International Journal of Research in Engineering and Science (IJRES)
ISSN (Online): 2320-9364, ISSN (Print): 2320-9356
www.ijres.org Volume 4 Issue 7 ǁ July. 2016 ǁ PP. 01-05

Research Status of SOC for Lithium-Ion Battery

Zhang Xiang

(College of Automotive Engineering, Shanghai University of Engineering Science, Shanghai, China, 201620)

Abstract: Nowadays, lithium-ion battery is the focus of research in the new energy industry, and SOC (State of Charge) is one of the key studies in the study of lithium-ion battery, the estimation and calculation of SOC is directly related to the efficiency and safety of the use of lithium-ion battery, a good SOC estimation and calculation method can make the work of lithium-ion battery more secure, and prolong the service life of the battery, conversely, a poor SOC estimation and calculation method will not only accelerate the aging of the battery but also bring the risks of explosion and combustion, endanger the users' life and property safety. Therefore, this paper has collected more widely used and mature SOC estimation and calculation methods for reference.

Keywords: lithium-ion battery, SOC, estimation and calculation

I. INTRODUCTION OF SOC

In the use of batteries, the state of charge (SOC) of the battery is a very important parameter, which directly affects battery's open circuit voltage, working voltage, resistance and other physical quantities, and closely related to the life, safety and efficiency of the battery. Therefore, SOC estimation is a key technology of the lithium-ion battery management system. In order to maintain good performance and prolong the service life of the battery, we need to carry out the necessary management and control, so it is the most basic and most important task for the battery management system to accurately estimat the battery SOC[1]~ [4].

II. SOC ESTIMATION METHOD

The SOC of lithium-ion battery is estimated and calculated by the detection and reprocessing of the parameters such as voltage, current and temperature of the battery. The followings are commonly used SOC estimation and calculation methods:

2.1 Ampere Hour Integral Method

Ampere hour integral method is the simplest principle, the most widely used algorithm. It is based on the current non-stop testing and integration to infer how much electricity the battery releases or absorbs, so as to obtain the SOC of the battery. The formula is as follows:

$$\mathrm{SOC} = SOC_0 + \frac{1}{C_N}\int_0^t \eta I \, d\tau$$ (SOC_0: initial state of charge)

The main drawback of ampere hour integral method includes three aspects: 1. the detection frequency and accuracy of the current demand need very high, otherwise it will lead to an increase in the integration error, and the cumulative error; 2. Battery charging and discharging efficiency and battery SOC value, current, temperature, aging, the change of resistance rate, life, are relates and difficult to measure accurately, resulting in the SOC estimation error is more and more big. Under high temperature or current volatile situation, subject to the influence of current measurement accuracy, accuracy of the ampere hour integral method is very poor,

usually uses with other methods[5].

2.2 Open Circuit Voltage Method

There is a certain relationship between the OCV and the SOC of the battery, by measuring the OCV and SOC value of a discharge rate, fitting the corresponding battery curve, then the SOC value can be determined by the OCV value. OCV and SOC of lithium-ion battery have approximate linear relationship, the estimated value of SOC can be obtained by measuring the OCV of the battery, which is the working principle of the OCV method; However, the accurate value of OVC requires the battery to be cut off for more than one hour in order to make it in a stable state, and the actual use of the battery can't meet the above requirements. Therefore, the open circuit voltage method is frequently combined use with ampere hour integral method, before use the battery, estimate the initial SOC with the open circuit voltage method to ensure the accuracy, when we start to use the battery calculated with the ampere hour integral method in order to guarantee the practicability, but the method of estimation accuracy still can't fully meet the requirements.

