Impact of the tabless electrode design on future cylindrical lithium-ion battery packs

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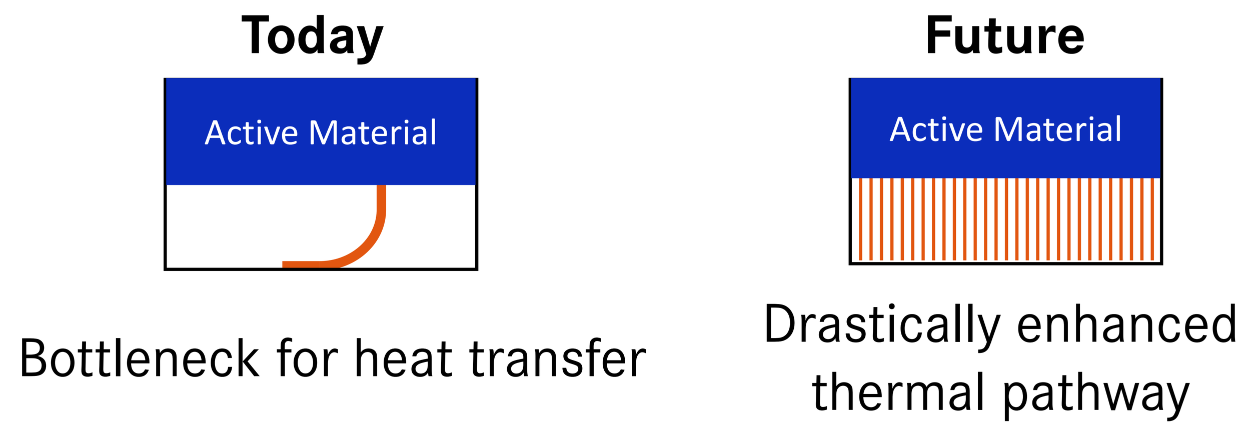
Motivation & Relevance

- Cylindrical lithium-ion cells with a tabless electrode[1] experience less current and temperature inhomogenities during cycling compared to single-tab design[2]
- Drastically enhanced thermal connection between jelly roll and cell casing through continuous metal foils enables cooling from the top/bottom
- Temperature gradient spreads in axial direction with high thermal conductivity, radial direction with low thermal conductivity has minor influence on temperature and current inhomogenities

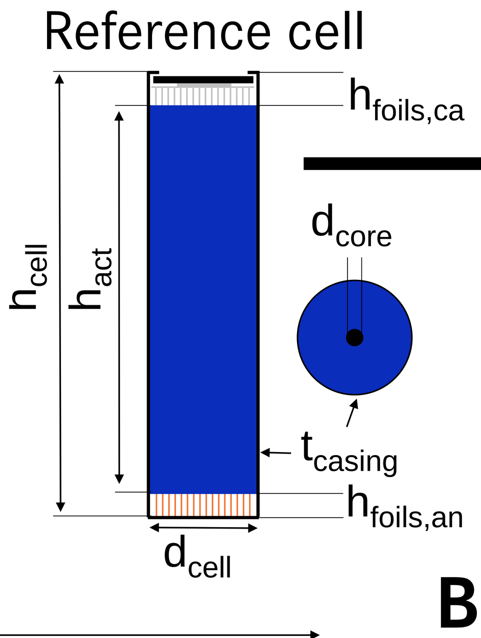


➡ **New possibilities for future automotive battery pack design with tabless cylindrical cells and larger diameters**

Modeling

Cell

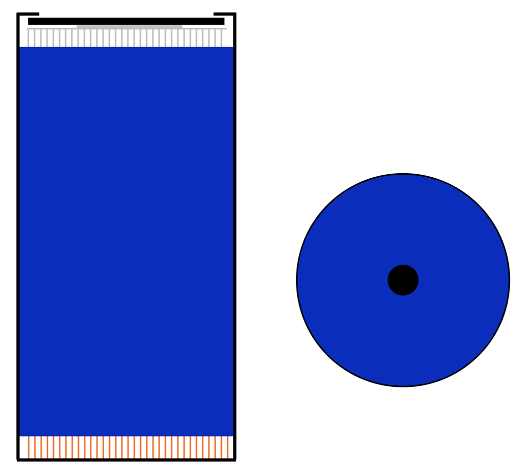
- Based on real prototype tabless cells made from deep drawn steel casing with crimped cap
- Anode current collector copper foils directly connected to the cell bottom
- Cathode current collector aluminum foils connected to a central terminal



