Comparative Study of Li-ion Battery Electrochemical Modeling Methods for Real Time Applications

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An Electric Vehicle (EV) Battery Management System (BMS) is essential for optimal usage of Li-ion battery (LIB) capacity and to minimize battery failure possibilities including thermal runaway situations. The BMS needs an online modeling method for the accurate estimation of state of charge (SOC) and state of health (SOH) to manage the real time usage of the battery. There are various modeling methods such as pseudo two-dimensional (P2D), single particle (SP) and equivalent circuit (EC) models, which have been employed to simulate the battery cycling behavior and estimate the battery state [1]. Currently, the EC model is commercially used in the BMS because of low computational cost and fast response time. However, this method is not always best to estimate the current state of the battery since it is parametrized by curve fitting and ignores the physical phenomena occurring inside the battery. Variable battery operating conditions can significantly affect the model parameters and reduce the accuracy of EC model.

The P2D model is a promising candidate for battery modeling since it considers the electrochemical reaction and physical processes occurring inside the batteries [2]. This method has a high precision for battery modeling, but it contains several partial differential equations (PDEs) which complicate the numerical solution in real time applications [3]. Furthermore, a simplification of P2D method known as SP model has a lighter computational burden compared with former method, however, this is less accurate in case of the high charge/discharge conditions[4]. In order to meet the increasingly requirement of the BMS for online control of the batteries, real physics based model needs to be utilized to replace the EC models [5]. However, the computational complexity for solving the PDEs is the major bottleneck to them being implemented in real time application in BMS. This research is focused on the comparative study of the P2D and SP methods in terms of computational cost, accuracy and the response time in view of their real time application in BMS. The quantitative and qualitative analysis is carried out for the results obtained through these modelling methods. Furthermore, the improvement of computational efficiency and accuracy for both methods is presented for potential implementation in BMS.

References:

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