Fig.1 OCV-SOC charging curve under different rate

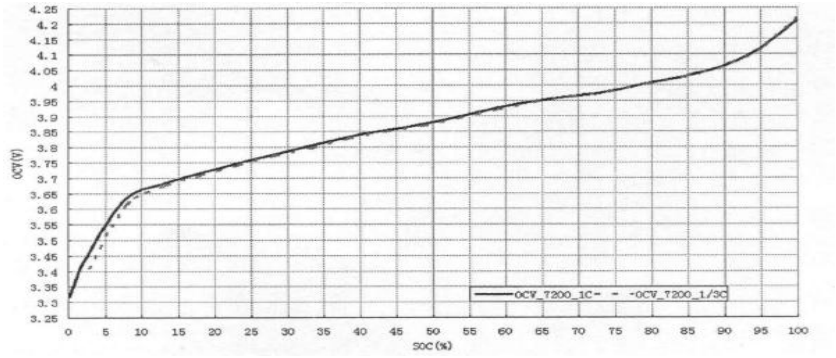
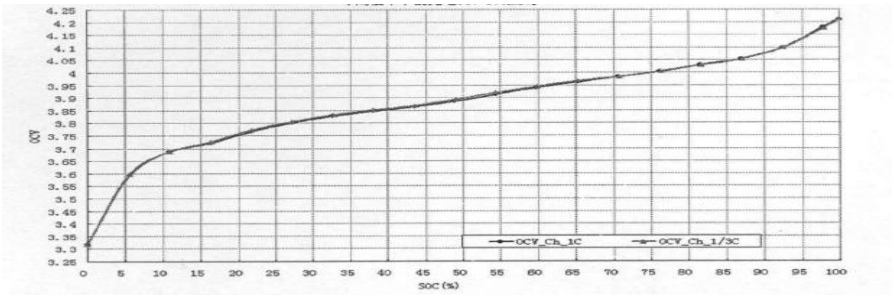


Fig.2 OCV-SOC discharging curve under different rate



2.3 Kalman Filtering Method

In recent years, people began to use the Kalman filter to estimate the state of charge of the battery, Kalman filter can not only get the estimated value of SOC, but also give the calculation error of SOC, it has higher precision and strong correction of the initial error value; However, due to its precision, it depends on the accuracy of the battery model, it is difficult to establish a precise battery model, and it is not widely used at the present stage[6].

Kalman filter is an optimal self-regression data processing algorithm, the real-time optimal estimation of state variables can effectively improve the accuracy of SOC estimation. Lose of Chinese experts work on the application of Kalman filtering in the battery SOC estimation research, but mainly take HEV Ni MH battery as the key research [7]. Although some researchers have already applied the extend Kalman filter (EKF) and the impedance Kalman filter (UKF) to the battery SOC estimation and get an important conclusion [8], but the

research is still not enough, And the standard UKF method ignores the influence of the measurement error in the SOC estimation [8].

2.4 Neural Network Method

When facing complex and nonlinear problems, we can establish an accurate mathematical model of neural network to simulate the dynamic characteristics of the battery, estimate the battery SOC. The neural network is divided into the input layer, the middle layer and the output layer, and the SOC input layer and the output layer neuron are determined by the actual problem. Input layer generally includes voltage, current and temperature, and other factors. This method needs to be trained on a large number of experimental data to get a high precision, and the neural network method is mainly divided into two categories: RBF neural network and BP neural network. They are similar in structure, and the output layers are both linear. The neural network must be trained by the training data to determine the free parameters in the training process. Voltage, current, temperature, resistance commonly used for the input. The input variables and the choice of input variables will directly affect the accuracy and calculation of the model. The method does not need to describe the exact formula of the relationship between input and output, it can be determined in the network training, and has the characteristics of self-adaptation. But it needs a lot of reference data to train, the data and the training method affect the estimation error very big [9] [10].

