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Deformation and failure analysis of pinch-torsion based thermal runaway risk evaluation method of Li-ion cells

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ABSTRACT

A new pinch-torsion test is developed for safety of Li-ion batteries that shows the stable capability of making small internal short-circuit spots effectively. The further deformation and failure analysis is conducted by finite element analysis and experiments. Two different loading conditions, pure pinch and pinch-torsion, are evaluated and compared which demonstrates that the addition of the torsion component significantly increased the maximum principal strain, and thus the internal short circuit induction. In addition, the vertical load in the pinch-torsion test is significantly less than it in the pinch test to generate the failure inside the battery, thus dramatically improving the applicability of the pinch test. Finally, an analytical stick-slip model rationalizes deformation mechanisms and the conclusion is made that the additional torsion only facilitates the failure of separator at the early stage which is typically a few degrees of rotation. The systematic investigation of the Li-ion cell deformation and failure provides insight for the optimization of the future battery safety experiment design.