FEM-based thermal analysis of NiMH batteries for hybrid vehicles

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TUG
Graz University of Technology

W. Renhart°, C. Magele° and B. Schweighofer*

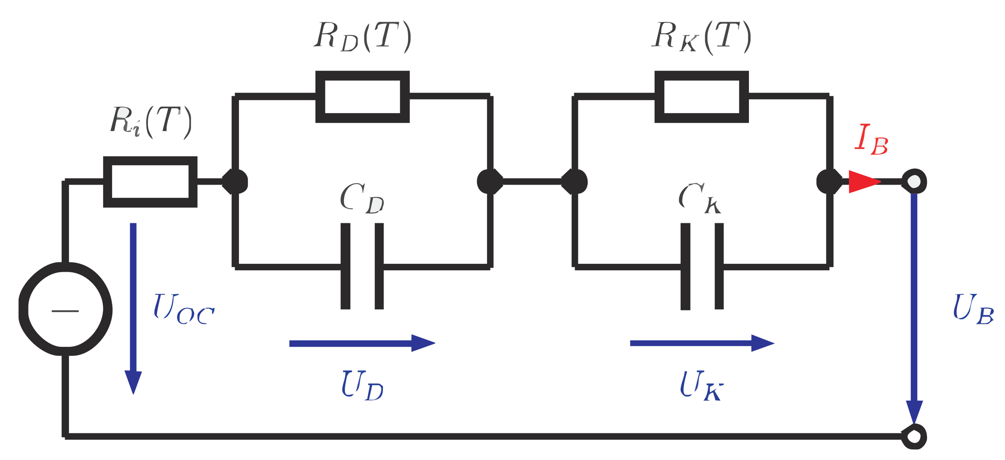
° Institute for Fundamentals and Theory in Electrical Engineering

* Institute of Electrical Measurement and Measurement Signal Processing

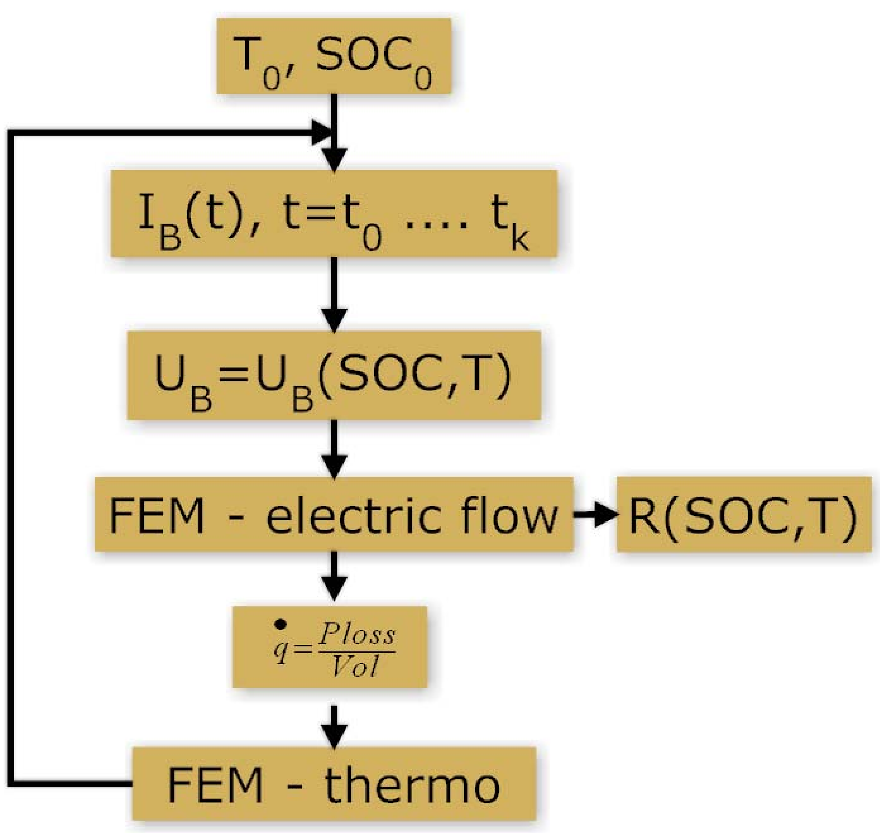
Kopernikusgasse 24, A-8010 Graz, Austria.

