Proceedings of 2020 IEEE International Conference on
Applied Superconductivity and Electromagnetic Devices
Tianjin, China, October 16-18, 2020 ID20170

Research on Reliability Analysis Method of Power Battery Based on Accelerated Life Test

Jingbo Liu[1], Zheng Wang[2], Junda Tong[2], Bo Yang [1], Wenying Shang[1]
1. State Grid Liaoning Electric Power Company Limited Economic Research Institute, Shen Yang, China, 110015.
2. State Grid Liaoning Electric Power Company Limited Shen Yang, China, 110004
solomonpp@126.com

Ning Yan
School of Electrical Engineering
Shenyang University of Technology
Shen Yang, China, 110870
E-mail: sutxny_yn@126.com

Abstract—**In order to accurately predict the life of the power battery. This paper proposes a method to measure the life of power battery based on acceleration life test. First, the mathematical model of the power battery and the method of analyzing the power battery are established. Second, establish the relationship between the state of charge (SOC) and the state of health (SOH). Finally, a method of accurately predicting the life of the power battery is obtained through simulation analysis. The results show that the life of the power battery can be accurately predicted.**

Keywords- Power Battery; Accelerated life test; reliability

I. INTRODUCTION

With the continuous improvement of clean energy penetration rate, network security is facing huge challenges, and the demand for system flexibility adjustment is increasing. The chemical energy storage equipment represented by power batteries, due to its good charge and discharge characteristics, will have a excellent smoothing performance for the fluctuation and randomness of distributed power supplies, and it will become an important basic support and key technical equipment for new energy systems. With the further expansion of market demand, related research on power battery condition assessment and stable operation has become a major hot spot.

II. POWER BATTERY LIFE ASSESSMENT METHOD

A. Establishment of mathematical model of power battery

Power battery as the key to safe operation of distributed power grid connection. To maintain the stability of the frequency and voltage of the entire system, the equivalent model and SOC characteristics of the power battery need to be analyzed during the reliability evaluation of the power battery, as shown in Fig. 1.

B. Power battery life calculation

After the power battery works for a period of time, as the number of charging and discharging continues to increase, the battery's rated capacity Ex continues to decrease, so it is difficult to accurately estimate the SOC characteristics of lithium-ion batteries. Therefore, the $\mathrm{SOC}_x(t)$ change rule over time is calculated as

$$\mathrm{SOC}_x(t)=\mathrm{SOC}_0(t_0)-\frac{\alpha i_a}{E_0}\times\Delta t\times 100\% \tag{1}$$

Among them, $\mathrm{SOC}_0(t_0)$ is the state of charge of the lithium battery at the initial time, and α is the charge and discharge efficiency of the lithium ion battery. i_a is the charging current of the power battery, and E_0 is the factory rated capacity.

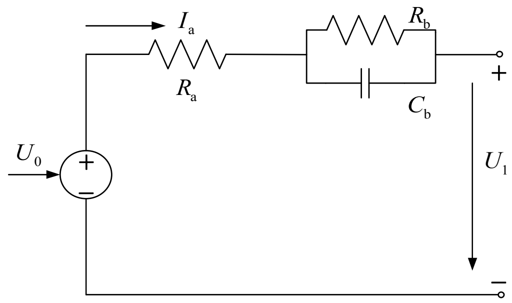

Figure 1. Power battery equivalent model.

According to formula (1), it can be inferred that the SOC characteristics of the power battery have a direct relationship with the charge and discharge efficiency, therefore, when considering the SOC characteristics, the life characteristics of the power battery should be calculated. In the case of different depths of discharge, the life calculation of the power battery is directly related to the loss during charging and discharging. After several tests on the life test of the lithium ion battery, the life cycle number of the lithium ion battery is

$$L=\beta_1+\beta_2 e^{-\beta_3 R_1}+\beta_4 e^{-\beta_5 R_2}+\cdots+\beta_{k-2} e^{-\beta_{k-1} R_k} \tag{2}$$

Among them, β_1, β_2, β_{i+1} are all constants, obtained by linear regression fitting;

III. SOH AND SOC CORRELATION CHARACTERISTICS

In the evaluation of the SOC characteristics and life of power batteries, existing studies have ignored the problem of

SOH decline in the application of energy storage batteries, resulting in a reduction in the accuracy of battery state estimation. Therefore, the comprehensive evaluation of the state of SOC and SOH in this study effectively improves the accuracy of state assessment. The relationship between the health of the power battery and the number of cycles is estimated based on the SOC characteristics as shown in Fig. 2.

