GT Gamma Technologies

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Lithium-ion Battery Pack Design for Electric Vehicles Using GT-AutoLion

Multi-Physics Simulation and Multi-Criteria Optimization Approach

Majid Astaneh
majid.astaneh@chalmers.se

Division of Vehicle Engineering and Autonomous Systems
Department of Mechanics and Maritime Sciences
Chalmers University of Technology

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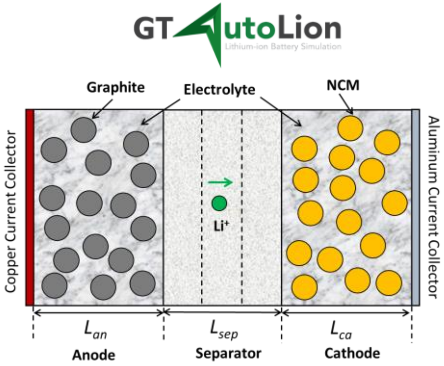
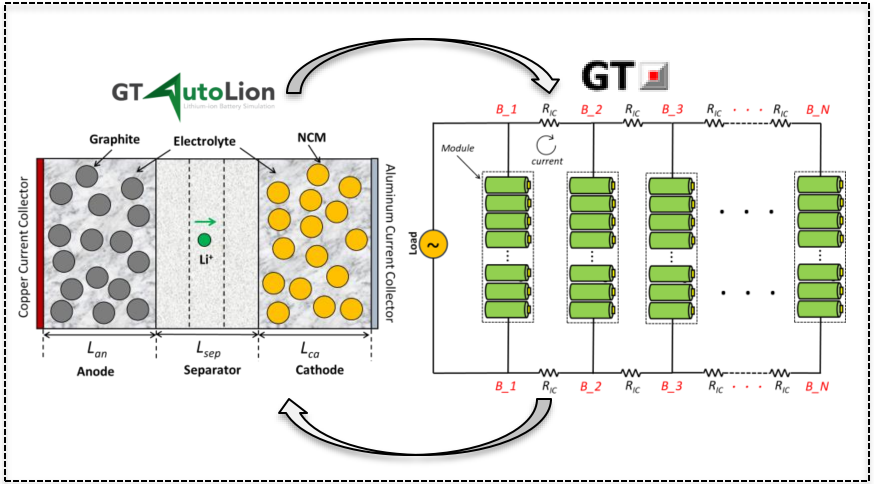
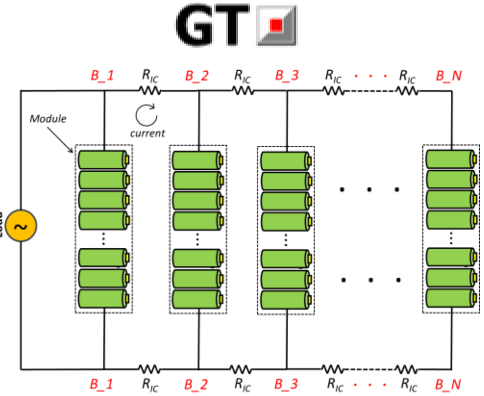
Problem: Lithium-ion Battery Pack Design for Electric Vehicles

