Comparative Study of Sidewall- vs. Top-Cooling of 4695 Cylindrical Lithium-Ion Secondary Battery Cells Based Module

Miba Battery Systems

Sajish Abraham[1], Hartmut Popp[1], Felix Burger[2], Alexander Kospach[2] , Martin Grininger[1]

1) Miba Battery Systems, 4190 Bad Leonfelden, Austria (sajish.abraham@miba.com)

2) Virtual Vehicle Research GmbH, 8010 Graz, Austria

Abstract

- Experimentally benchmarked sidewall and top/busbar cooling for 4695 cylindrical cells using MIBA FLEXCOOLER®
- The module underwent realistic and challenging scenarios to stress thermal headroom and expose hotspot under high load use.
- Measurements with time-synchronised test and simulation (OpenFOAM CFD model) were treated as a paired study for direct comparison

Cooling Strategy

- Both cooling concepts use MIBA FLEXCOOLER®, a flexible cooling system that conforms to the cell geometry.
- **Sidewall Cooling:** five FLEXCOOLER® ribbons are formed to the 4695-cell diameter (see Fig. 1a) to maximise contact with the can (Fig. 1b).
- **Top/Busbar Cooling:** a single FLEXCOOLER® is positioned to cover the entire module top, contacting the busbars and tabs across all cells (Fig. 1c).
- Both systems are cooled with deionized water at 25°C inlet. Only the flow rate differs: 5 l·min⁻¹ for sidewall and 3 l·min⁻¹ for top/busbar.

