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Calibration and Finite Element Simulation of Pouch Li-ion Batteries for Mechanical Integrity

by

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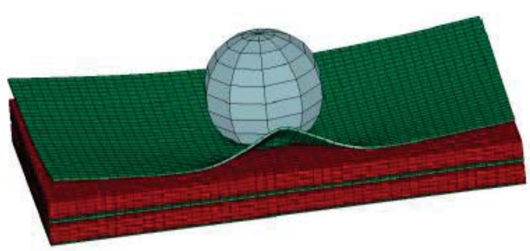

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Abstract

Mechanical tests were performed on fully-discharged pouched and bare lithium-ion cells under five loading conditions. These included through-thickness compression, in-plane unconfined compression, in-plane confined compression, hemispherical punch indentation and three-point bending. From the measured load-displacement data, the individual compression stress-strain curves were calculated for the separator, the active anode and cathode materials. The FE model was developed, composed of shell elements representing the Al and Cu foil, and solid elements for the active material with a binder lumped together with the separator. Very good correlation was obtained between LS-Dyna numerical simulation and test results for the through-thickness compression, punch indentation and confined compression. Closed form solutions were also derived to reveal the underlying physics and identify important groups of parameters. It was also demonstrated that a thin pouch enclosure provided considerable reinforcement and in some cases changed the deformation and failure mechanism. The present computational model of an individual cell provides a fundamental building block for modeling battery modules and battery packs across different length scales. The present test program differs substantially from the nail indentation or punch crush loading performed by the industry, and provides data for the development of an advanced constitutive model needed for strength/weight optimization and safety assessment of Li-ion batteries.

Keywords: Lithium-Ion Batteries, Mechanical Integrity, Cylindrical Cell