Solution: Multi-Physics Simulation and Multi-Criteria Optimization





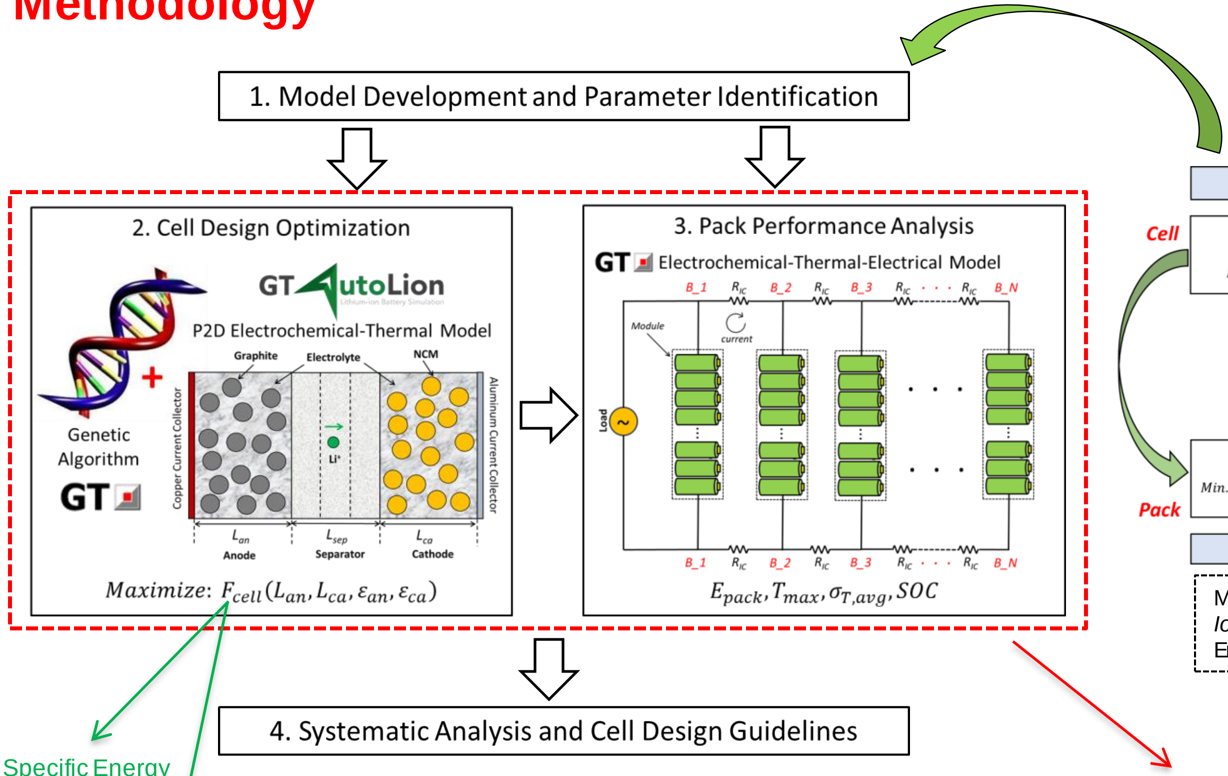


Cell
Electrochemical-Thermal Modeling

Cell-to-Pack
Multiphysics Modeling

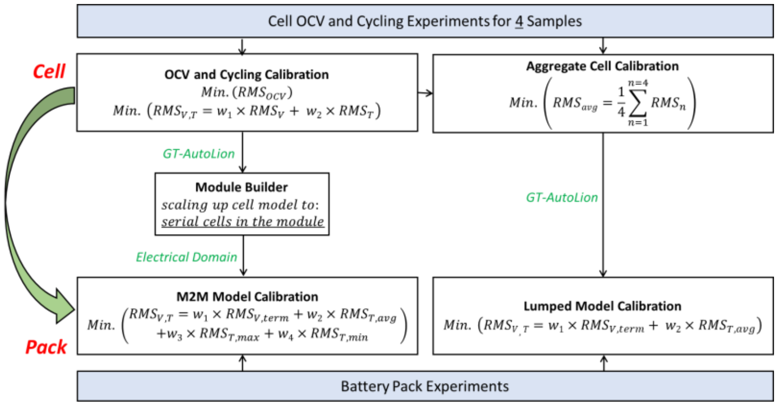
Pack
Electrical Modeling

Methodology



Specific Energy

Maximum Temperature



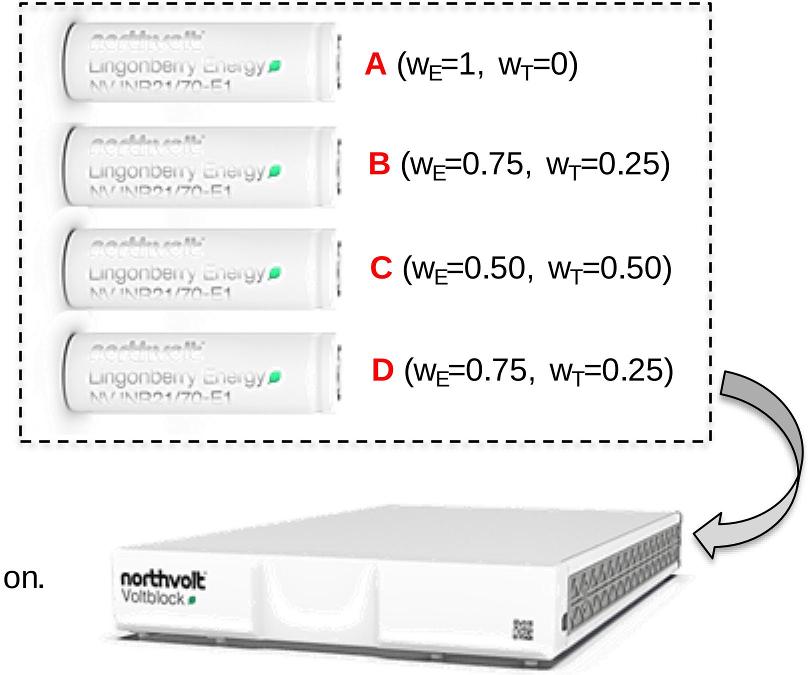
M. Astaneh et al., *"Calibration Optimization Methodology for Lithium-Ion Battery Pack Model for Electric Vehicles in Mining Applications".* Energies, 2020. 13 (14): p. 3532.

Multi-Physics Simulation and Multi-Criteria Optimization Framework