Varying diameter

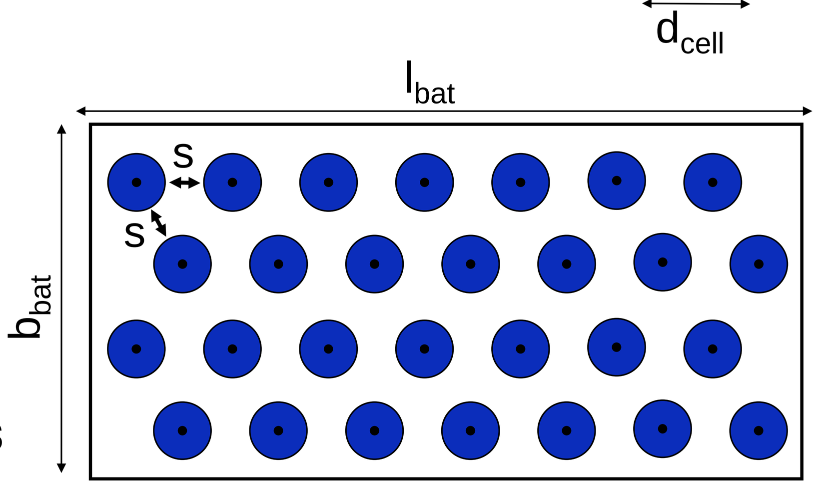
Cell geometry is influenced by:

- production, especially winding and welding
- bursting pressure and mechanical integrity
- electrode and SEI thickness growth



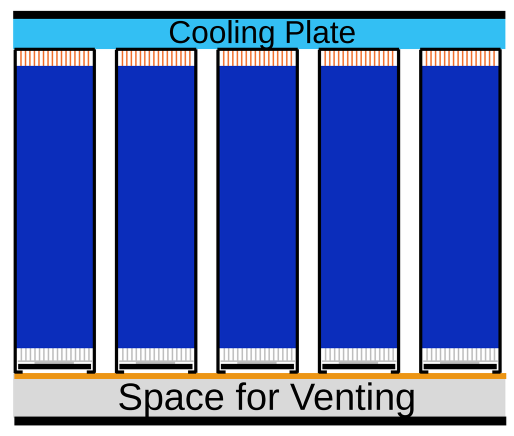
Battery x-y-plane

- Upright cells to avoid venting onto neighboring cells
- Honeycomb structure for maximum packing density
- Variable space *s* between cells

