bus bars	8890	385	388	388	388
Terminals	7870	460	52	52	52
Transistors	8890	385	388	388	388
Circuit board	6778	600	271	271	271

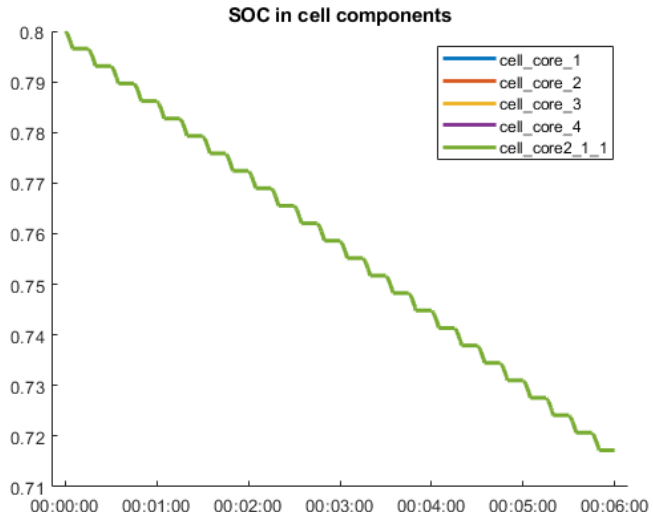
Example 1 – Normal operation

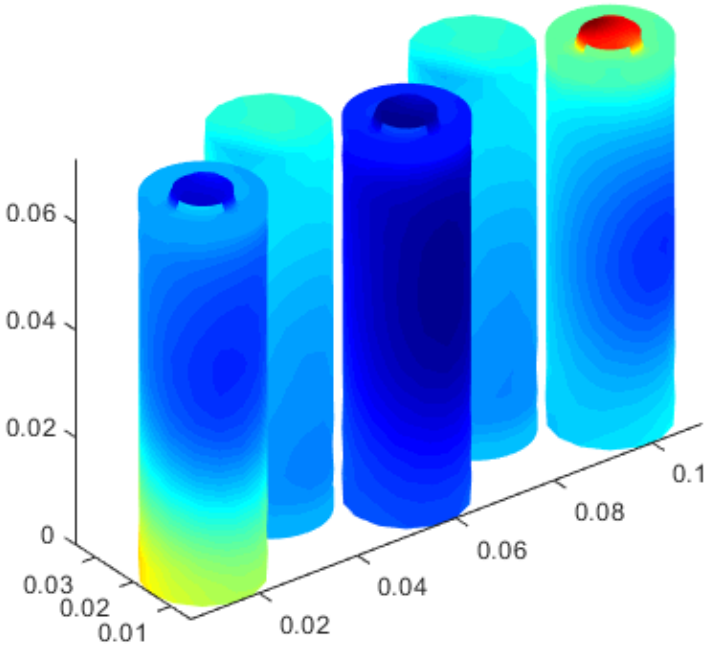
- Operation of battery pack during regular use of a power tool
- Current profile consists of 24 reapeted cycles, which simulate screwing in a screw followed by a break
- Initial state of charge is 80%
- Overall 360 seconds of operation simulated

