Physics-Based Thermal Degradation Modelling of Lithium-Ion Batteries

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The heat generation in a lithium-ion battery is a complex electrochemically/thermally controlled process. The thermal maps of batteries are determined by the local sources of heat generation, in conjunction with cooling sources and conduction through the battery. It may be possible to use these thermal maps to gauge the state of health of the battery, determine how it has aged and for how long. Some of these maps were experimentally demonstrated by Veth, Dragicevic and Merten (2014). However, Li-ion battery experiments are time-consuming and often not safe. Moreover, the characterization of these maps is non-trivial and requires perfect harmony between the electrochemical, thermal and aging models, as well as their parameters.

In this research, two-dimensional physics-based local thermal degradation models for lithium-ion battery (LiB) cells have been developed based on the Fuller, Doyle and Newman (1994) model to investigate 1st and 2nd life behaviour of LiBs. The models have been utilised to investigate electrochemical variable gradients in a single electrode layer for two different chemistries of LiBs and various charging rates for 1st life of LiBs. Moreover, the results will be presented to show how electrochemical variable gradients (change in potential, current and state-of-charge) impact local heat generation sources and local temperatures, which are critical parameters associated with non-uniform aging of LiBs and their degradation.

It is expected that the results of this study will enable us to predict 2nd life behaviour in order to safely use end-of-life lithium-ion batteries for second life and other applications, such as grid storage and peak shaving. Furthermore, these models can be utilised to investigate fast charging as it is a critical issue to achieve the full potential of battery electric vehicles.

References

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[2] T. F. Fuller, M. Doyle and J. Newman,"Simulation and Optimization of the Dual Lithium Ion Insertion Cell", *Journal of The Electrochemical Society*, **141**, (1), 1-10, 1994.