Transient thermal analysis and Simulation of a Thermal battery

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Abstract

Thermal batteries are primary batteries that specially designed to a high energy density in a short period. The unit cell of thermal batteries use molten salts as an electrolyte and employ an internal pyrotechnic source to heat the cell stack to operating temperatures, typically between 400 and 600 ^{o}C, heat transfer is crucial to the operation of the battery, determining the operation time in which power can be supplied. Thermal analysis is a critical part of thermal battery design because of the need to hold the temperature above the electrolyte melting point. This paper mainly focused on the transient thermal model studies of unit cell to simulate the heat transfer of unit cell. Thermal properties in the electrolyte caused by phase change are a critical design consideration of thermal batteries because the thermal conductivity and specific heat could be changed. The simulation results show the trends in temperature and heat flux.

Key word: Thermal battery, Thermal analysis, Simulation

1. Introduction

Thermal batteries are used in guided missile systems where there is a sudden demand in electric power. The main requirement from such a battery would be high power density, low maintenance, very long shelf life and perform even in extreme environments. A typical battery contains a stack of cell, and each has its own anode, cathode, electrolyte, heat pellet, separator and current collector. Thermal batteries are constructed using a variety of different electrochemical system. Selection of a cell system depends upon the requirements of the specific application such as power, volume, weight, operating time, voltage regulation and load profile.

Complex multi-physics phenomena occur in a thermal process including thermodynamics, multi species diffusion, convection, energy transport and electrochemical reaction. A framework for modeling thermal batteries process is multi-dimensional mainly due to energy transport and characteristics of the cell. In the present work, the thermal cell model has been implemented in thermal analysis tool. The simulations computed predictions of thermal transfer and model design-parameter. Most modeling efforts have been conducted at the stack level, neglecting the other thermal properties. Furthermore, the heat transfer may be seriously under-predicted in thermal battery modeling with a transient heat transfer term.

A transient model of heat generation and propagation with in thermal battery is carried out, using a thermal analysis simulation program. That computer programs devoted to solve the systems of heat flow and time/temperature-dependent. These systems are, typically executed to find temperature distribution, temperature gradient, and heat flowing in the model, as well as the heat exchanged between the model and its environment. The software, also, must use suitable numerical methods for the task and provide an adequate graphical interface for both information input and output.