Journal of Electronic Research and Application, 2025, Volume 9, Issue 4
http://ojs.bbwpublisher.com/index.php/JERA
ISSN Online: 2208-3510
ISSN Print: 2208-3502

Fast Charge Test Method for Battery Pack Systems with Thermal Management

Zidan Gong[1], Jun Yang[1], Zhaoming Li[1], Yuebing Feng[2]

[1]Dongfeng Motor Corporation Research & Development Institute, Wuhan 430056, Hubei, China
[2]Dongfeng Motor Corporation Passenger Vehicle Company, Wuhan 430056, Hubei, China

Abstract: This paper introduces a kind of substitute bench testing method for vehicle application development and testing method of the test requirements, including battery fast conversion cycle test equipment, enter type incubator, liquid-cooled machine and ancillary equipment composed of a set of test system, through the walk-in constant temperature box to simulate the new energy vehicles under different environmental conditions of the test requirements, Liquid-cooled machine and auxiliary parts to complete the battery thermal management system need cooling fluid conditions, the battery conversion cycle test equipment to simulate the dc fast charging way of filling pile, complete battery thermal management system test, shorten the filling fast charging time and improve battery fast charge security, for troubleshooting and data collection and analysis, Improve work efficiency, save costs, and eliminate customer anxiety about battery life and charging time.

Keywords: Thermal management battery pack system; Fast-charging bench system; Test method

Online publication: August 7, 2025

1. Introduction

In September 2020, China proposed the "dual carbon" goal [1]. In 2023, the sales volume of new energy vehicles was 9.495 million, accounting for 31.6% of the market, and 1.203 million were exported. The cumulative sales volume of power batteries was 616.3GWh, an increase of 32.4% [2] year-on-year. In order to ensure the safe and efficient operation of the battery system, the thermal management fast charge test of the battery pack is very important. Due to the improvement of users' requirements for the range, life, and charging efficiency of electric vehicles, most power batteries have thermal management and high-rate charging and discharging functions, which require a large number of related tests. The temperature of the battery pack affects the performance of the battery cell, and maintaining the appropriate temperature is key. The mainstream of new energy vehicle battery packs uses forced circulation liquid cooling, and the coolant is driven by a water pump. The high heat transfer coefficient of the liquid is used to effectively cool down and improve the consistency of the temperature field.

2. Technical basis of battery thermal management

2.1. Overview of battery thermal management

Battery thermal management is mainly based on the temperature effect on battery performance, combined with its electrochemical and heat production features, to maintain the best working state, maintain battery solution temperature anomalies caused by thermal runaway, such as insufficient performance range, and improve the whole battery performance [3]. Its functions include cooling, heating, and temperature equilibrium; the former two respond to the external environment temperature influence, which reduces the battery pack temperature difference and attenuation to avoid local overheating. In short, the temperature will affect the battery's internal resistance and voltage and other parameter information to a certain extent, and then affect the endurance performance and cycle life of the whole vehicle [4].

2.2. The principle of battery fast charging technology

Fast charging is a method of charging the battery to full power or close to full power in a short time with the fastest speed [5]. Through the communication between the device and the battery BMS system, according to the highest/lowest temperature and voltage of the monomer, check the table to determine the best rate of charging current, so as to ensure the cycle life, safety, and electrical performance of the lithium-ion battery, and shorten the charging time. Common lithium-ion battery is composed of graphite anode and lithium metal oxide anode, rechargeable Li^+ by solid electrode, electrode/electrolyte interface, and electrolyte transport. High current and high power fast charging have higher requirements for battery materials and thermal management system, and problems such as heat accumulation, thermal runaway, shortened life, and unstable performance are prominent during charging.

2.3. The combination of thermal management and fast charging

Rising power battery capacity and charging rate increase is the inevitable trend of its development, big ratio to charge and discharge conditions, the battery module will generate a lot of heat in a short period of time, a higher request of the cooling system [7]. Liquid with high thermal efficiency, quick charge when the battery module can be the highest temperature, minimum temperature, and temperature difference are maintained in a safe range, can allow the battery to be in the appropriate temperature range, selection ratio allowable maximum charge of the battery charging current.