e-mail: werner.renhart@tugraz.at

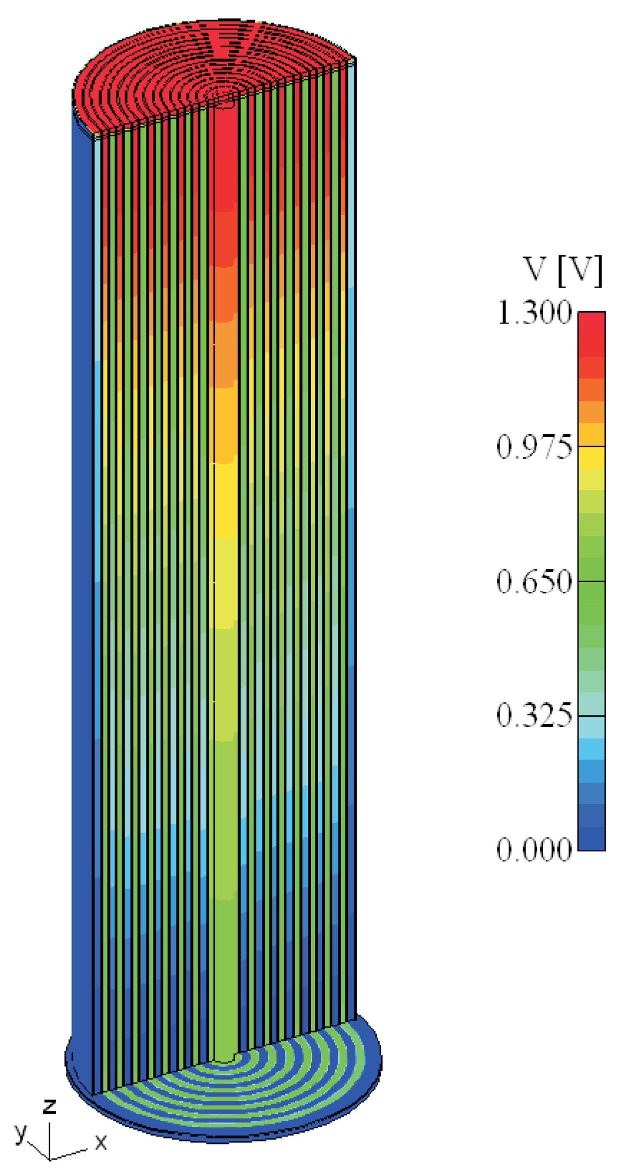
Abstract: Hybrid vehicles require advanced battery management systems. Amongst others the knowledge of the temperature during operation is substantially. This parameter strongly affects the behavior of the electrical energy source. In this paper the finite element analysis has been applied to predict the thermal performance capability. Our investigations have been accomplished on a standard NiMH type. The temperature found will be involved in an equivalent battery circuit network in order to simulate realistic drive cycles.



Equivalent network circuit for NiMH-cell.



