COMSOL Modelling for Li-ion Battery Diagnostics

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Abstract

Introduction: Recently, Li-ion battery is being widely used as a power source for various applications from electronic gadgets to the automotive industry. The performance and cycle life of Li-ion battery are becoming gradually important issues as the applications are shifting from small-scale consumer electronics to dynamic power applications (Electric Vehicles, Hybrid Electric Vehicles). To create a better control over the performance and cycle life of a Li-ion battery, accurate modeling for battery diagnostics is essential. During a battery lifetime, its health tends to deteriorate slowly due to irreversible physical and chemical changes like: internal impendence rise, excess out-gassing, internal temperature rise, electrolyte decomposition and electrodes' cracking. This paper describes a non-invasive magnetic field probing (MFP) approach to induce above parameters under battery diagnosis. Once their effect on battery health is determined, an acute battery diagnostic model can be created to determine battery's age and predict its future health.
Use of COMSOL Multiphysics: In this work, a 2D model using Newman's pseudo two-dimensional (P2D) model of lithium-ion battery, has been developed with the COMSOL Multiphysics environment in order to investigate the impact of applied magnetic field on the Li-ion battery chemistry. Magnetic field equations are coupled with the Li-ion battery modeling equations based on J. Newman and others.
Results: The simulation results will provide the behavior of the battery during charging/discharging and rest conditions. In the process of a magnetic field response analysis, we get a magnetic field response with each domain 1, 2 and 3 and determine the behavior pattern of each domain separately. The fairly early simulation work is shown in figure 1, 2 and 3. We may expect to get the following results after completion of simulation work.
• The effect of MFR (Magnetic Field Response) with respect to the capacity of the Li-ion battery
• MFR with respect to changes in internal impedance of the Li-ion battery
• MFR with respect to charging/discharging behavior of the Li-ion battery
Conclusion: This 2D model of a Li-ion battery combining with magnetic field probing is a simulation tool that can be useful in predicting battery health and age. It helps to design a prototype for real-time health prediction. COMSOL Multiphysics tool has been used to determine Li-ion model and its initial response to magnetic field probing. This paper mostly defines a simulation work of the prototype system.

Reference

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[3] M. Rashid, A. Gupta, M. Engineering, and N. Delhi, “A Computational Study of Cycling Performance of Li-ion Batteries a b c,” p. 110016, 2014.
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Figures used in the abstract

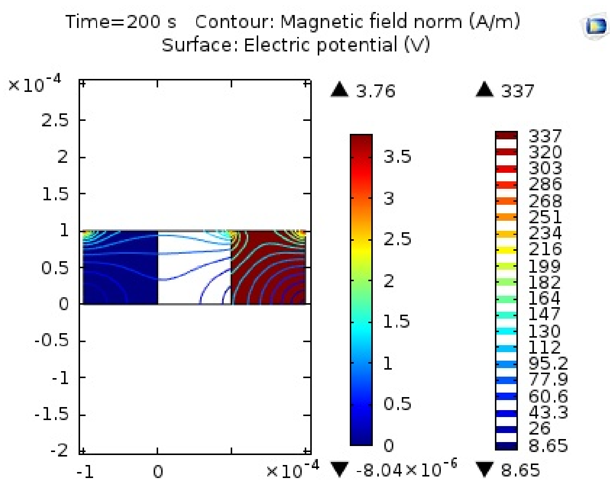

Figure 1: Surface View: Electric potential (V), Contour: Magnetic field norm (A/m) during discharging process at 200 second.

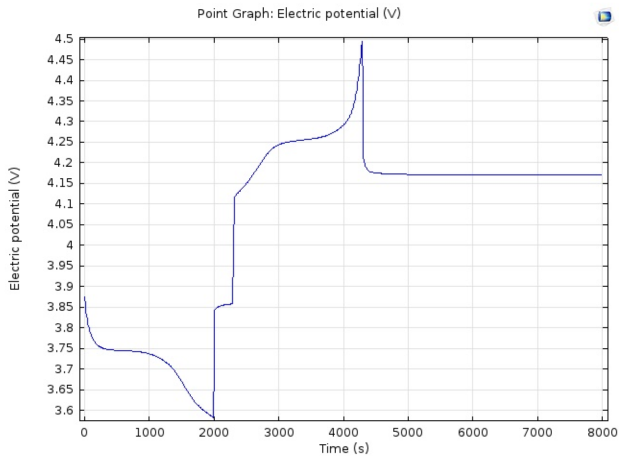

Figure 2: Cell voltage during the applied cycle.

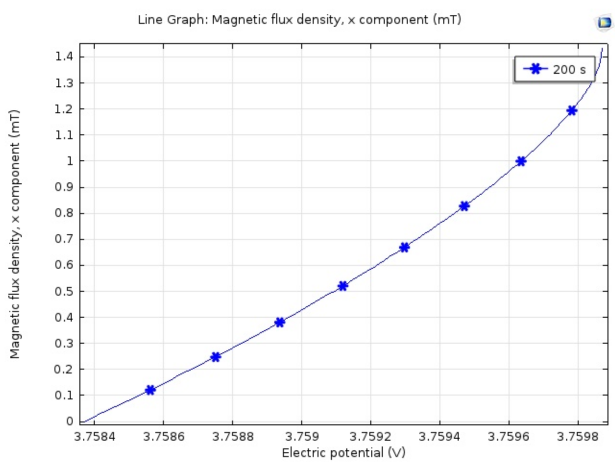

Figure 3: Line Graph between Magnetic flux density (mT) and Electric Potential (V) of Li-ion battery during discharging process at 200 second.

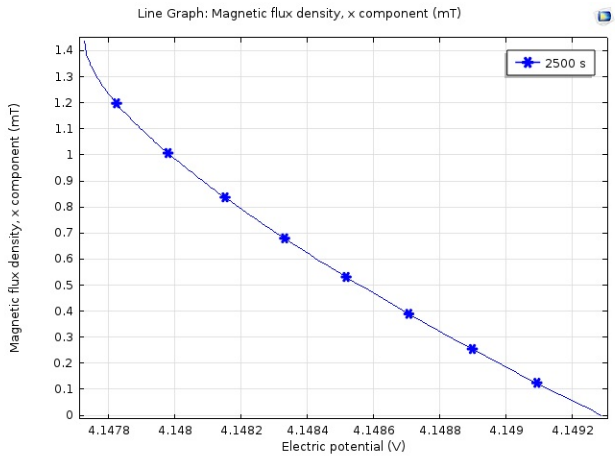

Figure 4: Line Graph between Magnetic flux density (mT) and Electric Potential (V) of Li-ion battery during charging process at 2500 second.