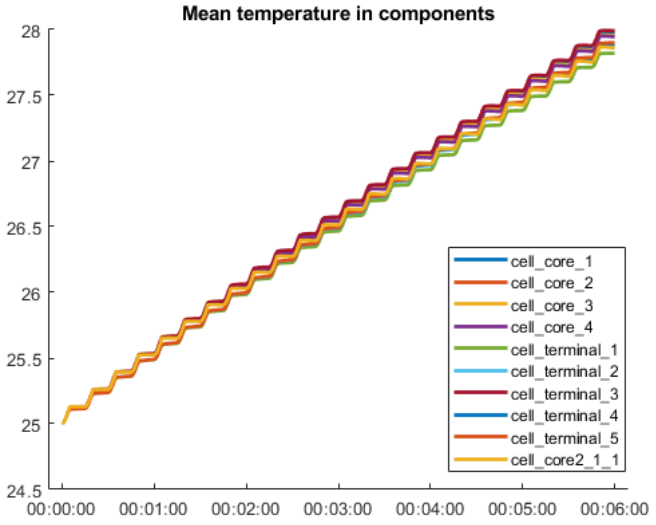


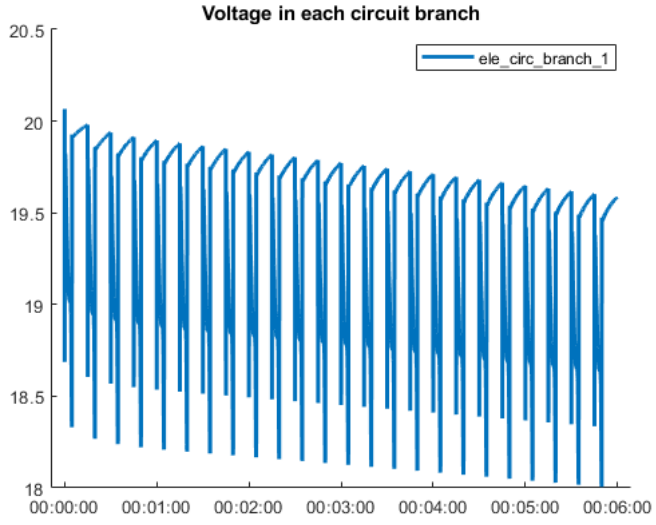
Example 1 – Post-processing





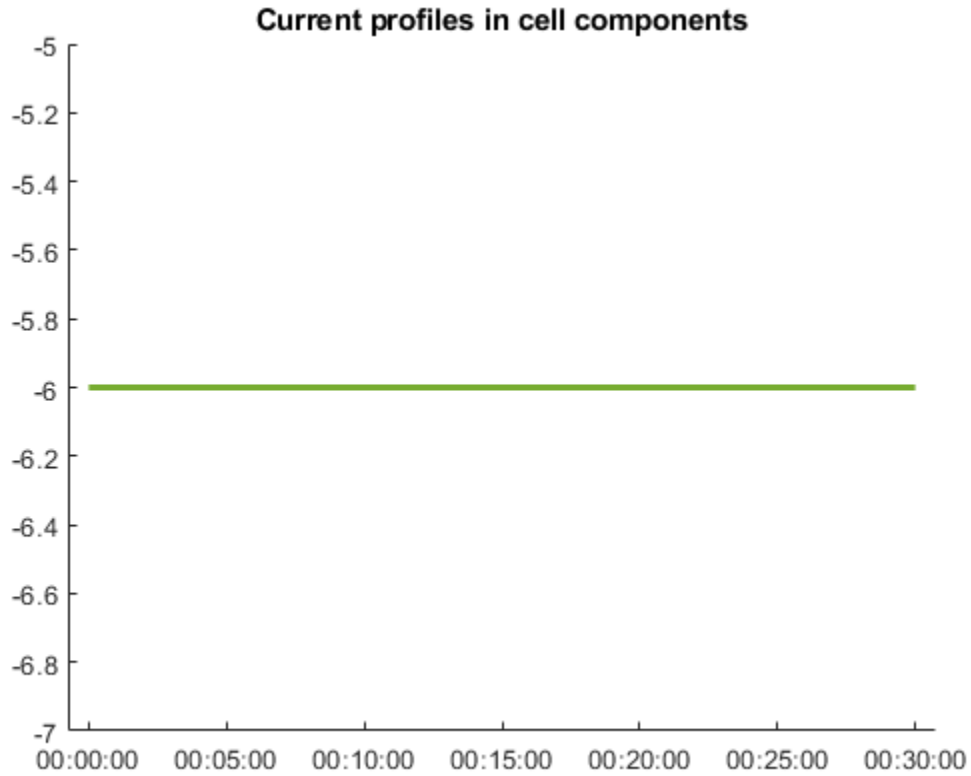




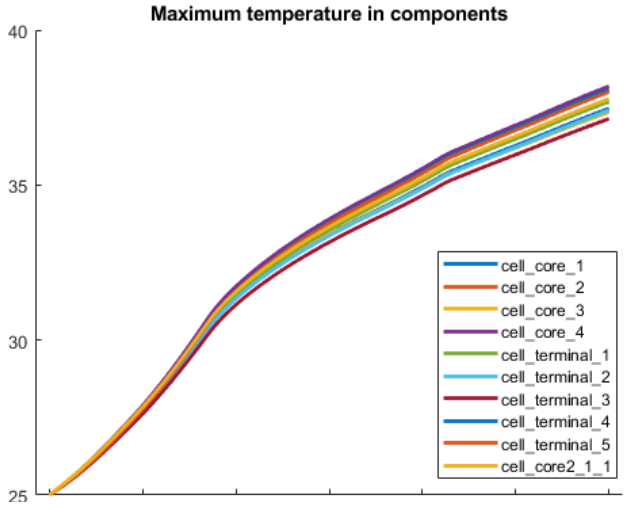


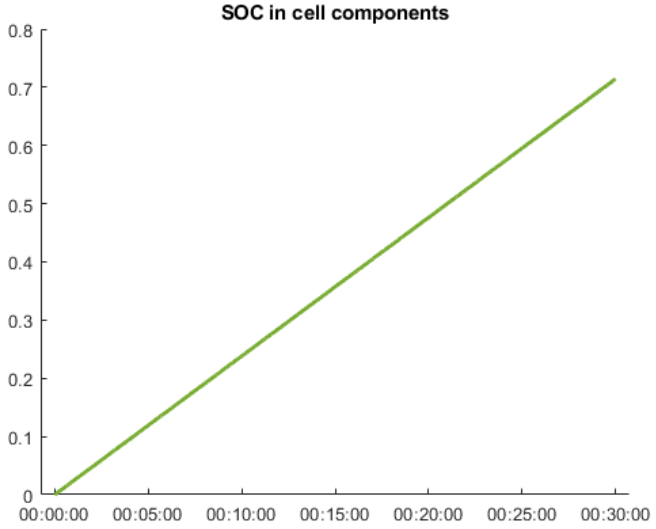