3. The status quo analysis

3.1. Existing technical solutions

A fast battery pack with a thermal management system test method is a kind of: the vehicle state directly on the high-power dc charging pile tests.

3.2. The disadvantages of existing technology

Now to bring a new energy vehicle thermal management system in dc fast charging, this way, the filling pile test method is needed together with the whole vehicle in dc fast charging pile above to do a series of tests, and the test cost is high. The tests need to be done on the vehicle, which is not conducive to finding a very convenient assembly. Vehicle dc fast charging pile top can perform a quick charge test, can meet the test battery pack temperature for different purposes, and cannot complete thermal management under the battery capacity test validation.

4. Battery fast charge method, thermal management

4.1. The problem solved

The test tries to enter a type constant temperature box is used to simulate different atmospheric environments, so as to realize the battery pack system in different environmental temperatures under the condition of quick charge test [6].

With battery pack system structures, a test bench, and the management of the vehicle with heat, to simulate the way of quick charge can more accurately meet the test requirements, also can avoid the problem that dismantling the battery pack, conducive to the test data collection to provide more convenient [7]. The whole test process only uses a battery pack system, which can realize the hot management under the condition of the battery capacity test.

4.2. Complete technical scheme

Battery thermal management rapid test for new energy vehicles on a quick charge with power battery thermal management system test method substitute bench testing method for the vehicle of experiments is developing rapid testing requirements, including battery fast conversion cycle test equipment, enter type incubator, liquid-cooled machine and ancillary equipment composed of a set of test system is shown in **Figure 1**, Through walk-in constant temperature box to simulate the new energy vehicles under different environmental conditions in all kinds of test requirements, liquid-cooled machine and auxiliary parts to complete the battery thermal management system need cooling fluid conditions, the battery conversion cycle test equipment to simulate the dc fast charging way of filling pile, complete battery thermal management system test, Assessment in the vehicle thermal management strategy and the simulation of the rapid charging efficiency, etc., provide technical support for the development of new energy vehicle [8].

Test method: test mainly using a constant temperature box to realize the simulation and control of environmental temperature, in order to achieve the test required atmospheric environmental temperature conditions. In the process of test, the reservation will accept to BMS CNA information first, and then after DBC file parsing, then feedback to the computer system, after its surface unit cell cycle quickly response equipment and test equipment, thus forming test loop by this way, Eventually the battery pack inlet cooling fluid temperature and battery pack charging rate control [9]. With such a test method, not only can it effectively ensure the safety of the battery can also use the shortest possible time to car full of electricity, in order to better meet all kinds of test requirements, more can be implemented through the way of inner loop battery pack balanced temperature field [10].

4.3. The test steps

Under the condition of safety norms, put the power battery pack in the walk-in constant temperature box, connect the power battery pack high-voltage dc fast charging cable to the battery fast conversion cycle test equipment;

Will surface out of the unit, return pipe connected to the battery pack on the inlet and outlet pipe, according to **Figure 1**, the principle diagram of the test method of connection in various equipment and other auxiliary equipment test wiring harness.