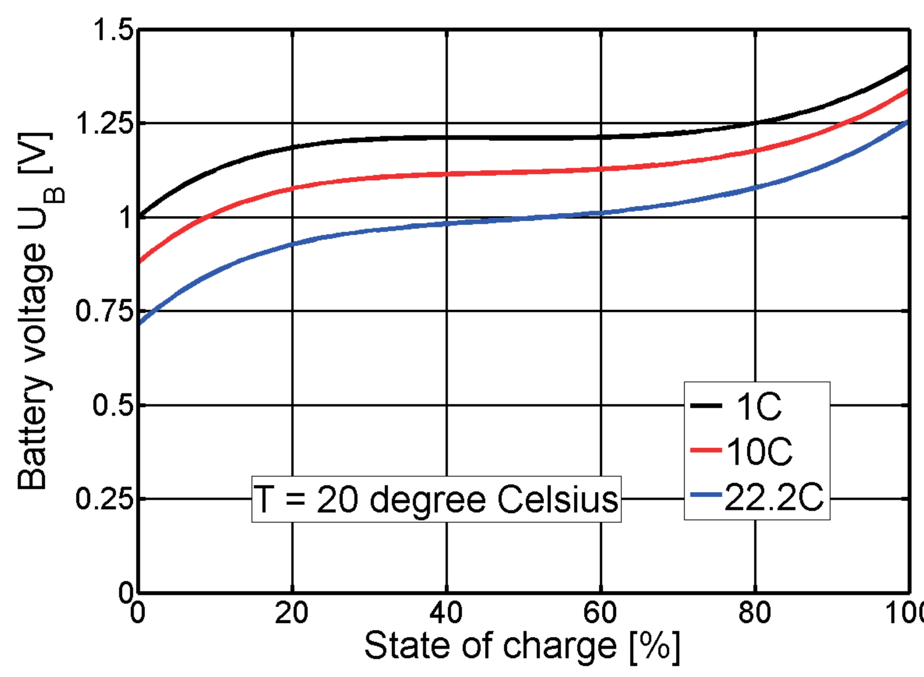
Computation procedure.



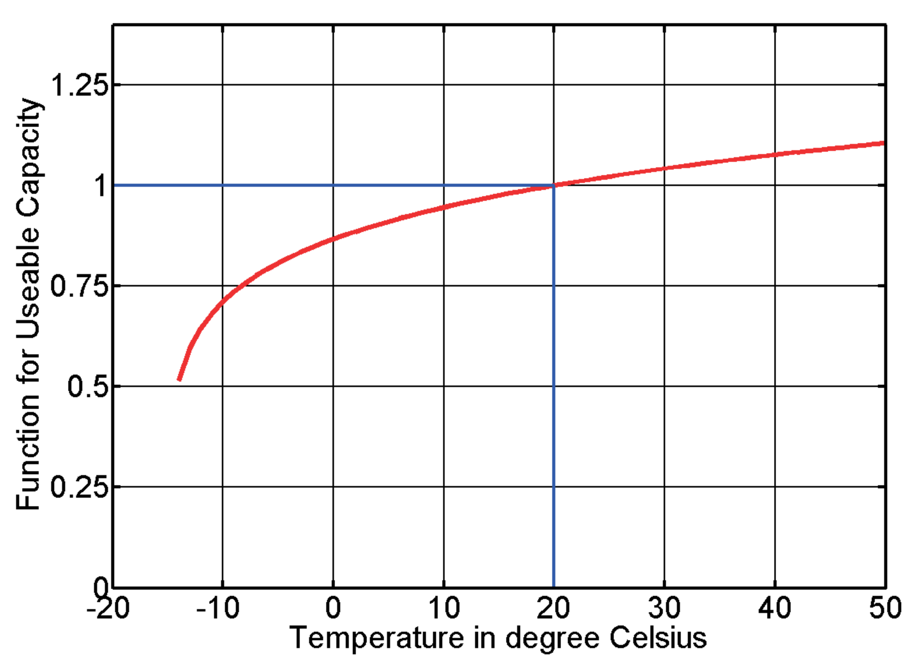
Potential distribution inside the cell.