Example 2 – Rapid charging

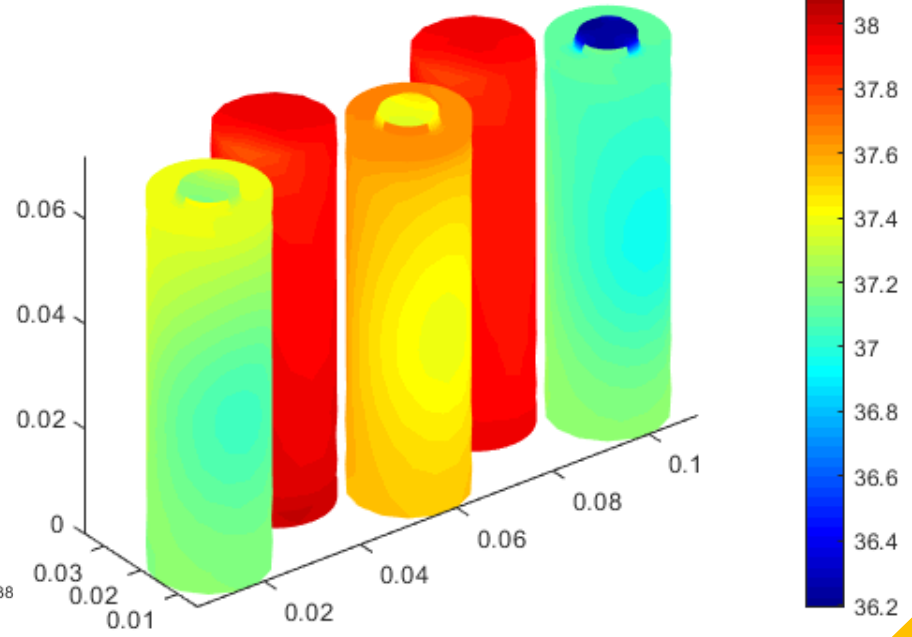
- Operation of battery pack during fast charging
- Constant current of 6 A
- Initial state of charge is 0%
- Overall half an hour of operation simulated

