sccer mobility
Swiss Competence Center for Energy Research
Efficient Technologies and Systems for Mobility

In cooperation with the CTI
Energy funding programme
Swiss Competence Centers for Energy Research
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Confederation
Commission for Technology and Innovation CTI

Battery Cooling Concepts – Which is The Best for Prismatic Li-ion Cells?

There are different cooling concept for Lithium-ion batteries available. The most common one is bottom cooling, while the most efficient one is expected to be at the cell terminals. Following, the influence of the before mentioned cooling strategies will be investigated in concern of their resulting internal temperature distribution and the temperature difference between heat transfer fluid and internal battery cell layers, which is a measure for their effectiveness. As could be shown the cooling of the battery bottom is quit efficient, but unfortunately the resulting internal temperature variation is significantly high. For comparison a second test with cooling of the cell terminals was performed. This method showed a high temperature difference between heat transfer fluid and internal cell layers – that means it is less efficient – but the homogeneity of the internal temperature distribution is excellent.

Dr.-Ing. Gerhard Rizzo
NTB, Interstaatliche Hochschule für Technik Buchs
Gerhard.Rizzo@ntb.ch

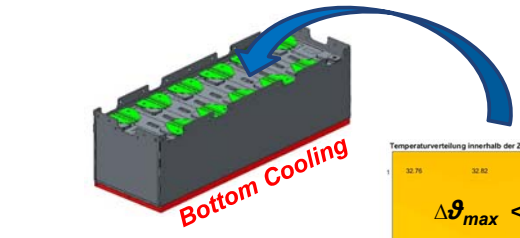
M.Eng. Rouven Christen
NTB, Interstaatliche Hochschule für Technik Buchs
Rouven.Christen@ntb.ch

Prof. Dr.-Ing. Max Stöck
NTB, Interstaatliche Hochschule für Technik Buchs
Max.Stoeck@ntb.ch

Introduction

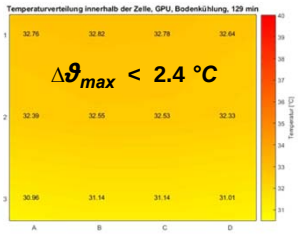
Lithium-ion batteries are the most promising electrochemical energy storages for direct storage of electrical energy. Therefore their use is recently widely spread: from power tools up to electrical vehicles and even for grid stabilization. Unfortunately, their capacity fades significantly if operated at too high and low temperatures [1]. In addition, the temperature distribution inside a single cell and between different cells of a battery should be as homogeneous as possible. Hence, the operating temperature has to be kept in a narrow temperature range, to prevent fast battery aging. This is usually done with the help of a thermal management system.
But where is the best place to cool or heat a battery ? And what is the influence of the chosen concept on the resulting internal temperature distribution ? Following, two typical cooling concepts will be analysed in detail.

Bottom Cooling and Its Impact on Internal Temperature Distribution

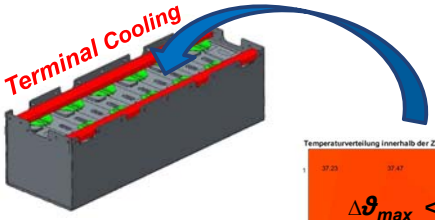


⊕ *small* $\Delta\vartheta$ *(≈ 9 °C) between cell and cooling fluid*

⊖ *large* $\Delta\vartheta$ *inside cell*

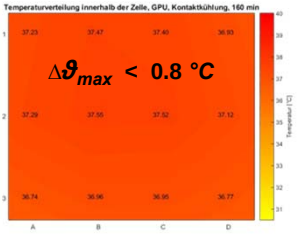


Terminal Cooling and Its Impact on Internal Temperature Distribution



⊖ *large* $\Delta\vartheta$ *(≈ 12 °C) between cell and cooling fluid*

⊕ *small* $\Delta\vartheta$ *inside cell*



Outcome

The investigated cooling concepts show characteristic influences on the relation between cooling effectiveness and homogeneity of the internal temperature distribution. Depending on application, environmental conditions and requirements of the customer the one or other is beneficial. It's the decision of the designer of a thermal management system, if the efficiency of cooling in terms of temperature difference between internal cell temperature and heat transfer fluid is more important, or the deviation of the internal temperature of a single cell.

In general it can be said, that bottom cooling is the cheaper version of cooling concepts for Li-Ion batteries. With the disadvantage of introducing higher temperature variation inside the battery cell and thus faster aging. The terminal cooling has the best homogeneity in concern of internal cell temperature distribution, but is less efficient.

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.