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Development of a Calendar and Cycle Life Prediction Model For Li-Ion Batteries in Electric Vehicle Applications

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Context

In a world where the number of vehicles is increasing very quickly, total or partial electrification of powertrains should have a positive effect on greenhouse gas emissions, which are responsible for the rapid changes to our atmosphere. The dissemination of electric vehicles will only be done if the energy performance and ride comfort are equivalent to that of regular vehicles all while maintaining a keen price. This can be achieved through a good choice of energy storage system using intelligent energy management. Li-ion batteries have been widely used in modern electrified vehicles due to their unique abilities such as high voltage operation, high energy density, low self-discharge, no memory effect, fast charging and durability. This technology is currently at the core of the company's offer for transportation.

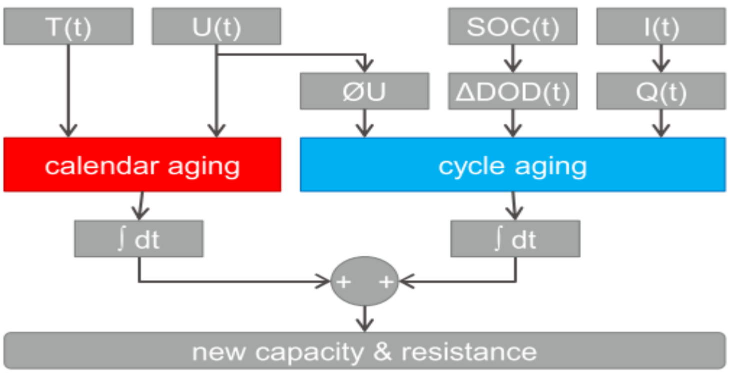

Fig. 1. Schematic of the calendar and cycle life prediction model [3],[4].

Knowledge on lithium-ion battery aging and lifetime estimation is a key requirement for successful market introduction in high-priced goods like electric and hybrid vehicles. The aging process of a lithium-ion battery is described by the degradation of its physical properties over time and / or during its use. In other words, aging in lithium-ion batteries leads to increase of inner resistance, power loss and capacity decrease as well as to changes in impedance spectra due to electrochemical and mechanical processes. The calendar and cycle aging are two main modes of the battery degradation related to the operation and rest conditions. Different approaches are used for modeling of aging mechanisms occurring in Li ion batteries, either on rest or on cycling, like e.g. approaches based on neuronal networks, physic-chemical characterization, semi-empirical method, and electrochemical processes. The most realistic models are based on physical approach with mathematical expressions, which are able to extrapolate the data from accelerated aging tests to get real life condition lifetime predictions. The mathematical expressions used in these models allow reproducing the factors influencing aging, such as temperature or storage voltage, and extrapolating from a fixed set of tests to a wide range of applications. The proposed configuration of the calendar and cycle life prediction model is shown in Fig. 1.

Objective

The aim of this internship is to carry out a calendar and cycle life prediction model for Li-Ion batteries in electric vehicle applications. The developed aging model based on mathematical expressions will be integrated in the existing multiphysics model of Li-ion batteries incorporating electric and thermal aspects.

Work Progress

The candidate will work at *Centrale Lille*. He will first have to carry out bibliographic researches on lifetime modeling of Li-ion batteries. An appropriate model based on physical approach using mathematical functions will be developed. Then he will simulate the aging mechanisms occurring in Li ion batteries, either on rest or on cycling, by using the Matlab Simulink software. Computer simulations will be carried out to verify the proposed model and to compare with an existing model previously developed within the L2EP laboratory. Lastly and according to the work progress, the aging model of Li-ion batteries will also be integrated in the multiphysics model already developed.

Key words

Li-ion battery, calendar aging, cycle aging, electric vehicles, battery model, lifetime prediction, electric and thermal aspects.

Reference

[1] S. Käbitz, J. B. Gerschler, M. Ecker, Y. Yurdagel, B. Emmermacher, D. André, T. Mitsch, and D. U. Sauer, “Cycle and calendar life study of a graphite|LiNi1/3Mn1/3Co1/3O2 Li-ion high energy system. Part A: Full cell characterization,” *J. Power Sources*, vol. 239, pp. 572–583, Oct. 2013.

[2] T. Mesbahi, “Influence des stratégies de gestion d’une source hybride de véhicule électrique sur son dimensionnement et sa durée de vie par intégration d’un modèle multi-physique,” Thèse de doctorat, CentraleLille, 2016.

[3] J. Schmalstieg, S. Käbitz, M. Ecker, and D. U. Sauer, “A holistic aging model for Li(NiMnCo)O2 based 18650 lithium-ion batteries,” *J. Power Sources*, vol. 257, 2014.

[4] M. Ecker, J. B. Gerschler, J. Vogel, S. Käbitz, F. Hust, P. Dechent, and D. U. Sauer, “Development of a lifetime prediction model for lithium-ion batteries based on extended accelerated aging test data,” *J. Power Sources*, vol. 215, pp. 248–257, Oct. 2012.