Development of a Constitutive Model Defining the Point of Short-Circuit Within Lithium-Ion Battery Cells

By

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Abstract

The use of Lithium Ion batteries continues to grow in electronic devices, the automotive industry in hybrid and electric vehicles, as well as marine applications. Such batteries are the current best for these applications because of their power density and cyclic life. The United States Navy and the automotive industries have a keen interest in making and maintaining these batteries safe for use within the public. The testing necessary to ensure this safety is time consuming and expensive to manufacturers, thus a constitutive model that can emulate the effects of mechanical abuse to a battery cell or pack is necessary to be able to rapidly test various configurations and enclosures to preclude possible short circuit and thermal runaway of an installed battery is necessary. Homogenized computational cells have been developed at the MIT Crashworthiness Laboratory and this research validates and refines those models for use in future work with both cylindrical and prismatic cells.

A total of 22 mechanical abuse tests were conducted on partially charged cylindrical and pouch/prismatic Li-Ion cells under multiple loading conditions. The tests included lateral compression by cylindrical rods of various sizes, three point bending tests, and hemispherical punch tests on cylindrical cells. For the pouch/prismatic cells, the tests included hemispherical punch tests of various sizes as well as a conical punch test, vertical cylindrical punch test, and rectangular punch test. The tests measured the force imparted to the cell, linear displacement of the punch into the cell structure, voltage output of the cell, as well as the temperature at the surface of the cell.

The test data was utilized to validate and refine homogenous computational models for both cylindrical and pouch/prismatic Li-Ion cells for future use in the MIT Crashworthiness Laboratory. The computational models subjected to simulated tests that were conducted on actual cells in the laboratory conclude that the computational models are valid and behave well compared to actual cells.

This paper reports on results generated for the Li-Ion Battery Consortium at MIT.

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