FEM - electric flow model

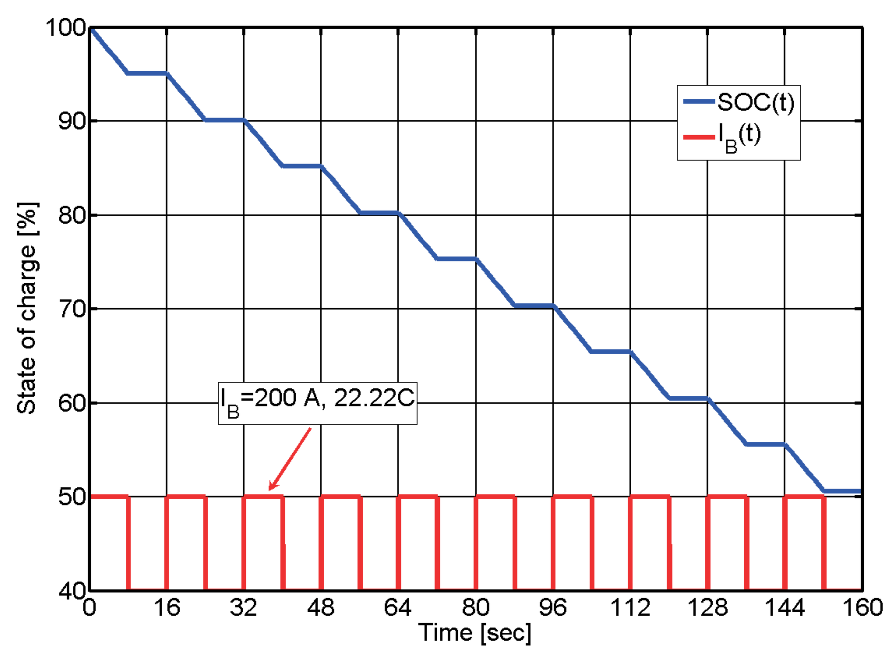
$$\vec{E} = -\nabla V$$
$$\vec{J} = \gamma \vec{E}$$
$$\nabla \cdot (\gamma \nabla V) = 0$$



Battery voltage versus state of charge (SOC) for variant loads.



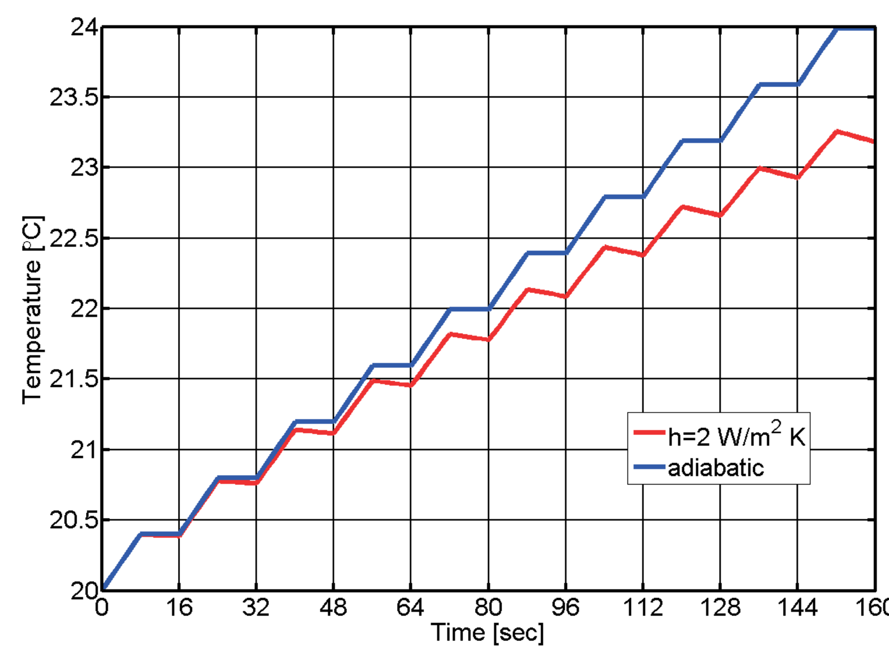
Correction function for UB to describe the temperature influence on the battery.