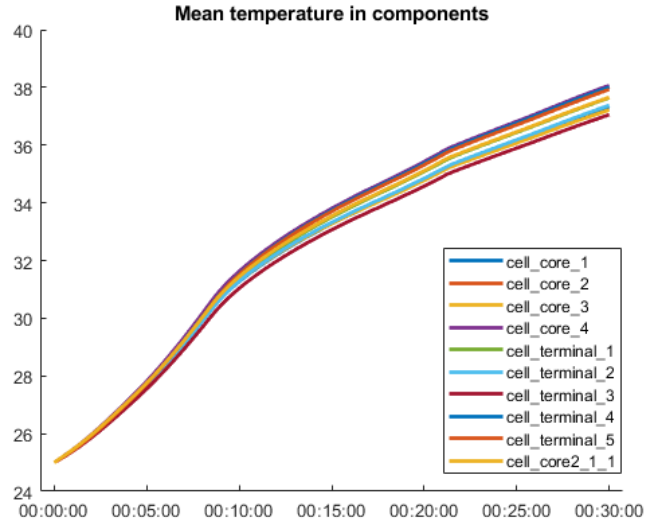


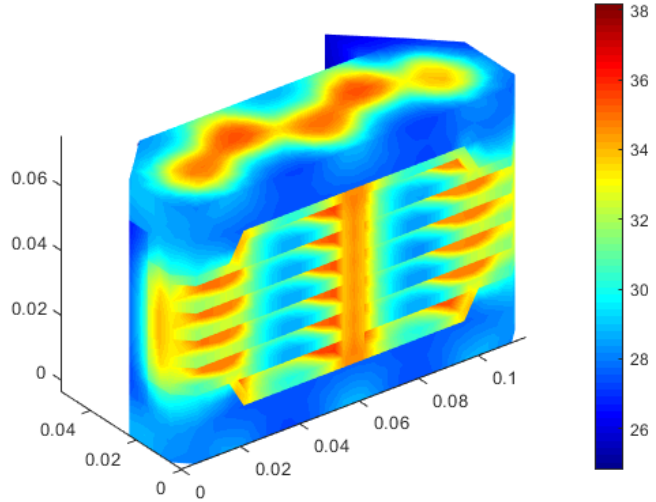
Example 2 – Post-processing





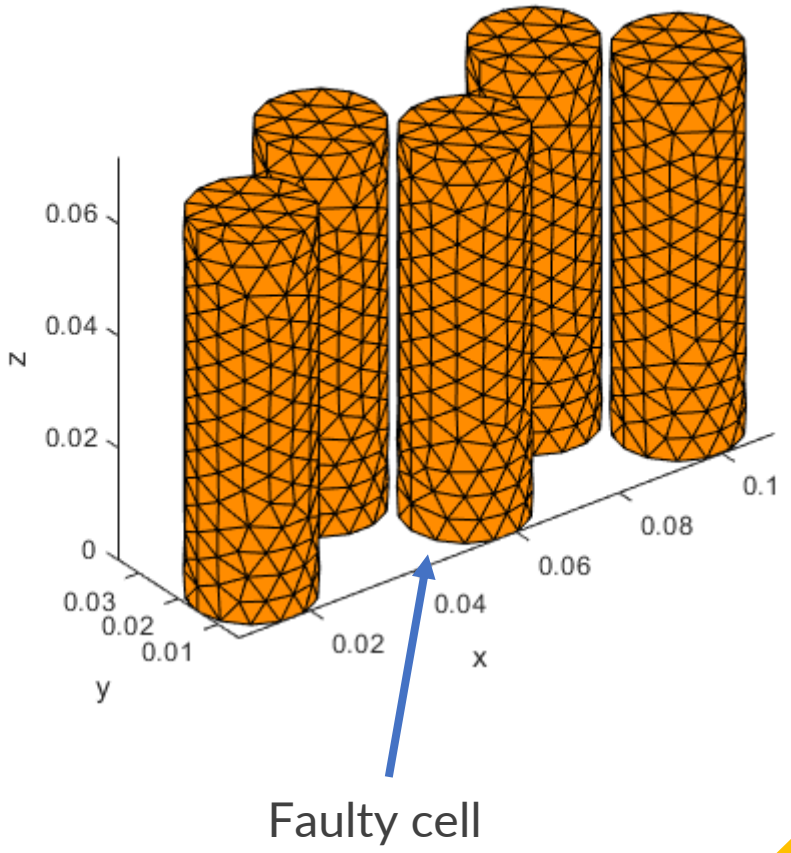






Example 3 – Thermal propagation

- One cell is heating significantly more due to malfunction. Heat dissipation from a faulty cell will be checked.
- Constant current of 6 A
- Initial state of charge is 0%
- Overall half an hour of operation simulated