Key assumptions

At the cell level:

- Optimizations are performed at 1.5 C discharge current.
- Four cell design cases are considered.
- The baseline case corresponds to a commercial cylindrical cell.

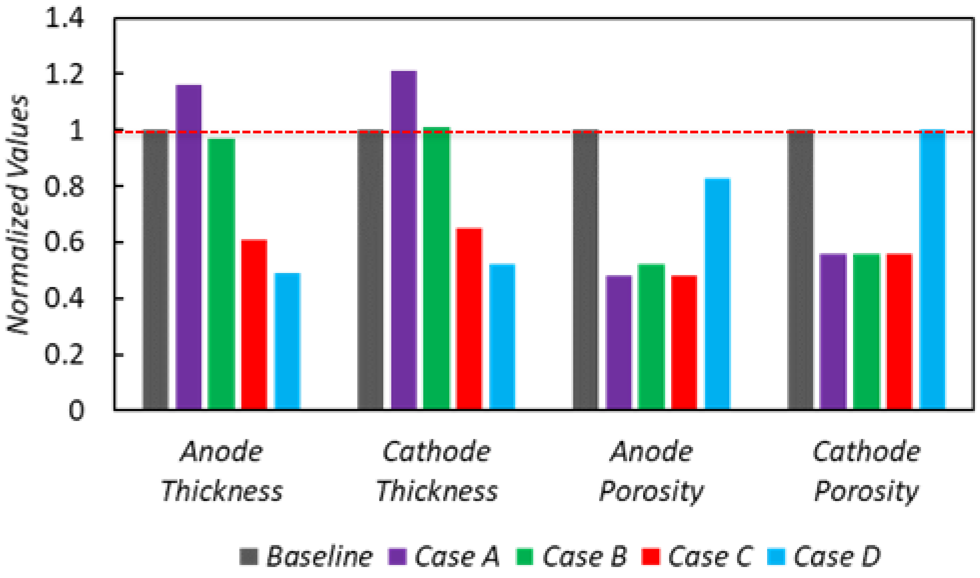


https://northvolt.com/

At the pack level:

- The pack electrical topology (current imbalances) is considered.
- Optimally designed cells are evaluated separately under pack operation.
- The discharge currents of 1.5 C and C/2 are considered.
- The pack cut-off voltage and temperature constrain the pack operation.