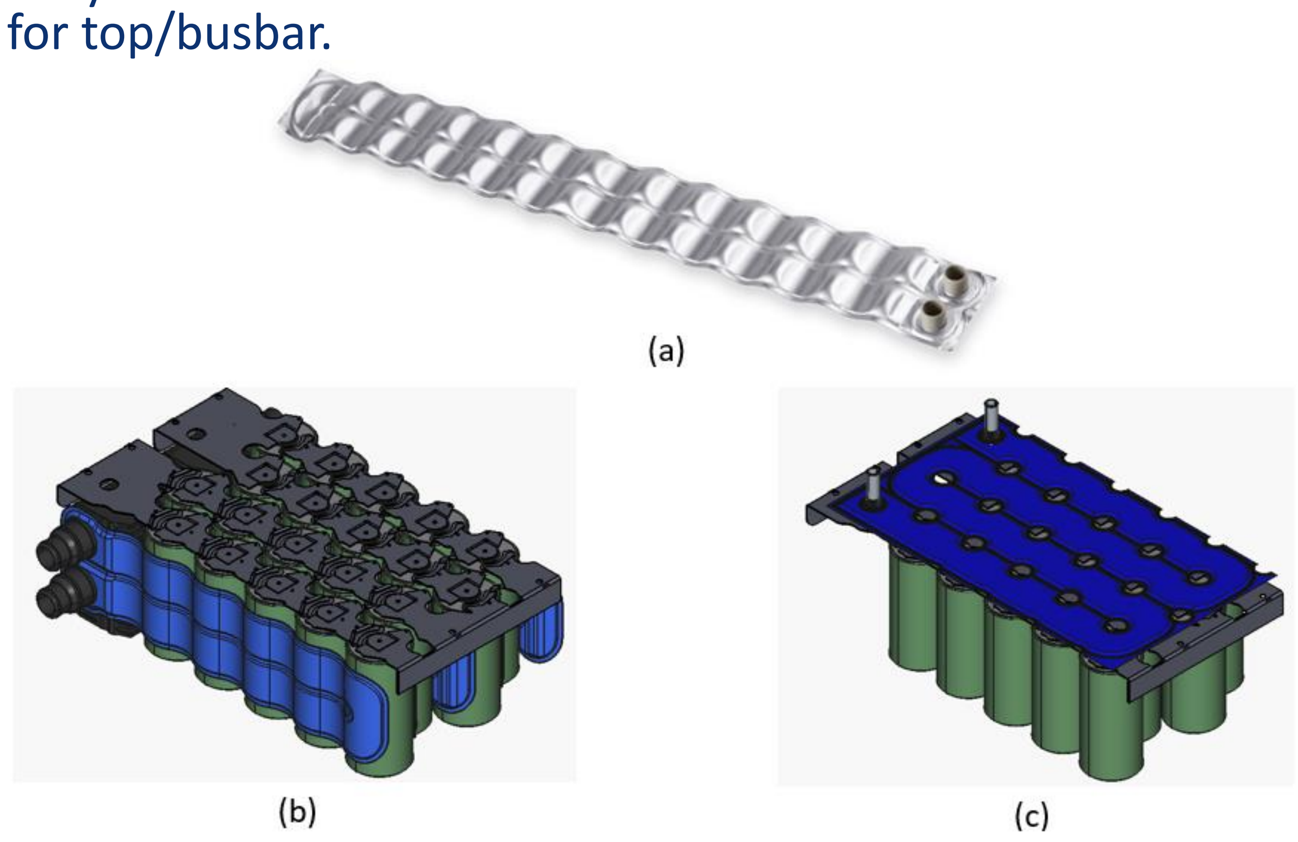

Fig. 1: (a) Single-formed FLEXCOOLER® ribbon. (b) FLEXCOOLER® in Sidewall-cooling orientation. (c) FLEXCOOLER® in Top-cooling orientation

Results & Simulation

- Sidewall consistently lowers peak cell temperature within each profile and narrows the spread across.
- Busbar temperature spread is smaller for top cooling, resulting in improved electrical-thermal coupling at the tabs and more uniform current distribution under higher load.
- Simulation fit at 3C discharge shows a mean R^2 of 0.79 for top-cooling cell, 0.66 for side-cooling cells and 0.80 for side-cooling busbar.

Table 1: Measured Cooling Performance Metrics Across Operating Conditions

Test Step	Peak Dissipated Power To Coolant [W]		Peak Cell Temp. [°C]		Avg ΔT For Cell [°C]		Avg ΔT For Busbar [°C]	
	Side Cooling	Top Cooling	Side Cooling	Top Cooling	Side Cooling	Top Cooling	Side Cooling	Top Cooling
1C CC Dchg	127	40	37.7	50.4	0.84	2.4	4.5	4.8
3C CC Dchg	526	85	49.3	70.3	3.7	4.1	35.6	16.9
Fast Charging	355	49	41.0	61.9	2.1	3.6	13.4	10.9

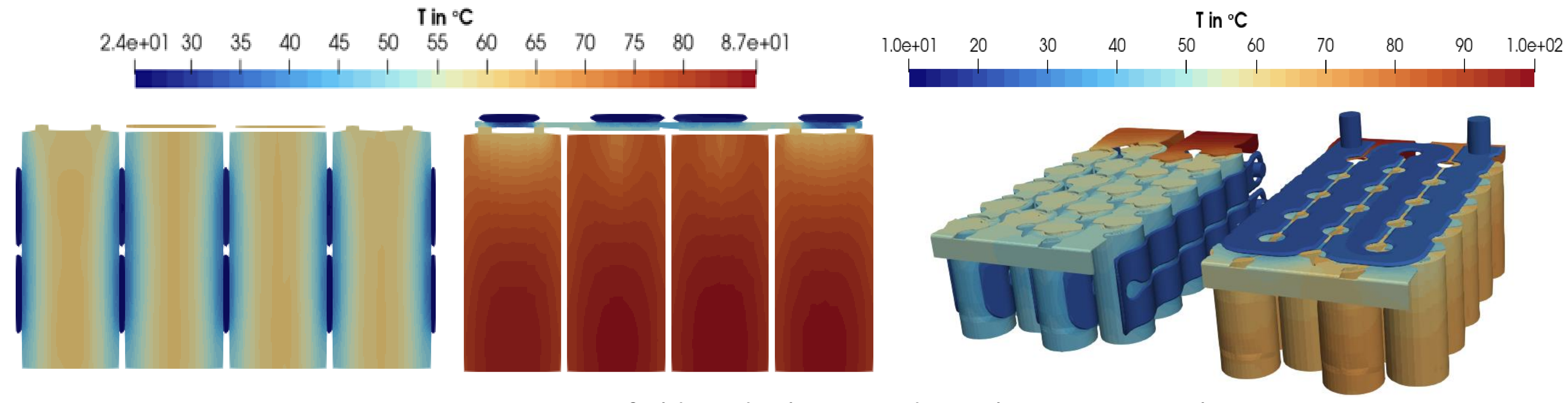

Fig 3: Temperature field 3C discharge: Side cooling vs. Top cooling.

