

Impact of initial open-circuited potential on the consistency of lithium ion battery

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Abstract. Impact of initial open-circuited potential on the Consistency of Lithium ion battery was studied, and the results showed that the greater the initial open-circuit potential difference, the greater the discharge voltage difference between the two cells, and the greater the voltage gap between two cells, the more serious the battery pack performance degradation will be caused, the greater the probability of safety accidents, the more serious safety problem.

1. Introduction

The power battery inconsistency refers to the differences in voltage, internal resistance, capacity and other parameters of the batteries of the same specifications and same type, these differences are resulted from two main reasons: one reason is that the technology-related problems and material unevenness in manufacturing process lead to slight differences in battery plate thickness, micro-porosity and activation level of active substances, causing incomplete consistency to the internal structure and materials of the battery, eventually resulting in some differences existed in the capacity, internal resistance and other parameters of the batteries of the same batch and same type; the other reason is that, the impacts of differences existed in temperature, ventilation condition, self-discharge degree and operating environment of cells in the battery pack increase the inconsistency of battery voltage, internal resistance, capacity and other parameters to a certain extent [1-7]. In this paper, impact of initial open-circuited potential on the Consistency of Lithium ion cell was studied.

2. The consistency tests

2.1. Test sample

The model and the parameters of cell in this paper as follows:

- 1) The model: domestic battery, rated voltage 3.7 V, rated capacity 10 Ah, internal resistance < 6 mΩ, weight < 320 g
- 2) Dimensions: 133 mm×66 mm×18 mm.
- 3) The composing of the battery: the cathode material is LiMn₂O₄, the anode material is graphite, the electrolyte is LiPF₆, EC and DMC, and battery separator is celgard 2325.

2.2. Test Instrument

Thermostat box, model SPHH-101; Integrated battery tester, MACCOR battery performance test systems; Data acquisition system, model MV2000. The test is shown in Fig. 1.



2.3. Test Method

Select 4 cells of good capacity and internal resistance consistency, and inconsistent initial open-circuited potential (for example, the initial open-circuit potentials of the test sample at 20°C: sample 1: 4.120V, sample 2: 4.122V, sample 3: 3.986V and sample 4: 4.086V), to form two battery cell blocks connected in series, respectively, charge and discharge and monitor the real-time voltage and temperature at 20°C/20°C/40°C/65°C.



Fig.1 The consistency tests

3. Results and Discussion

The results of power batteries which were charged and discharged at 20°C/20°C/40°C/65°C temperature are shown in Fig. 2, Table 1 and Table 2.

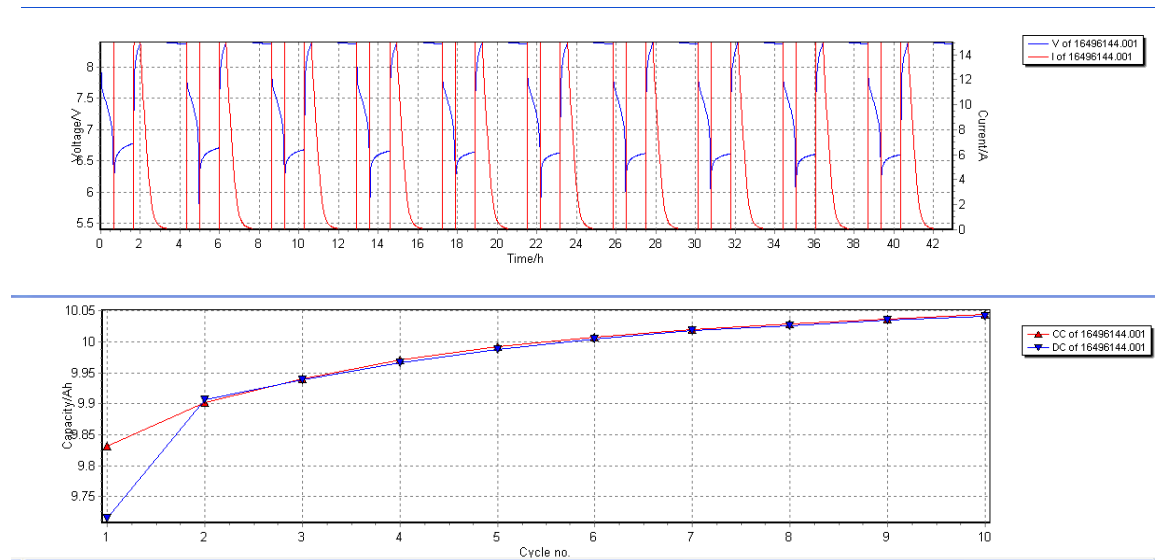


Fig.2 The results of consistency tests

Table 1 The results of the consistency tests

Temperature	Sample	Initial open-circuited potential /V	The maximum charge voltage /V	The minimum discharge voltage /V	Remarks
-20°C	T-1-3	3.760	4.198	2.699	