2.5 Least Square Method

When we got a curve of voltage under a certain rate of charge and discharge cuerrent the least square method can be used, the curve is fitted with high accuracy by means of pure mathematics, and the mathematical model is established for the charging and discharging process. Through the control of the change law of the battery terminal voltage at different SOC stages in the mathematical model, the control of the charging and discharging process is controlled, and the occurrence of the phenomenon of the over-charging and over-discharging is avoided. Because of the choice of the dependent variable is the voltage, and the voltage at different charging and discharging current is different, so the least square method to establish mathematical model in the actual application process is more complicated, but it has a high precision. But nowadays, there are some types of lithium-ion batteries such as polymer batteries, when using the least square method and establishing the model we will find there are no obvious mathematical feature points, so,for some batteries, least square method does not apply [11].

III. SUMMARY

From the above we can see that there are many methods in estimating and calculating the lithium-ion battery. But on a particular method, there are some flaws, the effect is not very good, they need to be combined use. Thus it may be known, the SOC estimation method is developing very rapidly, lose of methods have been published. However, there haven't been a method can be used with most of the time, and can solve practical problems independently. Therefore, we need to do more developments of the SOC estimation method under the existing research situation.

IV. EXPECTATION

The new energy will replace the traditional fossil energy, and the lithium-ion battery will be the main carrier of new energy sources, so the lithium-ion battery will be a very promising industry and research topic and direction Therefore, it is necessary to pave the way for the development of basic research topics related to lithium-ion battery. Lithium-ion battery SOC is one of the most important topics, with the continuous improvement of SOC estimation methods, lithium-ion battery industry is bound to occupy an increasingly important position in the new energy industry.

REFERENCES

[1]. Xiangsheng Li，Sanying Yang，Yongjun Zhou. Simulation and correction of SOC in HEV's batteries. Chinese Journal of Power Sources，2011，35(12): 1589-1591.

[2]. Taofeng Tang. SOC prediction and consistency of lithium-ion batteries in EV. Journal of Chongqing University，2011.

[3]. Jiang Wei，Lijian Chen，Wanliang Chen. SOC estimation of power lithium battery management system. Marine Electric & Electronic Technology，2011,31(6):38-39

[4]. CHENG K W E. DIVAKAR B P. WU H J, et al. Battery management system(BMS) and SOC development for electrical vehicles[J].IEEE Transactions on Vehicular Technology, 2011, 60(1): 76-88

[5]. LEE S J, KIM J H, LEE J M, et al. The state and parameter estimation of a Li-ion battery using a new OCV-SOC concept.Proceedings of 2007 IEEE Power Electronics Specialists Conference.Orlando: 2007 IEEE PESC, 2007

[6]. Arbarisi O，Vasca F，Glielmo L．State of charge Kalman filter estimator for automotive batteries[J]．Control Engineering Practice，2005(3)：56—58．

[7]. Jean Ernst Bester; Ahmed El Hajjaji; Augustin Mpanda Mabwe.Modelling of Lithium-ion battery and SOC estimation using simple and extended discrete Kalman Filters for Aircraft energy management.Industrial Electronics Society, IECON 2015 - 41st Annual Conference of the IEEE,2015:002433-002438.

[8]. Zhiwei He; Yuanyuan Liu; Mingyu Gao; Caisheng Wang.A joint model and SOC estimation method for lithium battery based on the sigma point KF.2012 IEEE Transportation Electrification Conference and Expo (ITEC),2012:1-5

[9]. Chao Dong,Guanlan Wang.Estimation of power battery SOC based on improved BP neural network.2014 IEEE International Conference on Mechatronics and Automation,2014:2022-2027.

[10]. Bingxiang Sun; Lifang Wang.The SOC Estimation of NIMH Battery Pack for HEV Based on BP Neural Network.Intelligent Systems and Applications,2009:1-4.

[11]. V. H. Duong; H. A. Bastawrous; K. C. Lim; K. W. See; P. Zhang; S. X. Dou. SOC estimation for LiFePO4 battery in EVs using recursive least-squares with multiple adaptive forgetting factors.2014 International Conference on Connected Vehicles and Expo(ICCVE),2014:520-521.