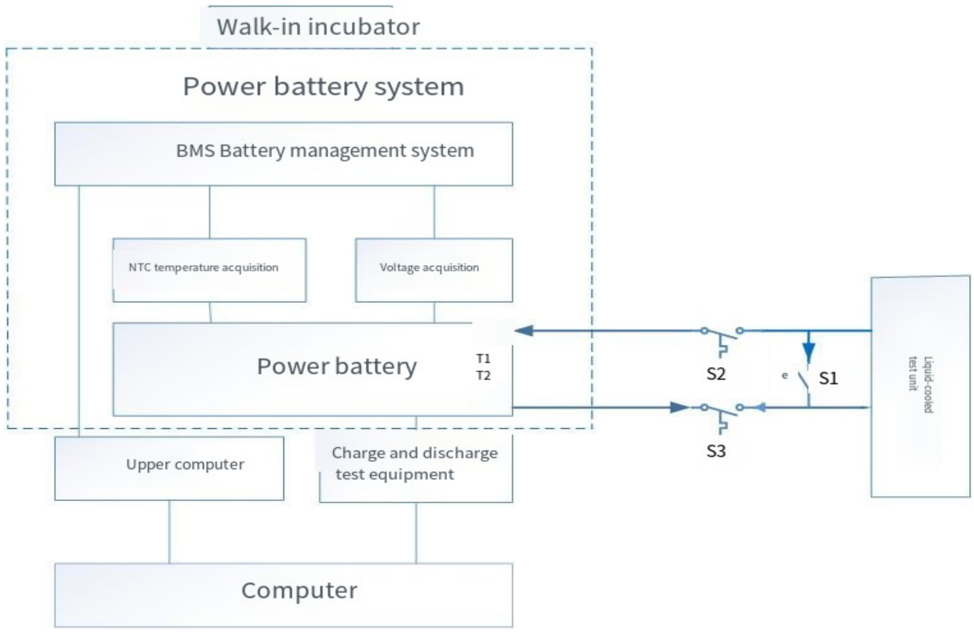

Figure 1. Test principle structure

Set the required vehicle enter type constant temperature box in the environment temperature, after being stable information read by the upper machine CAN determine the battery pack in the highest temperature of monomer and monomer lowest temperature (rapid cooling as monomer corresponding to the maximum temperature in **Figure 2** temperature T, heating quick charge when monomer lowest temperature corresponding temperature T) in **Figure 2**, Read battery pack inlet temperature T1 (**Figure 1** the T1 is the temperature of the coolant temperature), read the highest monomer in the battery pack voltage V voltage V of (**Figure 2**).

			5%	10%	12%	30%	40%	45%	50%	55%	60%	65%	70%	75%	80%	90%	95%	
97% T/degC	SOC (0%, 2%) (2%, 5%) (5%, 10%) (10%, 12%) | (12%, 30%) (30%, 40%) (40%, 45%) | (45%, 50%) (50%, 55%) (55%, 60%) (60%, 65%) | (65% (70%, 75%, 70%)) (75%, 80%) (80%, 90%) (90%, 95%) (95%, 97%) (20 °C to -																	
Charging is not allowed below -20 ° C)[-20,																		
-	Voltage/V	3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	4.2
5	Current/C	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.05	0.05	0.03	0.03	0.03	0.03	
	4.2 Current/C	3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	
10)	0.03 Voltage/V	0.14	0.14	0.14	0.14	0.14	0.14	0.07	0.07	0.07	0.07	0.07	0.07	0.05	0.05	0.03	0.03	
4.2 [-10, -5) Current/C		3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	
	0.03 Voltage/V	0.14	0.14	0.2	0.21	0.21	0.14	0.14	0.14	0.07	0.07	0.07	0.07	0.07	0.07	0.05	0.05	
4.2 [-5, 0) Current/ C		3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	
	0.07 Voltage/V	0.2	0.2	0.25	0.28	0.28	0.28	0.21	0.21	0.21	0.21	0.21	0.21	0.14	0.14	0.14	0.14	[illegible]
4.2[0, 5)		3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	
	Current/C 0.1 Voltage/V	0.3	0.3	0.5	0.6	0.6	0.6	0.5	0.5	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.2	
4.2[5, 10)		3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	
	Current/C 0.1 Voltage/V	0.3	0.3	0.5	0.8	0.8	0.7	0.55	0.55	0.5	0.5	0.4	0.4	0.3	0.3	0.2	0.2	
4.2 [10, 15) Current/C		3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	
	0.1 Voltage/V	0.33	0.5		1.4	1.4	1.2	1	1	0.8	0.8	0.7	0.7	0.5	0.5	0.33	0.2	
		3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	
	0.1Voltage/V	0.33	0.5	1	1.5	1.5	1.25	1.1	1.1	0.8	0.9	0.8	0.7	0.7	0.5	0.33	0.2	
4.2 [20, 25) Current/C		3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	
	0.1Voltage/V	0.33	organisation	1	2	2	1.7	1.6	1.4	1.2	1	0.9	0.9	0.7	0.7	0.5	0.2	
4.2 [25, 30) Current/C		3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	
		0.33	0.5	1	4	3	3	2.8	2.6	2.4	2.2	2	1.8	1.5	1.25	0.5	0.2	0.1
	Voltage/V	3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	4.2
	Current/C	0.33	0.5	-	4	3	3	2.8	2.6	2.4	2.2	2	1.8	1.5	1.25	0.5	0.2	0.1
[30, 35)[35,	Voltage/V Current/C	3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	4.2
40)[40,	0.33 Voltage/V		0.5	11	4	3	3	2.8	2.6	2.4	2.2	2	1.8	1.5	1.25	0.5	0.2	0.1
45)[45,	Current/C	3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	4.2
50)	Voltage/V	0.33	0.5		4	3	3	2.8	2.6	2.4	2.2	2	1.8	1.5	1.25	0.5	0.2	0.1
	Current/C	3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	4.2
	0.33 Voltage/V		0.5	1	3	3	3	2.6	2.5	2.3	2	1.8	1.6	1.3	1	0.5	0.2	0.1
[50, 55] Current/C		3.276	3.418	3.533	3.766	3.841	3.925	3.966	4.004	4.034	4.064	4.101	4.149	4.172	4.18	4.183	4.197	4.2
0.33(above 55)			0.5	1	2.8	2.8	2.8	2.4	2.3	2.1	1.8	1.6	1.4	1.1	0.8	0.5	0.2	0.1
		Charging is not allowed above 55 ° C																