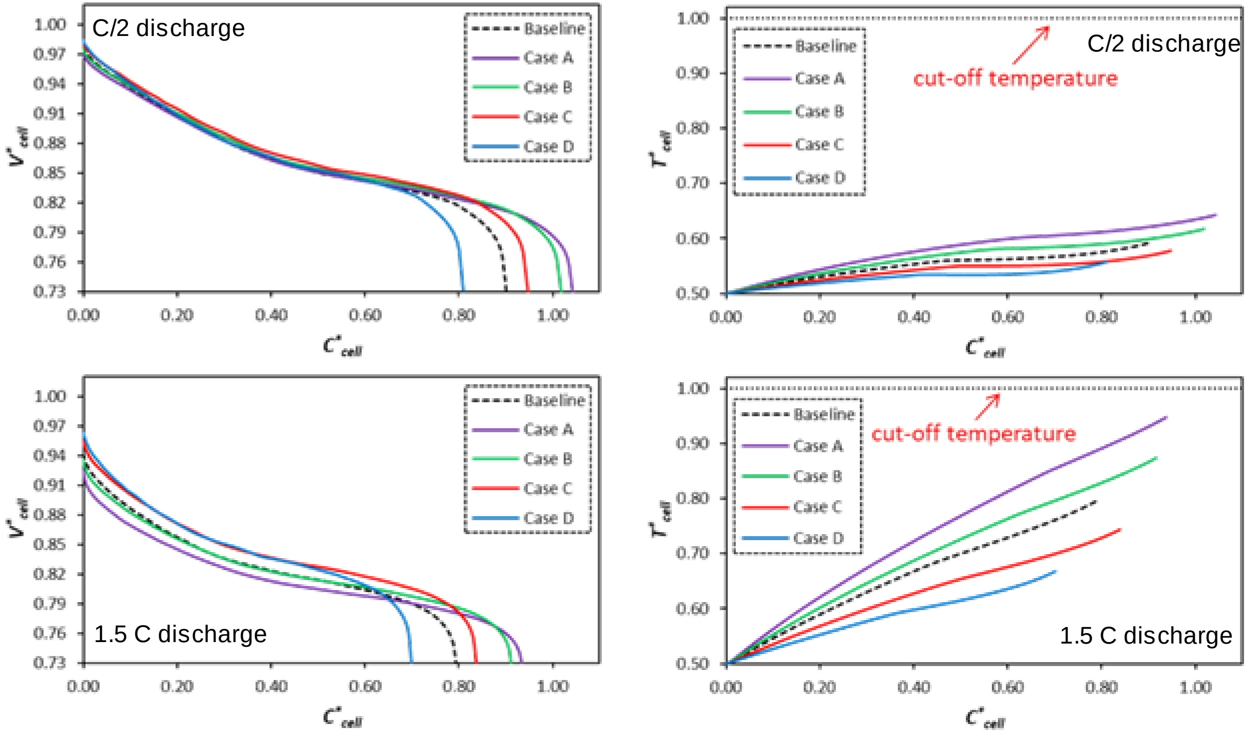
Results: Cell Design Optimization



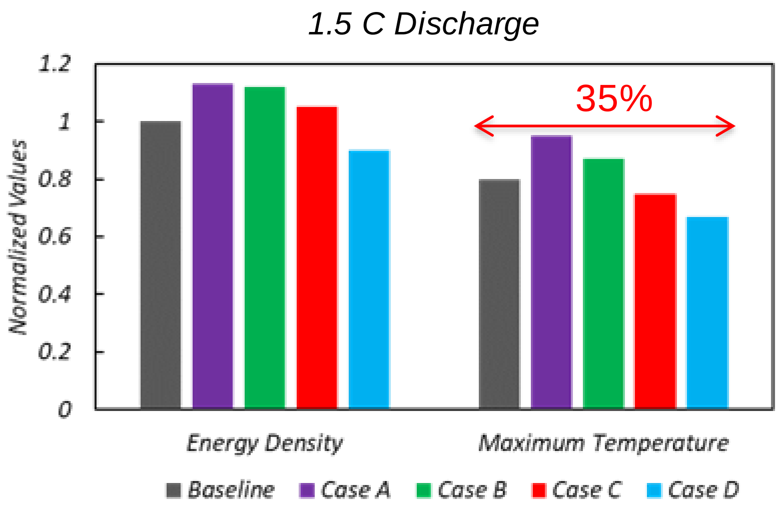
Thick and less porous electrodes maximize the cell *specific energy.*

