Battery cell thermal runaway in an enclosed volume: preliminary 3D simulations of an experiment

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1 ABSTRACT

Electric vehicles (EVs), a well-known sustainable mode of transportation, are becoming more popular. In such vehicles, lithium-ion cells are connected in series and parallel to constitute high voltage batteries. Many hazards, such as thermal, mechanical or electrical stress may lead a cell to internal chemical reactions between cathode, anode and electrolyte, to internal short circuit, and potentially to a thermal runaway of the cell. These exothermal reactions lead to significant energy release within the cell and matter ejection through venting. The subsequent high-energy release has to be understood and modeled to evaluate the risk of thermal runaway propagation to the surrounding cells. The involved heat transport phenomena include simultaneous: conduction, convection and radiation, solid (and possibly liquid) particles ejection, combustion of the gas (and possibly liquid and solid particles) released. Moreover, all along these events, the cell internal heat generation due to the exothermal reactions has to be considered. A transient 3D model is being developed in order to study the thermal runaway propagation behavior of Li-ion cells at module and pack scales. This model couples the internal exothermic reactions within each cell with the gas vented out by each cell. A k - ω Shear Stress Transport (SST) with Reynolds-Averaged Navier-Stokes (RANS) model is used to describe the turbulent flow of the gas released by the cell. Preliminary simulations are conducted on a simple geometry consisting of a single cell fixed inside an adiabatic stainless-steel vessel. Furthermore, a resistance with a constant heat addition on the cell's external shell is chosen to simulate the experimental overheating abuse conditions. This simple geometry is used in order to qualify the numerical model. Results include the temperature and pressure distribution of the gases released by the cell. Studying the influence of some phenomena, such as Lagrangian particle transport and combustion model, will be included in this work. Finally, the model will be validated and evaluated with experimental data.

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