Transposition of a Weighted Ah-throughput model to another Li-ion technology: is the model still valid ? What other informations can we learn ?

*Nathalie BARNEL

EDF - R&D
Département LME / Groupe M2A
Avenue des Renardières - Ecuelles
77818 MORET SUR LOING Cedex FRANCE

Tiphaine DELETANG

EDF - R&D
Département LME / Groupe M2A
Avenue des Renardières - Ecuelles
77818 MORET SUR LOING Cedex FRANCE

The work of Badey [1] has proven that the aging of a Li-ion battery can be modelled by two contributions: during both an active regime and a temporal one, this latter appearing both during cycling and calendar. The decoupling of these two contributions is insured by the Weighted Ah-Throughput Model (WTM): it uses a modified approach of the Ah-throughput counting method and takes into account that certain operating conditions may lead to an increased rate of ageing whereas others may lead to a decreased rate of ageing. The WTM includes the impact of the mains stress factors (here written as of f_i andg_i): Temperature, Current Intensity (rated) and State of Charge.

The loss of capacity due to the aging is therefore the sum of the terms: one proportional to the exchanged Ah, and one proportional to the square root of time [1] [2]. These two terms account for the system's irreversibility, since t cannot be replaced by –t without inconsistency:

$$\Delta Q = f_1(T) f_2(I) f_3(SOC).Ah + \ g_1(T) g_2(I) g_3(SOC).\sqrt{t}$$

(1) The rate is abusively written as I

A linear regression leads to the two proportions coefficients: the *f* and *g* function, products of f_i and g_i functions (all the parameters are intertwined). The aim is now to split it apart to find the f_i. The f_i(X) *(*resp. $g_i(X)$*)* function is the active regime (resp. calendar) aging part attributable to X. The weighting functions are independent, and therefore perpendicular to each other and can be interpreted as axes of a three dimensional space, the ageing space of the battery. We execute a predefined tests matrix, conceived in order to vary only one parameter (T,I or SOC) at a time. We then compute and interpolate the data points obtained for each f_i andg_i. It has to be noticed that these functions depend on the Li-ion technology. Therefore they have to be recomputed for other cells. Nevertheless, we can study the similarities between the functions obtained with LFP/graphite and NCA/graphite cells. These similitudes enable us to extract the generic hidden mechanisms that, by nature, the fatigue modelling methods don't provide. This innovative method enables us to reach energetic behaviour laws, so that we can work in a space of state variables with thermodynamic status. We finally suggest improvements on the tests matrix used to define the model, to better fit the outcome of the study.

[1] Badey Q., *"Etudes des mécanismes et modélisation du vieillissement des batteries lithium-ions dans le cadre d'un usage automobile"* thèse de l'université Paris Sud, 2012

[2] Bloom I., Cole B. W., Sohn J.J., Jones S.A., Polzin E.G., Battaglia V.S., Henriksen G.L., Motloch C., Richardson R., Unkelhaeuser T., Ingersoll D. and Case H.L. "An accelerated calendar and cycle life study of li-ion cells" Journal of Power Sources, Vol. **101**, pp. 238-247. (2001)