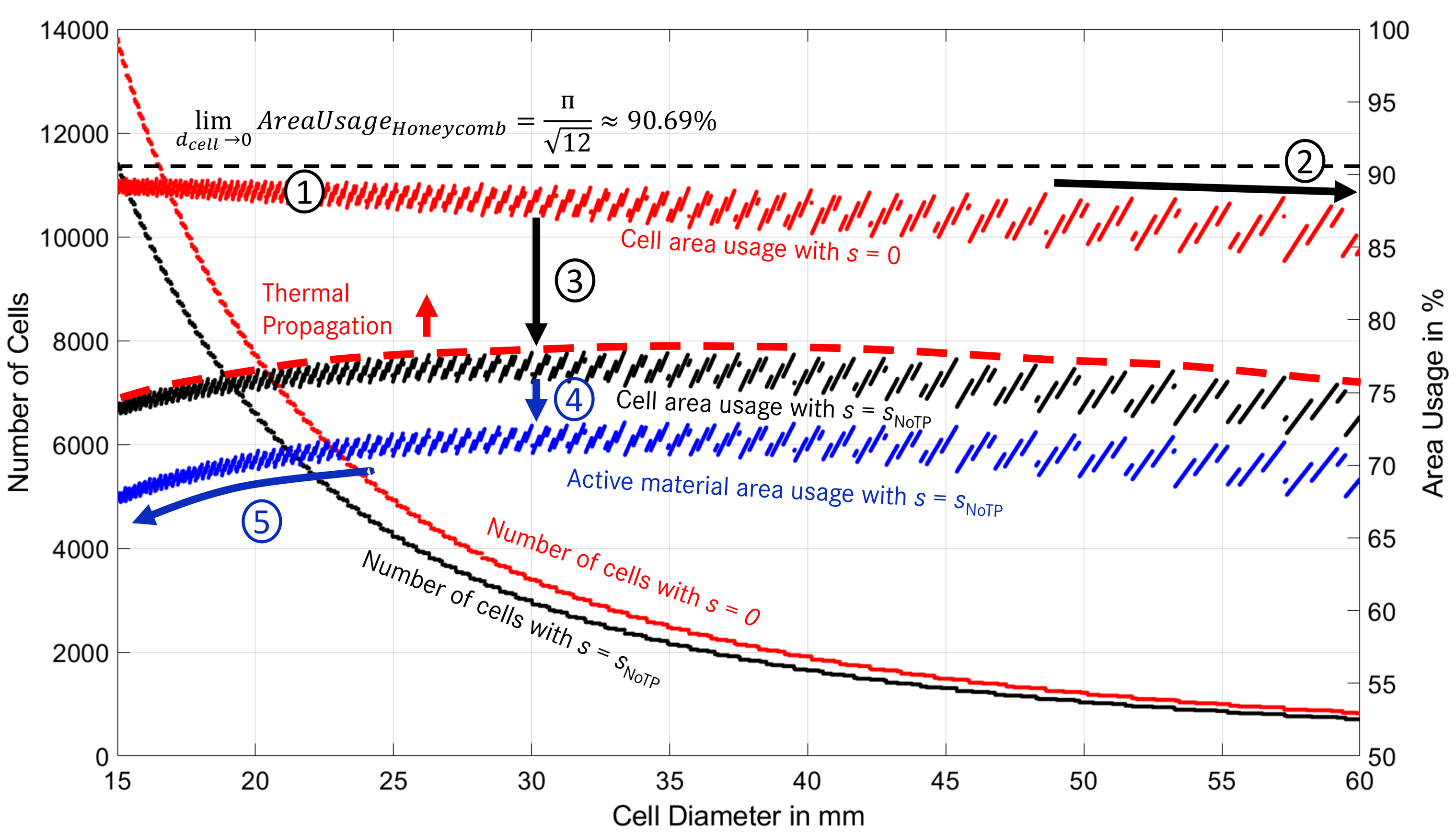


Battery x-z-plane

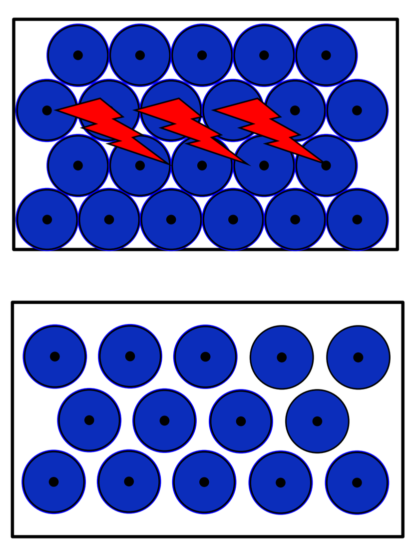
- Downward facing cells for venting away from the passenger compartment
- Cooling plate to make use of enhanced thermal pathway of tabless cells in axial direction
- Gap as space for venting



