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


Figures used in the abstract

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

**Figure 2**: Final temperature elevation of the first battery pack
Figure 3: Model of an elementary electric cell

Figure 4: Final temperature elevation of the second battery pack