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A Detailed Simulation Model to Evaluate the Crash Safety of a Li-Ion Pouch Battery Cell

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In crash situations with an electric vehicle, the integrity of the battery cells is critical for the consequences of the crash. A short circuit triggered by deformation and damage of the internal cell structure can cause overheating of the battery (thermal runaway) and may result in a vehicle fire or even an explosion. Thus, for assessing the crashworthiness of electric vehicles evaluating the deformation states of potential crash situations with respect to the occurrence of a short circuit is crucial. A particular challenge for building a cell model with acceptable computational time lies in the very different spatial scales regarding the overall cell size and the thickness of individual layers. Cells installed in vehicles have dimensions of several centimetres, whereas the thickness of the individual layers is in the micrometre range. Much research has already been conducted based on homogenized cell models that do not explicitly account for the internal layer structure, and existing material models calibrated to experimental data (e.g. [1]-[3]), while explicitly considering the layered structure is just pursued more recently (e.g. [4]-[7]).

Within our contribution we introduce a detailed numerical model which, as a part of a multilevel simulation approach, can be used to evaluate the criticality of a deformation state. The model mimics the layered structure of the cell, whereby the constitutive properties were determined by in-house experiments on the respective materials. For validation, bending tests and indentation tests with different punch geometries along with CT-scans at selected indentation depths are available. Comparing the simulation results with the failure sequence and the force-displacement curve from the experiment, a closer view on critical deformations and on their respective stress states is obtained. The results indicate that in-depth understanding and modelling of the failure behaviour is crucial for correctly modelling battery cells under crash loading scenarios.

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