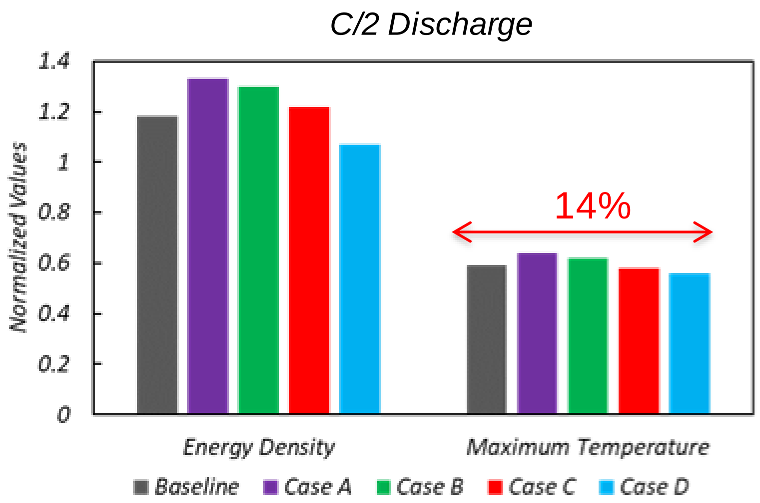
Thin electrodes with higher porosities minimize the cell *maximum temperature.*

Results: Cell Design Optimization



Results: Cell Design Optimization



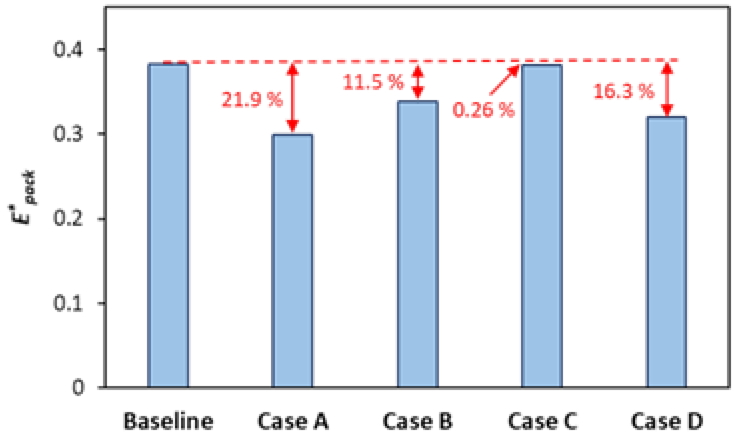


The maximum change in the delivered specific energy is 23%.

The impact of the cell design on the cell maximum temperature is amplified by the current.

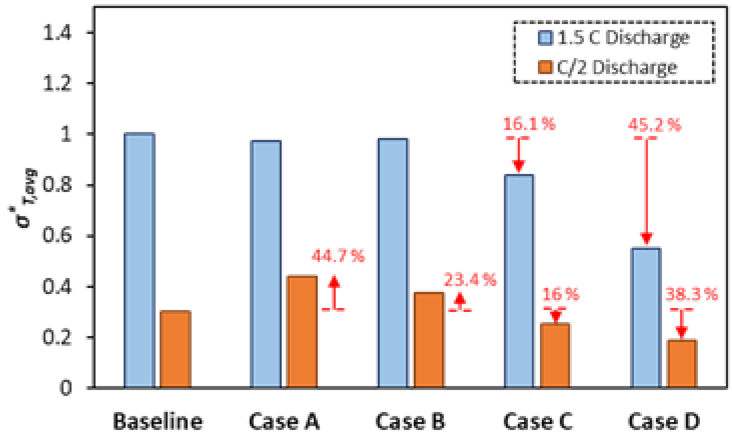
Results: Pack Performance Evaluation

Pack specific energy at 1.5 C discharge



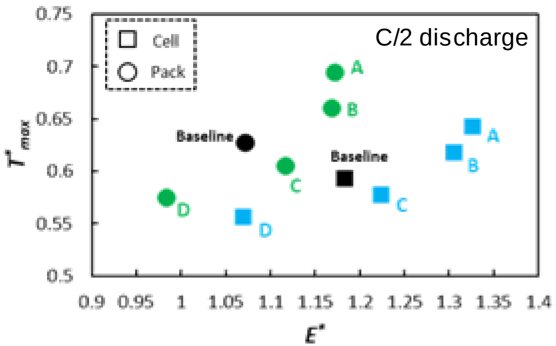
Pack designs **A** and **B** deliver low specific energies due to the fast temperature rise.
(The pack operation is constrained by temperature)