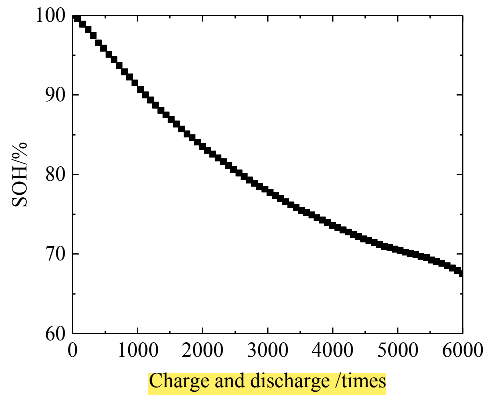

Figure 2. Correlation between power battery health and cycle times.

Suppose the limit value of SOH of the power sub-battery is [20%, 100%], and calculate the dynamic safety and health margin of the battery as

$$\left[\mathrm{SOH}_x(t),\mathrm{SOH}_x(t)\right]=\left[\frac{\mathrm{SOC}_x(t)-20\%}{\Delta t},\frac{1-\mathrm{SOC}_x(t)}{\Delta t}\right] \quad (3)$$

Among them, Δt is the time interval of SOH estimation, the smaller the value of Δt, the higher the accuracy of the joint estimation of SOC and SOH.

IV. Example Analysis

Accelerated life test of the lithium ion battery to analyze the reliability of the battery. The basic parameters of the battery are as follows: Take 1 # power battery as an example, its rated capacity is 1100mAh, the cut-off voltage and initial voltage 2.5V, 3.6V, discharge current 2A, initial internal resistance 60mΩ. The basic characteristics of the power battery under different charge and discharge rates are shown in Fig.3.

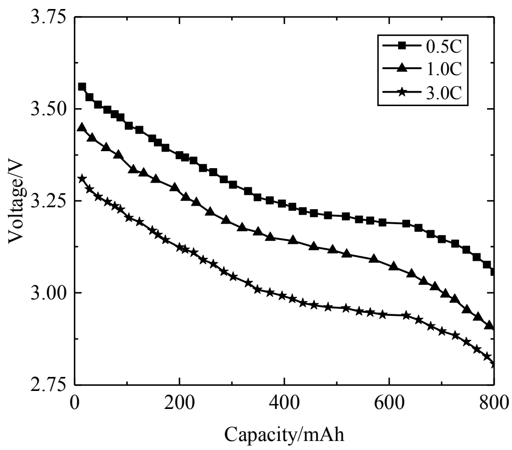

Figure 3. Characteristics of power battery with different charging rate.

This article compares two different rates of 1C and 2.0C for the accelerated life test to evaluate the difference in power battery health, as shown in Fig. 4-5.

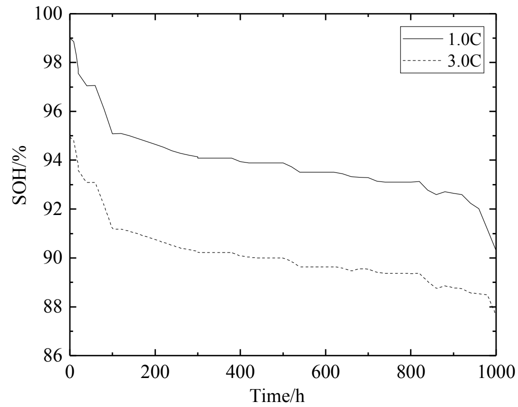

Figure 4. Correlation between power battery health and cycle times.

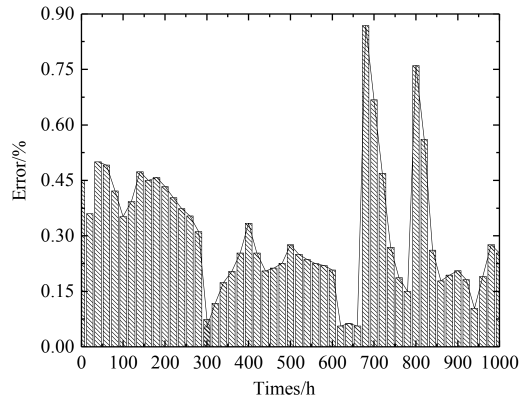

Figure 5. Correlation between power battery health and cycle times

It can be seen from the above figure that when the scenario analysis method is used for reliability analysis of the power battery, the greater the selected limit error, the greater the probability of reliability.

V. Conclusions

This paper presents a reliability evaluation of power batteries based on the use of accelerated life testing. First, establish the characteristics of SOC and SOH through power battery life calculation; second, use the inverse power rate equation to conduct accelerated life tests on lithium ion batteries to obtain accelerated life tests that can quickly detect the health of lithium ion batteries; The analysis method performs reliability analysis on the lithium ion battery, and can accurately obtain the reliability level of the lithium ion battery. Therefore, the reliability analysis method mentioned in this paper can not only quickly obtain the health of the power battery, but also quickly detect the reliability level of the power battery.

References

[1] Xiong R , Zhang Y , Wang J , et al. Lithium-Ion Battery Health Prognosis Based on a Real Battery Management System Used in Electric Vehicles[J]. IEEE Transactions on Vehicular Technology, 2019, 68(5):4110-4121.