Phenomenological Li ion battery modelling in Dymola

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A key enabler (or constraint) of the electrified power train is the need to store energy in a form that can be easily and robustly converted into electricity. Batteries have emerged as a preferred choice in alternative energy storage but the technology still comes with significant compromises for the customer. Many of the challenges and opportunities presented by battery technology can be traced to the li-ion cell at the heart of the battery.

The structure of a modular, acausal and reconfigurable electro-thermal battery model is described. In this paper, we extend the INEEL FreedomCar program model [1] to include temperature dependence, voltage hysteresis, self-discharge and diffusion limitation. The dynamic model structure adopted for the battery cell is based on an equivalent circuit whose parameters are generated using real cycling data through an optimisation routine written in the Modelica language. A linearised one-dimensional thermal mathematical model with lumped parameters is used to simulate temperature profiles for the cell. The cell and scaled-up pack model is parameterised for a number of commercially available cells ranging a number of cell formats, sizes and chemistries. These Dymola models are validated using highly transient and aggressive real-world as well as synthetic drive cycles.

The same battery models can be tested on virtual rigs, integrated into vehicle powertrains thanks to the multi-domain properties of the Modelica language on which Dymola is based.

Keywords: Lithium ion, battery, HEV, EV, PHEV, Acausal, Dymola, Modelica

References

[1] I.N.E.E. Laboratory, Battery Test Manual for Plug-In Hybrid Electric Vehicles, in, Assistant Secretary for Energy Efficiency and Renewable Energy (EE), Idaho Operations Office: Idaho Falls, ID, USA, 2010., 2010.