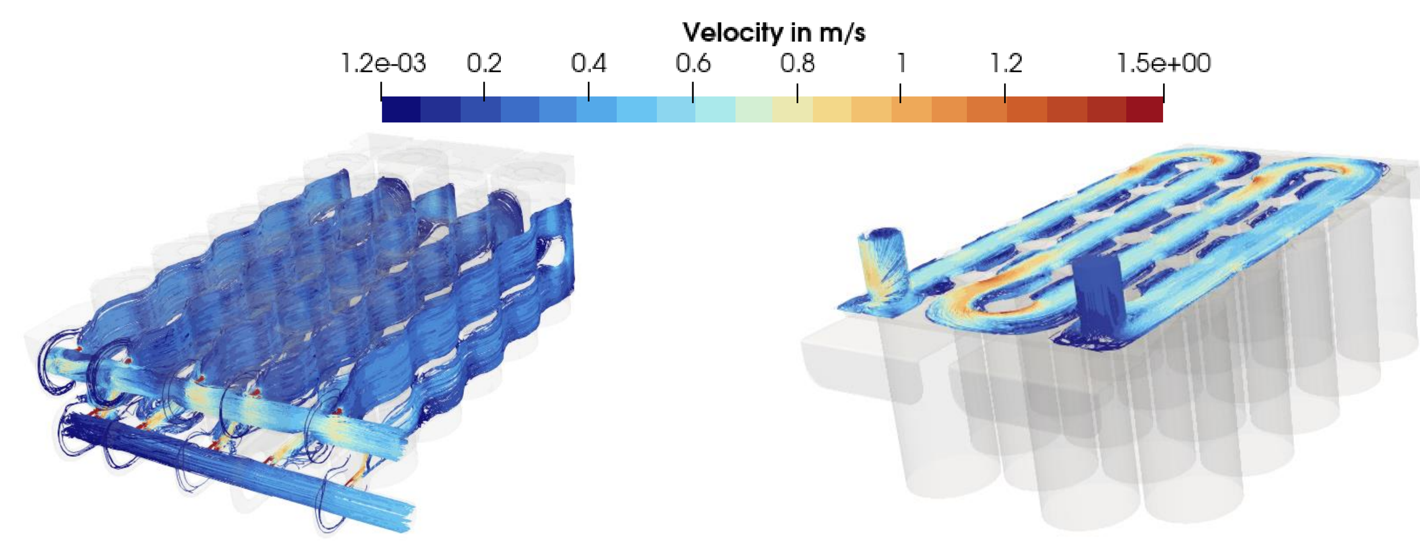

Fig 4: Simulation Coolant Temperature Streamlines: Side cooling vs. Top cooling.

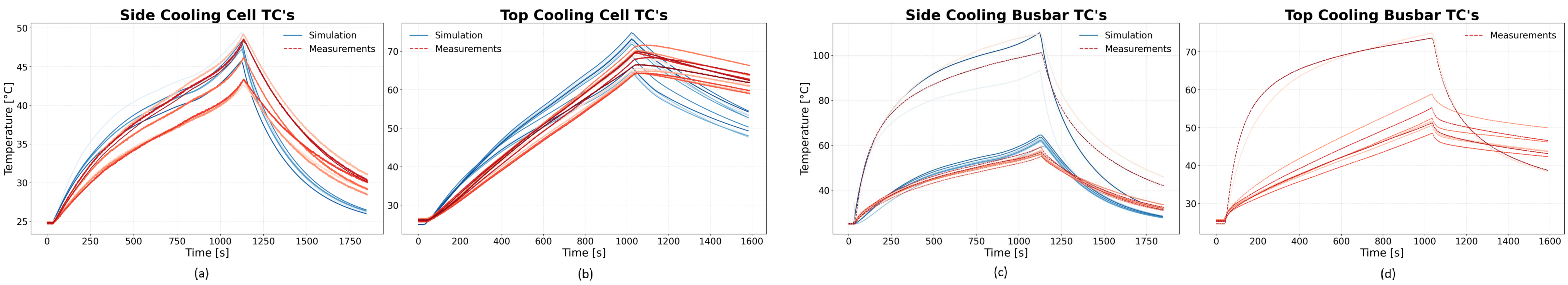

Fig 5: Thermocouple Temperatures with 3C discharge: Simulations vs. Measurements. Cell Temp with sidewall cooling (a) and top cooling (b). Busbar Temp with sidewall cooling (c) and top cooling (d).

