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Design and Simulation of a Lithium-ion Battery at Large C-Rates and Varying Boundary Conditions through Heat Flux Distributions

S. Panchal[1], I. Dincer[2], M. Agelin-Chaab[2], R. Fraser[1], and M. Fowler[3]

[1] Mechanical and Mechatronic Engineering Department, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, Canada, N2L 3G1

[2] Department of Automotive, Mechanical & Manufacturing Engineering, Faculty of Engineering & Applied Science, University of Ontario Institute of Technology, 2000 Simcoe Street North, Oshawa, Ontario, Canada, L1H 7K4

[3] Chemical Engineering Departments, University of Waterloo, 200 University Avenue West, Waterloo, Ontario, Canada, N2L 3G1

Corresponding Author's Telephone: +1-519-722-4420,

Corresponding Author's Email: satyam.panchal@uwaterloo.ca

Abstract

In this paper, the heat flux distributions on a prismatic lithium-ion battery at 1C, 2C, 3C and 4C discharge rates under various operating temperature or boundary conditions (BCs) of 22°C for air cooling and 5°C, 15°C, and 25°C for water cooling are presented. The goal is to provide quantitative data on the thermal behaviour of lithium-ion batteries. In this regard, a battery thermal management system with water cooling is designed and developed for a 20Ah capacity pouch type lithium-ion battery using dual cold plates. Three heat flux sensors are placed at different locations on the principle surface of the battery: the first near the anode, the second near the cathode, and the third at the mid surface of the body. From these the average and peak heat flux are obtained and presented in this study. In addition to this, the heat flux and voltage distributions are simulated using the neural network approach with the above mentioned discharge rates and BCs. The present results show that increased discharge rates and decreased operating temperature results in increased heat fluxes at the three locations as experimentally measured. Furthermore, the sensors nearest the electrodes (anode and cathode) measured the heat fluxes (and hence temperatures) higher than the sensors located at the center of the battery surface.

Keywords: Lithium-ion battery, thermal management, heat flux, tab temperature, simulation.

1. Introduction

Today, lithium-ion batteries have received much attention in the development of electric vehicles (EVs), hybrid electric vehicles (HEVs), and plug-in hybrid electric vehicles (PHEVs) [1]. Their extensive usage is due to: 1) high specific energy and power densities [2]; 2) high nominal voltage and low self-discharge rate [3]; and 3) long cycle-life and no memory effect [4]. During discharging and charging, precautions