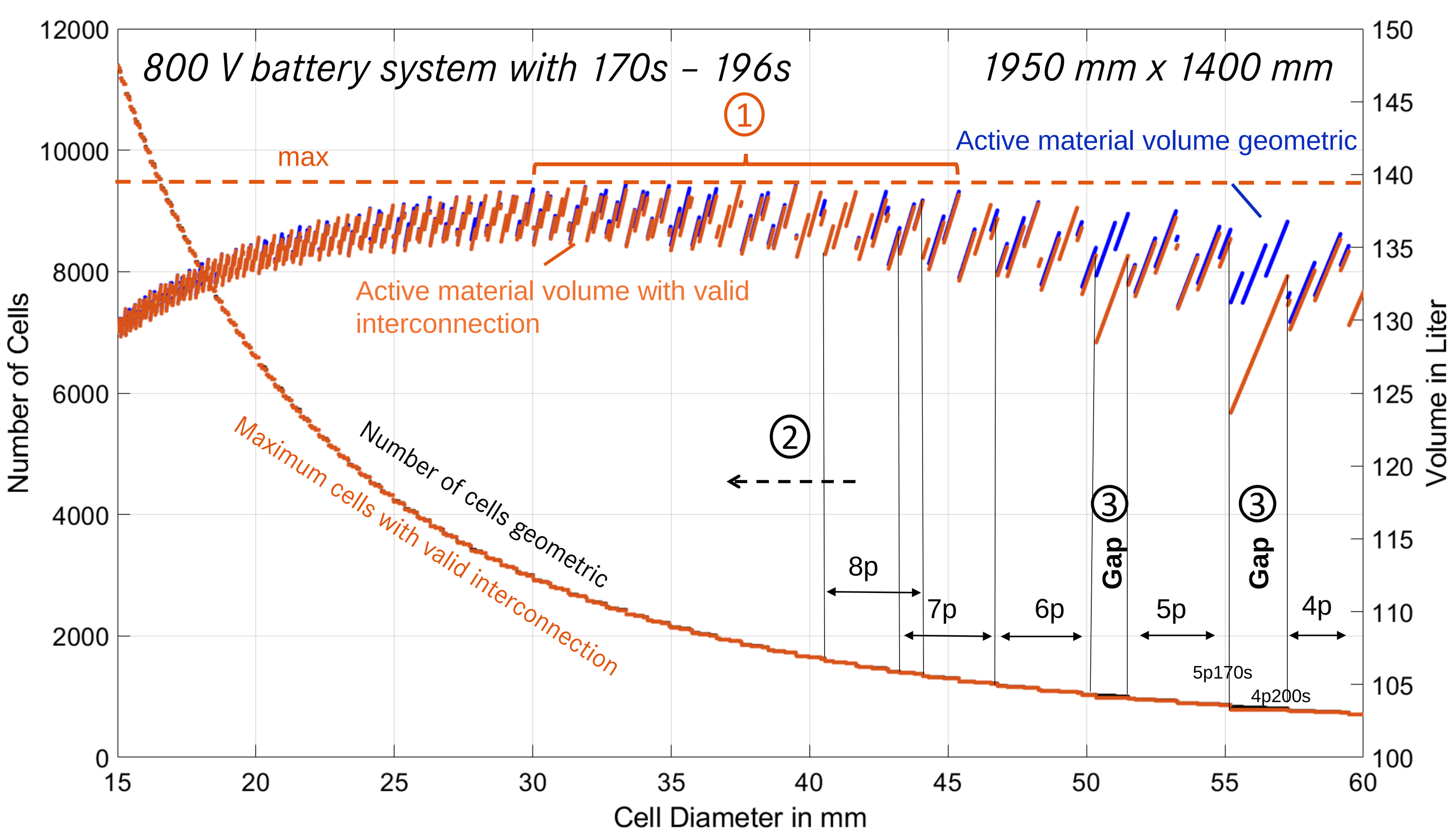
Results



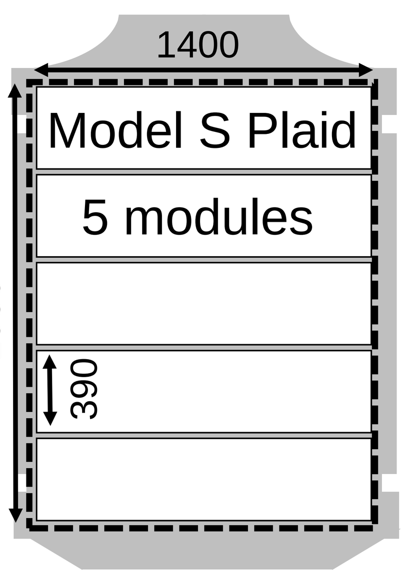
General understanding of packing density, safety and cell diameter



(1) No distance between cells leads to high packing density but also very high risk of thermal propagation
(2) Large diameters cause worse ratio of cell area to battery area
(3) Introduction of sufficient cell-to-cell distance to avoid thermal propagation leads to less packing density but compliance with GB- 38031-2020 safety norm[3]
(4) Housing material and hollow core further lower the area usage
(5) Ratio of active material area to cell area gets worse with smaller diameter



Case study: Tesla Model S Plaid battery dimensions with a single module, 80 mm cell height and varying cell diameter



(1) Cells with similiar active material volume inside the battery space between 3080 and 4680
(2) Small diameter lead to more options for interconnection
(3) Large diameter > 50 mm may have no sensible option for interconnection

Chosing a diameter

- Maximum battery energy density with ⌀37.5 mm, 1920 cells and 10p192s ($U_{nom} \approx 700$ V)
- Thermal properties of filling material may influence the result

For final decision additional criteria are important, for example:

- Fast-charging favors smaller diameter
- Productions costs favors larger diameter

Summary

The tabless electrode design enables:

- axial cooling and thus larger diameters that lead to more total active material volume and energy density on pack level
- more flexiblity to choose an optimal diameter when designing a portfolio of multiple batteries with the same cell geometry but different battery dimensions

Outlook

- Additional thermal-electric and production cost models to generate further understanding of optimal cell dimensioning
- Multi-objective optimization to resolve the trade-off between battery energy, charging time, power output and cost of production as a function of cell dimensions, cooling strategy, inter-cell-materials and choice of active material

References

[1] Tsuruta, K.; Dermer, M.E.; Dhiman, R. (2019): A CELL WITH A TABLESS ELECTRODE (EP3878029A1)
[2] Lee, K.-J., Smith, K., Pesaran, A. u. Kim, G.-H., Journal of Power Sources 241 (2013)
[3] GB 38031-2020 Electric Vehicles Traction Battery Safety Requirements

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