Test Setup

- Both cooling strategies are tested on the same 10s2p module of 4695 cells (33 Ah per cell) at room temperature held at 25 ± 1°C.
- The module is preconditioned to room temperature and a fixed state of charge before each test step.
- Three electrical profiles were applied: 1C discharge, 3C discharge and a fast-charging profile.
- Temperature measured at the cell surface and busbars.

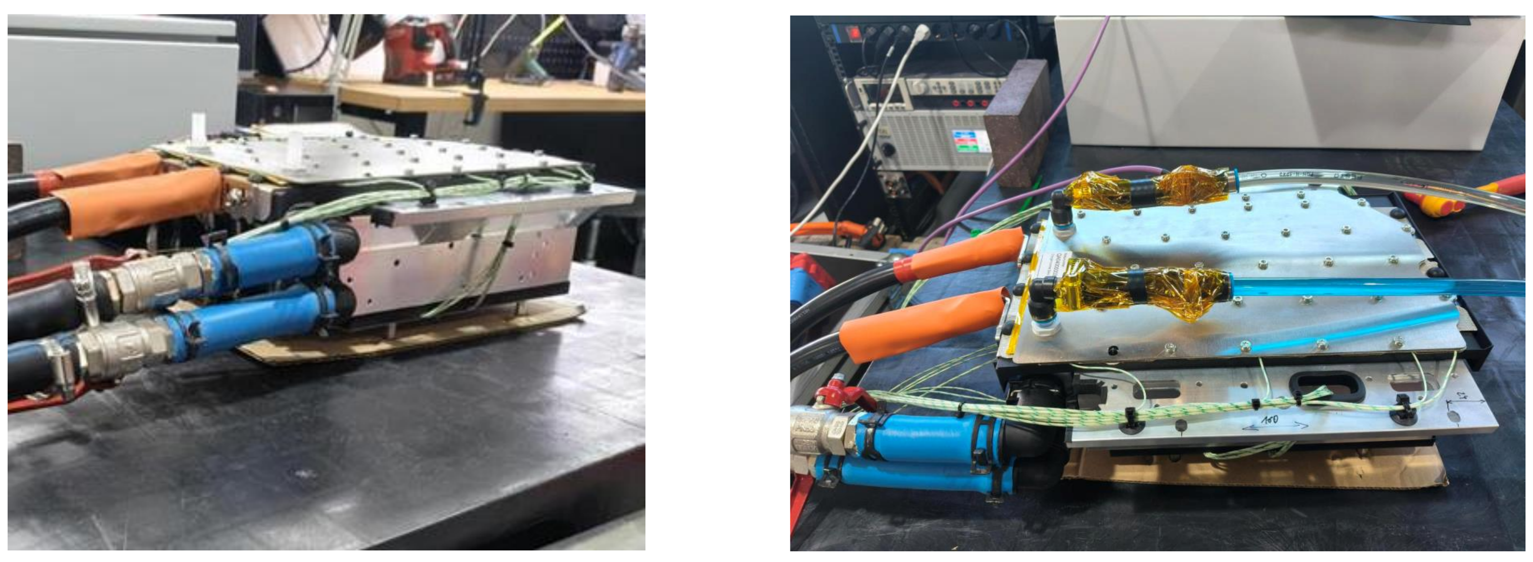

Fig 2: Module During test.

Conclusion

- With identical test conditions, the sidewall removed up to 526W with ΔT_max = 3.7°C at 3C (top: 85 W, 4.1°C) and to 355 W with ΔT_max = 2.1°C in fast charge(top: 49 W, 3.6°C).
- The top cooling fits the application targeting fast charging, where cost and integration simplicity are prioritized over max. thermal margin. Estimated cost <50 % vs sidewall, favouring simpler, lower-cost designs.
- Sidewall provides stronger thermal margins and more uniform cell temperature across all profiles.
- Simulation aligns well with the measurements while indicating areas that need further refinement and improvements.

Outlook

- Evaluate the effectiveness of FLEXCOOLER® sidewall as a thermal barrier under standardized abuse triggers.
- Extend module finding to pack level with correlated thermo-electric models and focused tests, evaluating performance, manufacturability and cost.

MORE+ Partners: virtual vehicle, ems, MAGNA

Powered by: Federal Ministry Innovation, Mobility and Infrastructure Republic of Austria; FFG Forschung wirkt.