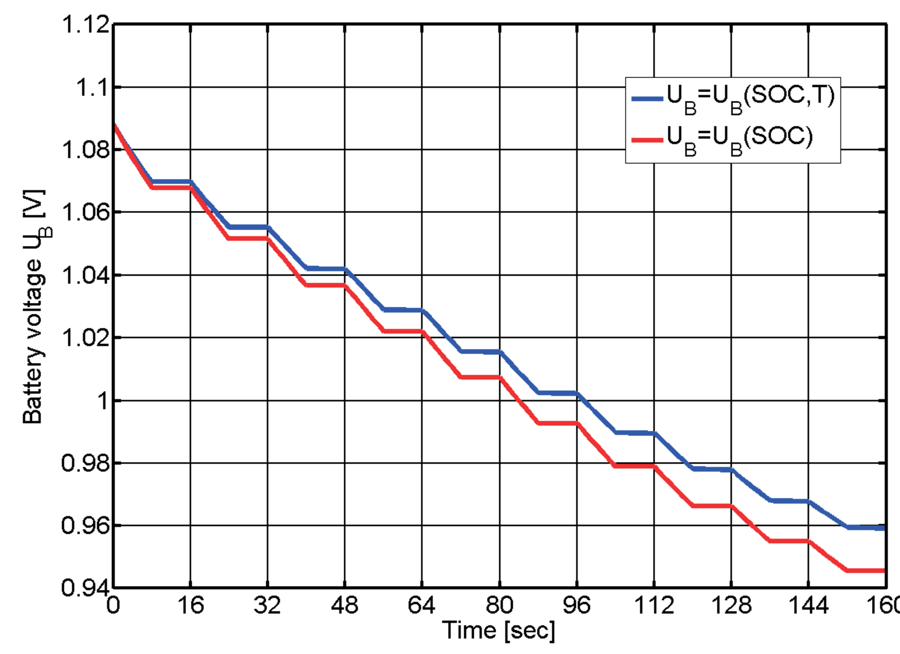
Current extraction and SOC.

FEM - thermal model

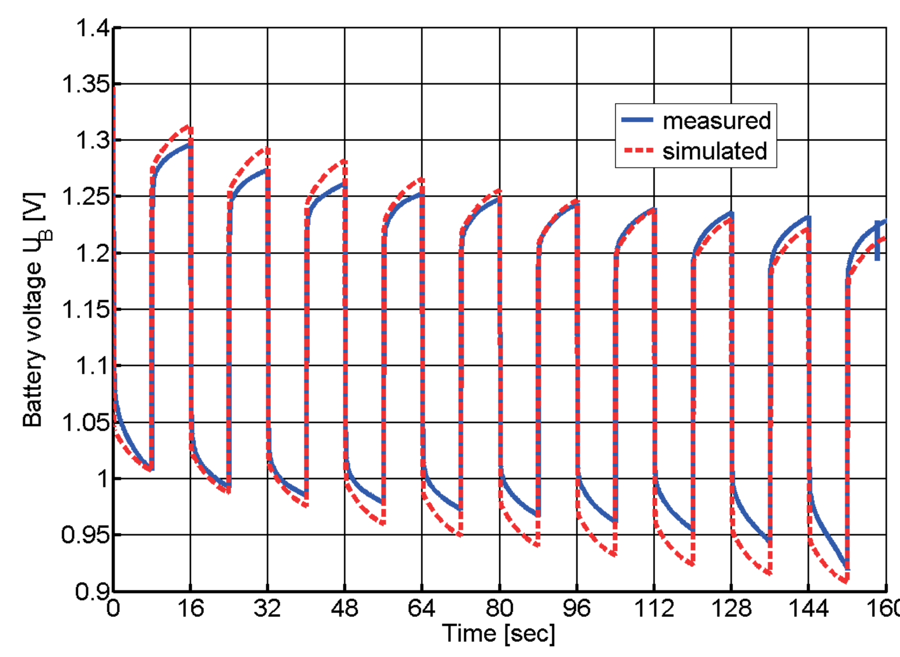
$$\frac{\partial}{\partial x}k_x\frac{\partial T}{\partial x} + \frac{\partial}{\partial y}k_y\frac{\partial T}{\partial y} + \frac{\partial}{\partial z}k_z\frac{\partial T}{\partial z} + \dot{q} = \rho \cdot c\frac{\partial T}{\partial t}$$
$$k\frac{\partial T}{\partial n} = h(T - T_a)$$



FEM-computed temperature lapse.



Run of battery voltage in comparison.



Measured and simulated results.

Conclusion:

Influence of the SOC on the battery voltage has been investigated.

Thermal model for the temperature dependence is given.

Realization in an equivalent circuit model.