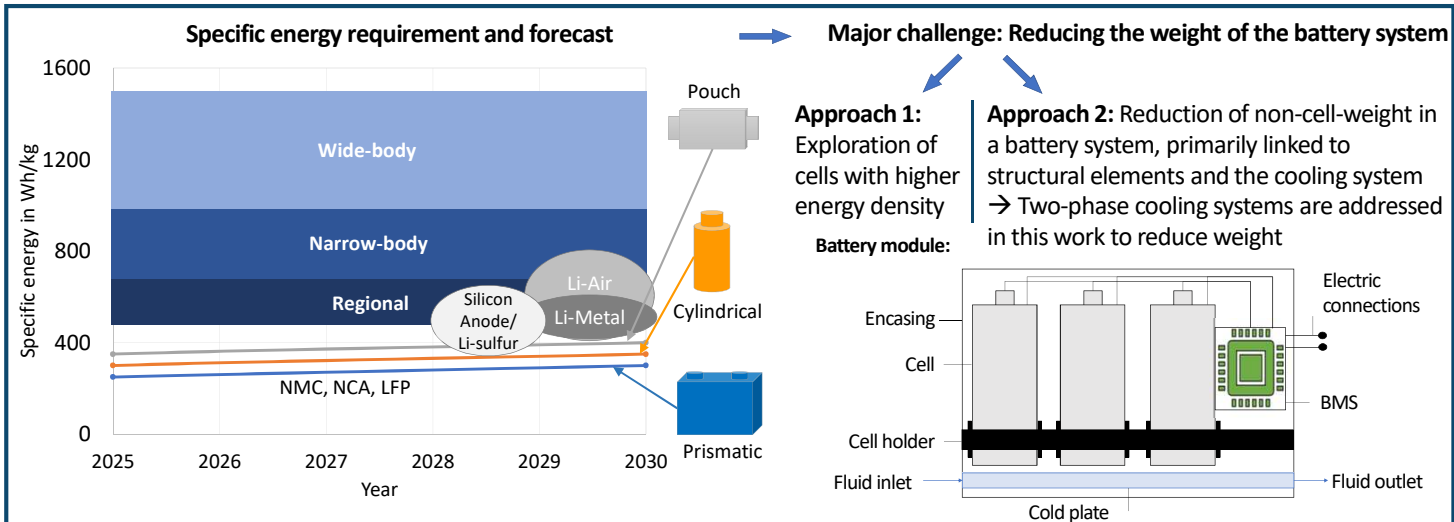


BATTERIES

Investigation of Two-Phase Cooling Systems for Battery Modules

A. Altun, F. Franke, S. Kazula - Institute of Electrified Aero Engines – German Aerospace Center (DLR)

Challenge

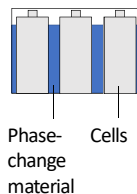


Investigation of Two-Phase Cooling Systems

Passive two-phase:

Phase-change material (PCM)

- Effectively reduces the overall temperature and temperature gradient
- Low level of complexity
- Increases the weight penalty
- Unable to respond to rapid temperature changes



Material	ρ_{liquid} [kg/m ³]	Melting Point [°C]	Latent Heat [J/g]
Hydrated Salt	1450	58	265
Paraffin	880	70	260
Xylitol	1520	95	320

Active two-phase:

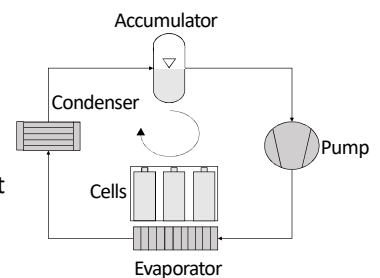
Pump two-phase cooling system

Potentials:

- Large evaporation heat
- Lower mass flow rate and higher heat transfer coefficient than single phase systems
- Reduced power consumption and weight

Challenges:

- Large accumulator size
- Avoid exceeding critical heat flux and critical mass flux causing choking
- Large pressure drop can cause oscillations and upstream vapor flow resulting in flow blockage



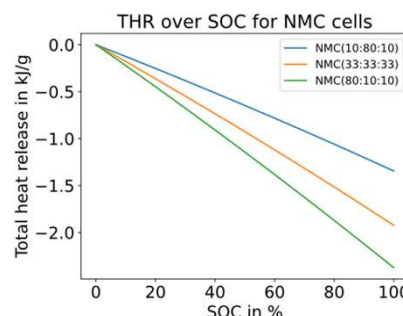
Fluid	h_{lv} for 35°C [J/g]	ρ_{liquid} [kg/m ³]
R1234ZE	159.3	1129.3
R1234YF	136.9	1054

Latent heat of PCM only used once during operation. Enthalpy of vaporization used continuously during the pump two-phase cycle!

Investigation of Thermal Runaway

Thermal runaway

- Can be triggered by mechanical failure, electrochemical failure or thermal failure
- Key characteristics are a rapid temperature increase (up to 1000°C) and high gas production
- Total heat release depends on cell chemistry and SOC
- Data based on analytical model and agrees with experimental results



Challenge: Develop two-phase cooling solutions to comply with EASA's containment and non-propagation requirements for thermal runaway!

Conclusions & Future Tasks

- Passive phase-change material only reasonable to absorb the heat in a thermal runaway event for low SOC
- Active pump two-phase cooling is promising to reduce weight
- Combination of both may be beneficial in terms of weight and thermal behavior
- Investigation of the optimal ratio of heat distribution for normal operation and in a thermal runaway scenario planned

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Publication

Altun, A.; Franke, F.; Kazula, S. (2024): Overview of the state of the art in battery packaging and Elaboration of a safe design process for battery packs in Large electric aircraft. Deutsche Gesellschaft für Luft- und Raumfahrt - Lilienthal-Oberth e.V.

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