Thermal Diffusivity Test Bench for Li Ion Cells Using LiveLink™ for MATLAB®

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Abstract

LiveLink™ for MATLAB® is used to fit the surface temperature of a battery cell within a COMSOL Multiphysics® model to the temperature measured by a thermal imaging camera. The view field of the camera is shown in Fig. 1. The test bench was designed and built up of ourselves to allow nondestructive thermal diffusivity measurement of Li Ion cells as a function of temperature, state of charge (SOC), state of health (SOH) and others. Cylindrical cells as well as Pouch cells can be measured. The idea of the experimental setup is based on the method introduced by Parker et al. in 1960, which is still present in a lot of modern laboratory apparatus. It describes a heat pulse measurement from which the thermal diffusivity of a specimen of distinct size is derived from a very simple analytical model. Although whole cells are measured here, which neither do not comply with a distinct specimen size, nor are homogenous, an analytical model can be found, when the battery cells are regarded as homogenous body with anisotropic properties (Fig. 2). In that way we determined the through-plane thermal diffusivity of Pouch cells in transmittance setup and the radial component of Cylindrical cells in reflective setup. As excitation sources a flash lamp or induction coil are used. Although the cell housing is ignored, the measurement can be fitted rather accurate by the models. But, as we fitted the Cylindrical cell measurements, we mentioned a systematic difference, short time after the heat pulse, which emerged as the influence of the housing. The comparison of the temperature curve from the measurement to a similar parameterized curve, derived from a two layer COMSOL Multiphysics® model, showed a good analogy between them. This motivated us to substitute the former analytical model in the MATLAB® evaluation by a three layered COMSOL Multiphysics® model which promises a perfect fitting from the very beginning. To limit the fitting parameters, respectively to keep the calculation time short, evaluation now takes place in two steps. At first, the single layer analytical model with only a few seconds evaluation time is fitted, from which we gather the pulse energy, the heat loss parameters for radiation and convection and an initial value of the jelly rolls thermal diffusivity. Finally, in the second run, the two unknown thermal diffusivities, with the other values fixed, are fitted (Fig. 3). The first one is for the already mentioned jelly roll. As the heat pulse is generated inductively and the skin depth is about the thickness of the metal housing, the second one is caused by the insulating plastic film between housing and jelly roll. Similarly to this explanation, the housing of Pouch cells can be measured. With a corresponding COMSOL Multiphysics® model, even the in-plane values of Pouch cells, respectively axial parameters of Cylindrical cells, can be determined using this approach.

Figures used in the abstract

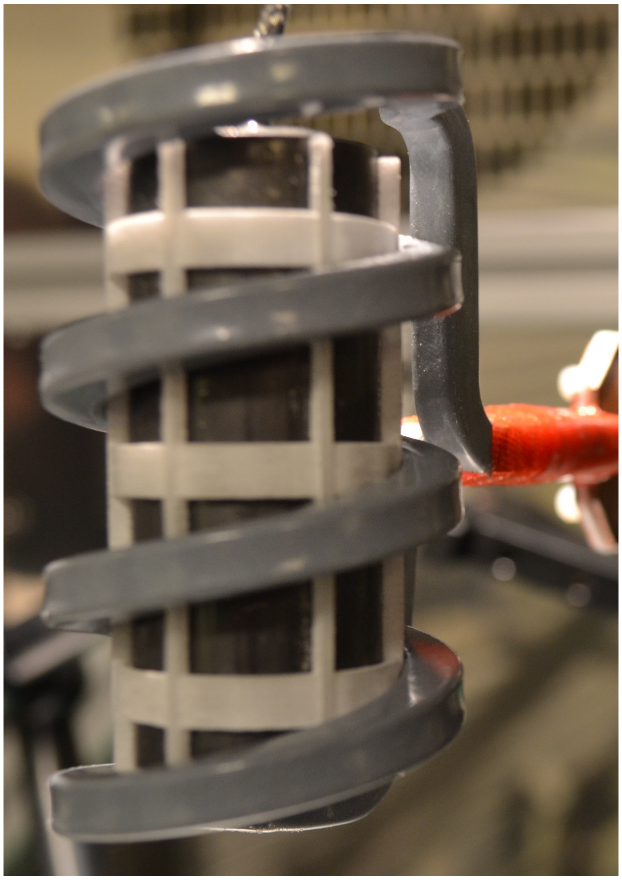

Figure 1: Experimental setup for Cylindrical cells. A special jig centers the cell inside the induction coil.

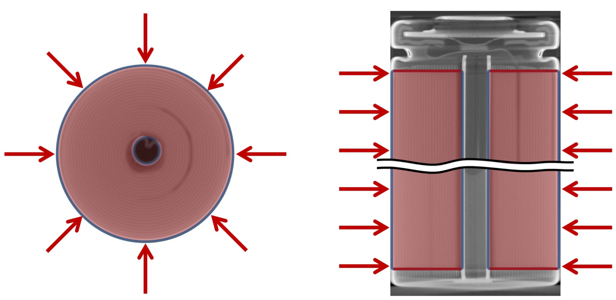

Figure 2: Colored X-ray pictures of a Cylindrical Li Ion cell. The red arrows indicate the symmetric heat flow after excitation.

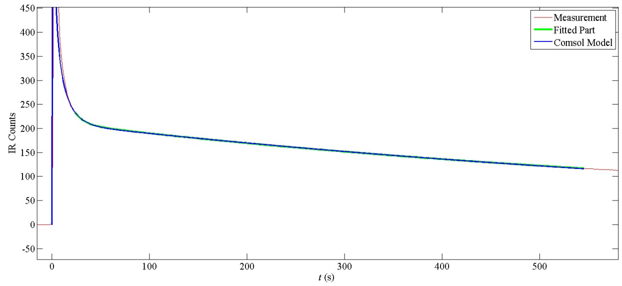

Figure 3: Graphical result. The measured temperature at a Cylindrical cells surface is fitted by a COMSOL Multiphysics® model using the LiveLink™ for MATLAB® and the MATLAB® Curve Fitting Toolbox™.