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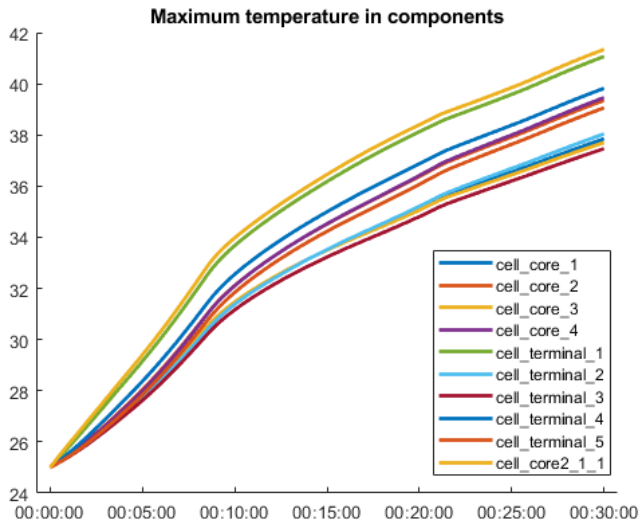
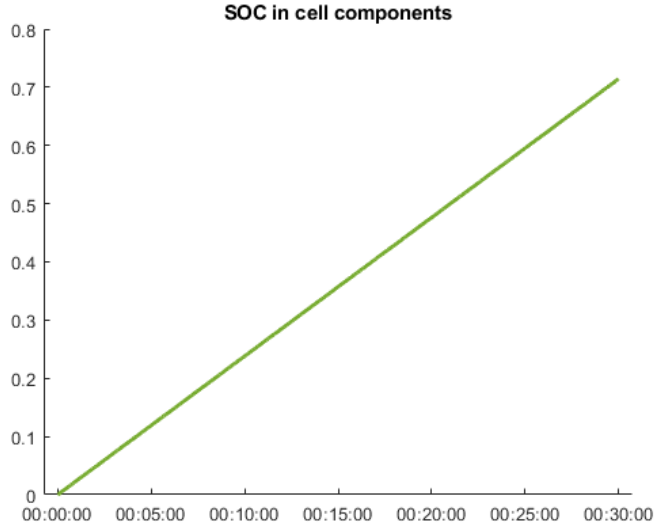
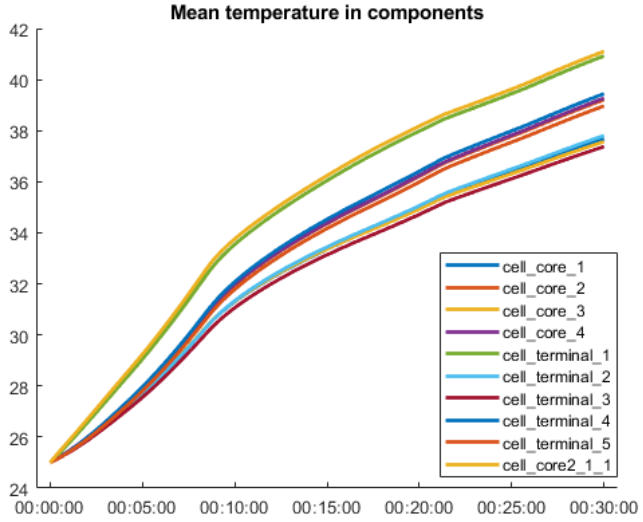
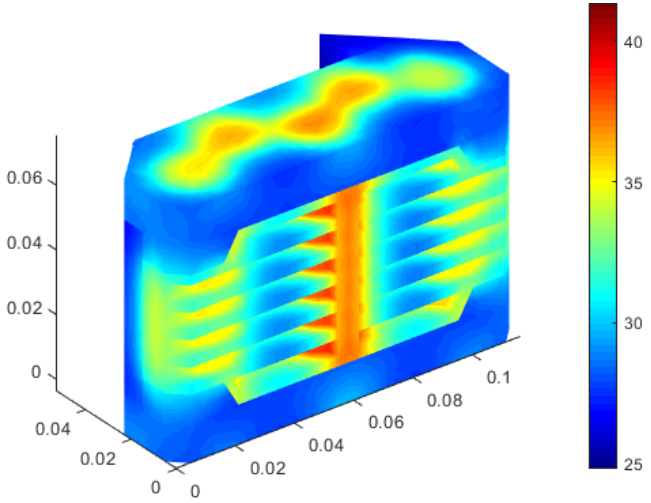
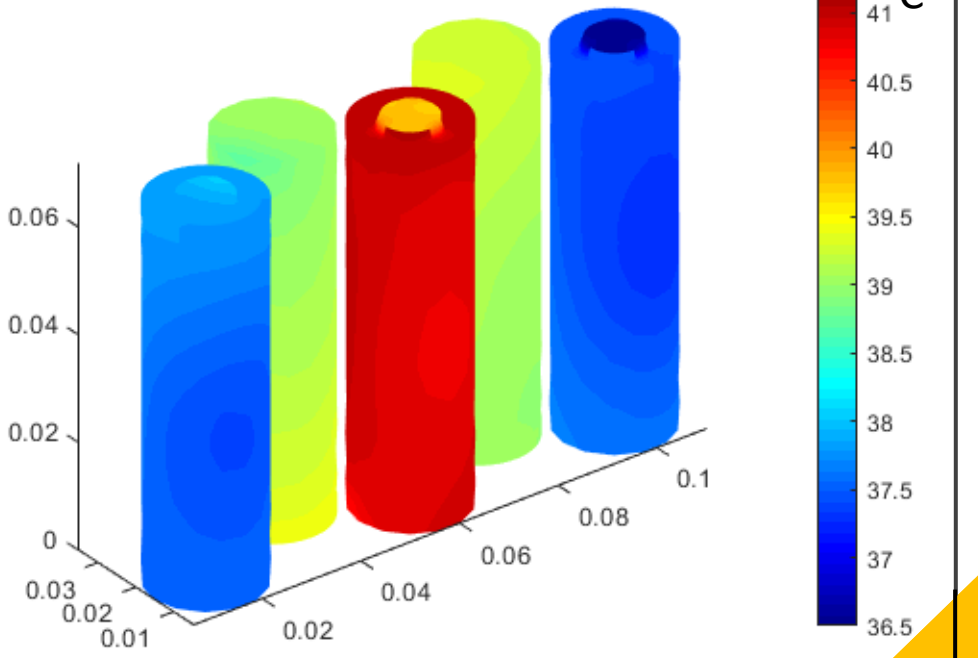
Example 3 – Post-processing







