Heat Generation Modeling of Two Lithium Batteries: From the Cell to the Pack in COMSOL Multiphysics® Software

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Abstract

1. Introduction
A thermal model to predict the heat generation during the charge and discharge of a battery pack is an essential tool to manage the thermal behavior, performance, and life of the batteries. In this work, two types of batteries (Liy CoO2, and LiFePO4) as shown by Fig. 1 are modeled in COMSOL Multiphysics® using the Batteries and Fuel Cells module and Heat Transfer in a Solid.

2. Heat generation
The thickness of the electrodes, the weight, the area, and the size of the particles were measured and implemented in the model described by Fig. 2. A 5C discharge (see [1]) was then simulated for the two batteries to know the heat generation.

3. Temperature elevation
Once their heat generation known, the batteries are set up in a battery pack to study the temperature reached. It is shown that the model can predict the heat generation with an error of 8.8 % compared to the experimental data of Kevin Parsons (see [1], Fig. 3). The heat generation of the second battery was then modeled (Fig. 4). The temperature elevation (about 14°C for a single battery) was compared to an experiment to validate the result. The heat generation was then implemented in the pack and the temperature elevation increased to 19°C.

4. Conclusion
The models were set up with the general parameters to end up with an error of about 9 % on the temperature elevation in the pack. This is a good approximation to do preliminary design in engineering. To improve the COMSOL models and decrease their error, the parameters could be tuned with deeper analysis like Newman did [2]. The companies that make the battery have their fabrication secrets, specific materials added to modify the properties of the electrodes, and the parameters. The diffusivity and the electrical conductivity have a big influence on the behavior of the battery.

Reference

[1] : Design and Simulation of Passive Thermal Management System for Lithium-ion Battery Packs on an Unmanned Ground Vehicle, K. K. Parsons, T. J. Mackin, CAL POLY, MECHANICAL ENGINEERING, SEPTEMBER 6, 2012.

[2] : Comparison of Modeling Predictions with Experimental Data from Plastic Lithium Ion Cells, M. Doyle, J. Newman, A. S. Gozdz, C. N. Schmutz, J.-M. Tarascon, J. Electrochem. Soc. , Vol. 143, No. 6, June 1996.

Figures used in the abstract

Figure 1: Figure 1 : Batteries studied Liy CoO2, and LiFePO4

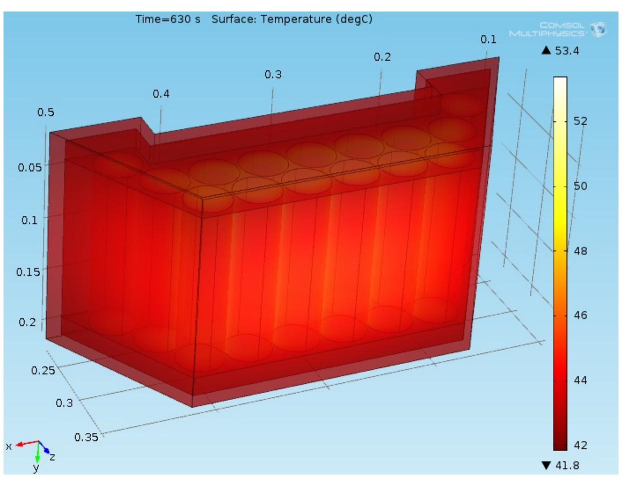

Figure 2: Figure 3 : Final temperature elevation of the first battery pack

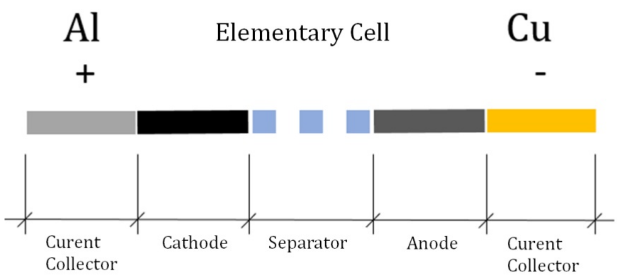

Figure 3: Figure 2 : Model of an elementary electric cell

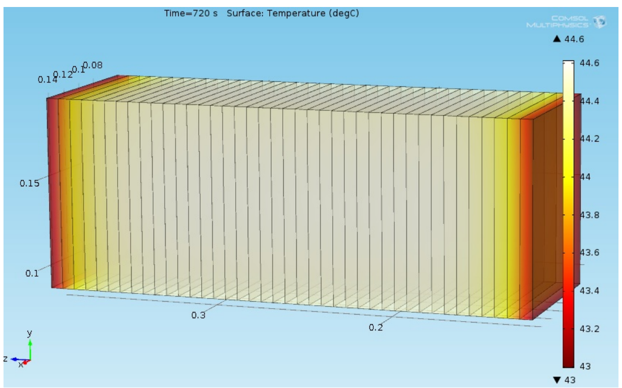

Figure 4: Figure 4 : Final temperature elevation of the second battery pack