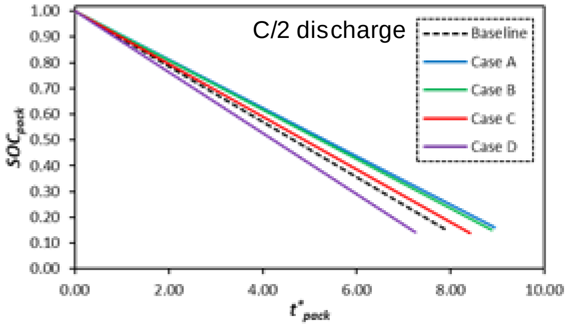
Average st.dv. of temperature within the pack

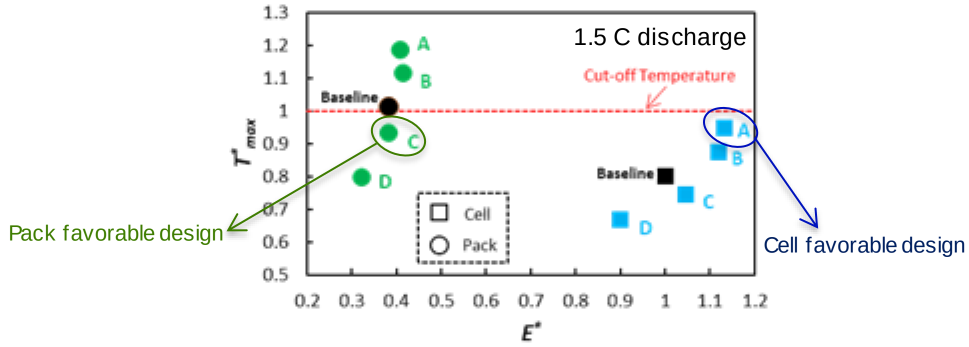


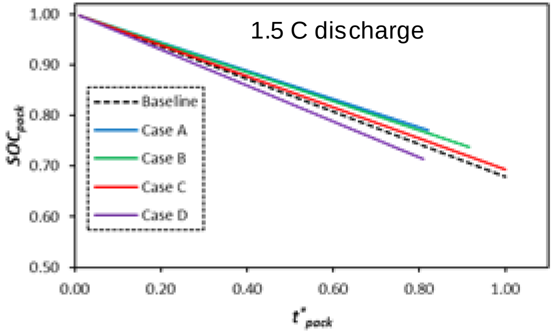
Temperature inhomogeneity increases by current and for the packs composed of high-specific-energy cells.

Results: Systematic Analysis









Pack designs **A** and **B** experience short times of discharge with around 75% underutilized capacity.

Concluding Remarks

- A novel multiphysics methodology for design optimization of large traction lithium-ion battery packs was proposed.
- Simulations and optimizations were performed in GT-SUITE/GT-AutoLion software.
- The developed method is aware of cell-to-pack interactions already at the initial cell design stage.
- Results showed that the multiphysics simulation-based optimization approach provides deep insight in efficient design of high specific energy battery systems with improved thermal performance.
- The proposed framework provides valuable knowledge for future cell and pack designs that employ different chemistries and configurations.

Astaneh, M.; Andric, J.; Löfdahl, L.; Stopp, P. Multiphysics Simulation Optimization Framework for Lithium-ion Battery Pack Design for Electric Vehicle Applications. Energy ***2021.***

Thanks for your attention

Recharge Your Batteries...

CHALMERS
UNIVERSITY OF TECHNOLOGY

Dr. Majid Astaneh
majid.astaneh@chalmers.se

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