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Best Practice to Design an Optimal Thermal Management System for Li-Ion Batteries

Depending on the application and environmental conditions batteries heat up during operation. In cold regions even cooling down of a battery can take place. By keeping the temperature distribution inside the battery system in a range of max. 5 K around 25 °C, aging can be prevented or at least protracted [1]. In addition, it is even more important to have a homogeneous temperature distribution along every single battery cell.

To design a thermal management system, which will be able to ensure this, one has to know where to cool or heat a battery system most efficiently. That means, that the thermal characteristics of a single cell has to be known or measured and out of this the thermal behavior of a battery module can be simulated. After optimization and experimental verification of the thermal management system of the modules, an adequate system for the final battery can be designed.

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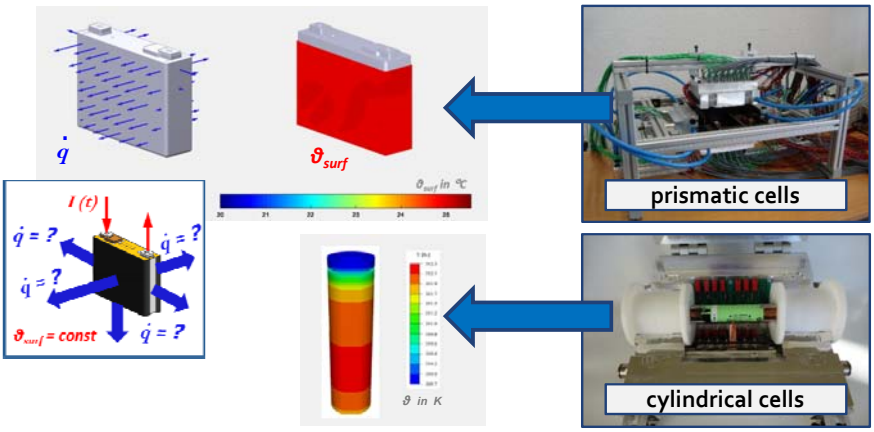
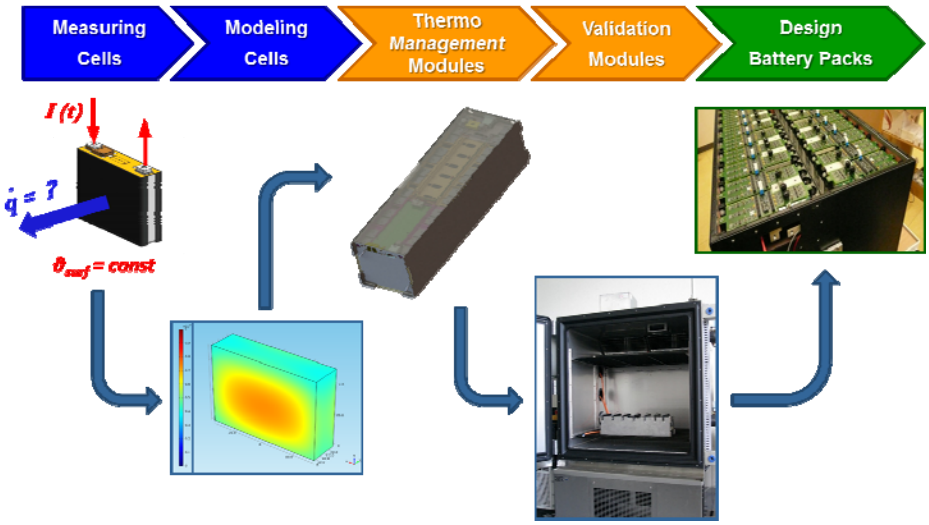
Introduction

Lithium-ion batteries are very sensitive to low and high operating temperatures. If they are operated outside their optimal temperature range the battery capacity will fade dramatically. The optimum is at appox. +25 °C, depending on cell chemistry [1]. To prevent a heat-up of the battery under use or by environmental impact as well as cooling down an adequate thermal management system is needed. Following a best practice method to design such a system is introduced.
Especially a unique test rig for thermal characterization of single Li-ion cells was build up and verified at NTB Buchs. With this setup it is possible to characterize the thermal behavior of single battery cells. In addition this test rig allows to verify a proposed cooling or heating system, without building-up of a prototype. With this knowledge a optimized thermal management system for the whole battery system can be derived.

Unique Experimental Thermal Cell Characterization at NTB Buchs SG/Swiss



Best Practice to Design a Thermal Management Systems



Outcome

- By optimizing the thermal management system with respect to reach an over all homogenous temperature distribution and under consideration of the thermal behavior of a single cell, it will be possible to reduce the capacity fading of Li-ion batteries significantly. Therefore
- Total cost of ownership can be reduced accordingly,
- Reliability and safety will be improved,
- Simulation and optimization of new thermal management system will be possible, even on cell level,
- Costs and time for design and verification of thermal management systems can be reduced,
- Detailed knowledge of the thermal behavior of Li-ion cells can be determined with sufficient resolution and
- By reverse engineering, the thermal design of battery cells could be enhanced.

References

[1] T. Waldmann, M. Wilka, M. Kasper, M. Fleischhammer und M. Wohlfahrt-Mehrens: „Temperature dependent ageing mechanisms in Lithium-ion batteries - A Post-Mortem study", Journal of Power Sources, Bd. 262,P. 129-135, 2014.

[2] G. Rizzo, R. Christen, M. Stöck: „Prüfstand zur thermischen Charakterisierung von Batteriezellen und Validierung geplanter Kühlkonzepten", 23. DESIGN&ELEKTRONIK-Entwicklerforum – Batterien & Ladekonzepte, München, 2016.