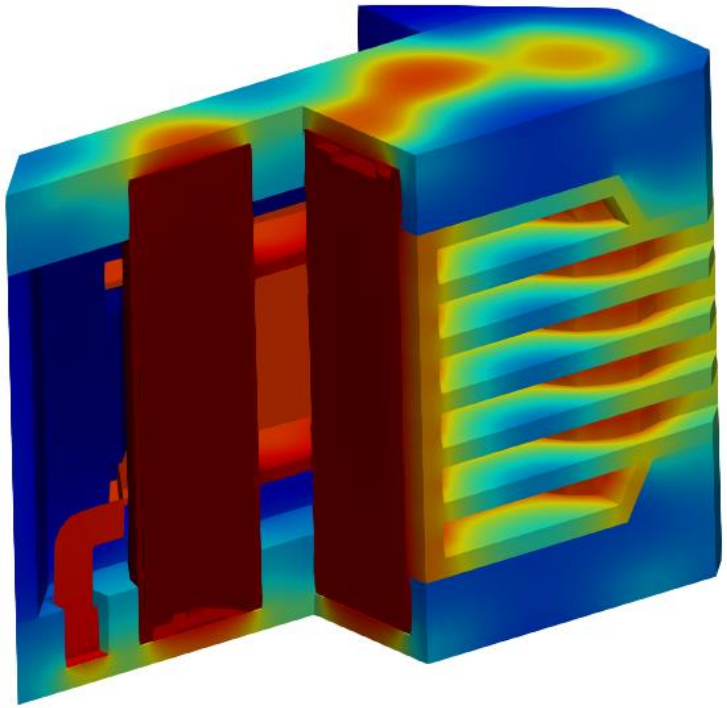




Summary

The model consists of:

- 13 prototypes,
- 28 components,
- 209 000 mesh elements,
- 64 contact regions.



The overall simulation time is only **10-20 minutes**.

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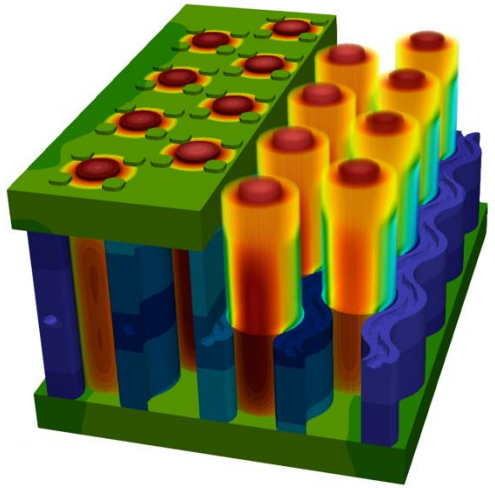
Learn more

- Q-Bat is a MATLAB-based product for real-time battery thermal simulation in 3D with CFD-like accuracy. Its main features are:
  - Near real-time execution
  - Accurate 3D data of battery temperature distribution
  - The capability of exporting the model to the Simulink
  - Fast model definition via dedicated GUI and TUI.



- To learn more:
  - QuickerSim https://emobility.quickersim.com/
  - Q-Bat product page https://www.mathworks.com/products/connections/product_detail/quickersim-q-bat.html

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