	T-1-4	3.758	4.065	2.632	
	T-2-5	3.720	4.196	2.699	
	T-2-6	3.718	4.126	2.652	
20°C	T-1-1	4.12	4.204	2.612	
	T-1-2	4.122	4.2	2.892	
	T-2-1	3.986	4.177	1.732	
	T-2-2	4.086	4.309	3.732	
40°C	T-1-7	4.067	4.219	2.518	
	T-1-8	4.071	4.198	2.943	
	T-2-9	4.094	4.206	2.752	
	T-2-10	4.092	4.204	2.738	
65°C	T-1-11	4.066	4.16	2.883	After tests, the battery was inflated
	T-1-12	4.063	4.281	1.868	
	T-2-13	4.116	4.291	1.828	
	T-2-14	4.119	4.167	2.828	

Table 2 The results of the consistency tests

Temperature	Sample	Difference of initial open-circuited potential /V	Difference of the maximum charge voltage /V	Difference of the minimum discharge voltage /V
-20°C	T-1-3	0.002	0.133	0.067
	T-1-4			
	T-2-5	0.001	0.07	0.047
	T-2-6			
20°C	T-1-1	0.002	0.004	0.28
	T-1-2			
	T-2-1	0.1	0.132	2
	T-2-2			
40°C	T-1-7	0.004	0.021	0.425
	T-1-8			
	T-2-9	0.002	0.002	0.014
	T-2-10			
65°C	T-1-11	0.003	0.121	1.015
	T-1-12			
	T-2-13	0.003	0.124	1
	T-2-14			

According to Table 1 and Table 2, it can be obtained that the greater the initial open-circuit potential difference, the greater the discharge voltage difference between the two cells.

It can be seen from the literature that the greater the voltage gap between two cells, the more serious the battery pack performance degradation will be caused, the greater the probability of safety accidents, the more serious safety problem.

4. Summary

1) The inconsistency of initial voltage of cells in the series-connected battery pack may cause some safety problems;

2) The larger the initial open-circuit potential difference of cells in the series-connected battery pack, the greater the discharge voltage difference of cells in series-connected battery pack;

3) The larger the voltage gap of cells in the series-connected battery pack, the more serious the battery pack performance degradation, the greater the probability of safety accident, and the more serious the safety problem.

The voltage inconsistency mainly affects the mutual charging of the batteries in parallel-connected battery pack, when the voltage of one battery in a parallel-connected battery pack is lower, other batteries would charge it. The capacity of lower voltage battery is increased slightly while the capacity of higher voltage battery is decreased sharply, the energy is consumed in the charging process and is unable to realize the expected external output.

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References

- [1] LI Xiang-zhe. Hybrid Electric Vehicle and Its Storage Batteries [J]. Battery Industry, 2003, 8 (2) : 81-85.
- [2] HAO De-li. Study on the Lithium ion Battery for Electric Vehicle [J]. Chinese Journal of Power Sources, 2003, 27: 160-165.
- [3] YANG Gu chang , et al . Research on the Selecting Methods for Lithium ion Cells [J]. Battery Industry, 2009, 14(3) : 152-154.
- [4] XIE Jiao, RUAN Xiao li, LI Yu-long. Study of the Lithium ion Battery Pack Consistency and Influence Factor. Dongfang electric review, Vol.26, No.103: 1-5, 2012
- [5] XU Wei. Consistency Study of Batteries System Based on Single Batteries Life Model [D]. Shanghai: Tongji University, 2009. (in Chinese)
- [6] Matthieu D, Liaw B Y. Development of a universal modeling tool for rechargeable lithium batteries [J]. J of Power Sources, 2007, 174(2): 856-860.
- [7] WANG Zhen po. Study on Inconsistency of Electric Vehicle Battery Pack [J]. Chinese Journal of Power Sources, 2003, 27(5): 438-441.