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Modelling of Heat Generation in a 18650 Lithium-Ion Battery Cell under Varying Discharge Rates

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Abstract : Thermal characterization plays an important role in battery pack design. Lithium-ion batteries have to be maintained between 15-35 °C to operate optimally. Heat is generated (Q) internally within the batteries during both the charging and discharging phases. This can be quantified using several standard methods. The most common method of calculating the batteries heat generation is through the addition of both the joule heating effects and the entropic changes across the battery. In addition, such values can be derived by identifying the open-circuit voltage (OCV), nominal voltage (V), operating current (I), battery temperature (T) and the rate of change of the open-circuit voltage in relation to temperature (dOCV/dT). This paper focuses on experimental characterization and comparative modelling of the heat generation rate (Q) across several current discharge rates (0.5C, 1C, and 1.5C) of a 18650 cell. The analysis is conducted utilizing several non-linear mathematical functions methods, including polynomial, exponential, and power models. Parameter fitting is carried out over the respective function orders; polynomial (n = 3~7), exponential (n = 2) and power function. The generated parameter fitting functions are then used as heat source functions in a 3-D computational fluid dynamics (CFD) solver under natural convection conditions. Generated temperature profiles are analyzed for errors based on experimental discharge tests, conducted at standard room temperature (25°C). Initial experimental results display low deviation between both experimental and CFD temperature plots. As such, the heat generation function formulated could be easier utilized for larger battery applications than other methods available.

Keywords : computational fluid dynamics, curve fitting, lithium-ion battery, voltage drop
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