Figure 2. Current matrix of fast charging window

Open the liquid cooling unit and close the inlet valve S2 and outlet valve S3, open the inner circulating water valve S1, set the initial coolant temperature according to the quick charging cooling strategy in **Figure 3** and quick charging heating strategy in **Figure 4**, and wait for the coolant temperature to be stable in the inner circulation.

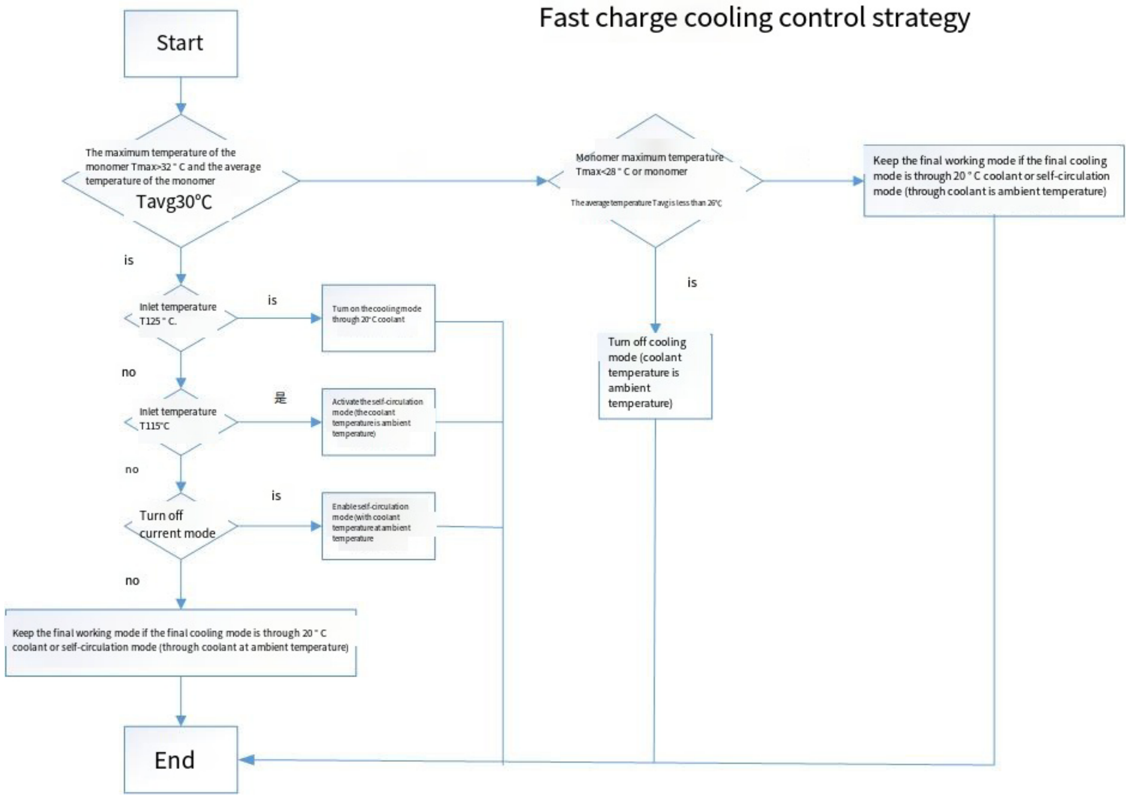

Figure 3. Cooling control strategy of fast charging vehicle

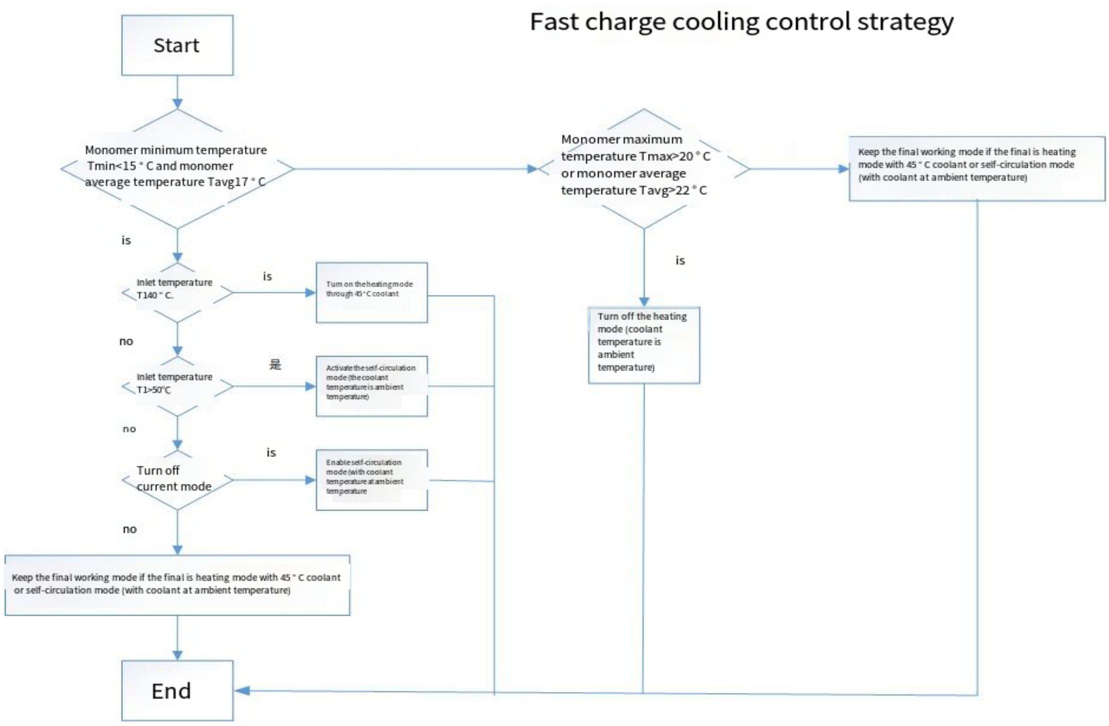

Figure 4. Heating control strategy for the fast enrichment vehicle

Figure 2 quick charge window current matrix in imported into the equipment (with analog dc charging pile function of battery fast conversion cycle test equipment) in accordance with the requirements of quick charge according to Figure 2 look-up table, select the highest temperature at this time of the monomer Tmax or monomer, the abscissa denotes the interval value of the minimum temperature Tmin highest voltage V and monomer was determined by the interval value for the y coordinate of the corresponding a value for the charging current ratio value;

According to the battery pack thermal management strategy is open the inlet valve S2 and S3, water valve closed circulating water valve in S1, at the same time monitoring in the process of the battery pack inlet temperature T1 and monomer Tmax highest temperature or the lowest temperature Tmin according to **Figure 3** and **Figure 4** strategies to control the surface unit makes the T1 temperature meet the requirements of control strategy;

Equipment to the rate of charging current of battery pack, if the abscissa monomer in the process of charging the highest temperature Tmax or ordinate monomer voltage V criteria to the next interval, equipment look-up table to choose corresponding charging ratio of current to the battery pack charging back to determine the charging rate in turn.

In the above process, the coolant temperature is controlled according to the control strategy in **Figure 3** and **Figure 4**, and the current look-up table is based on the battery fast-charging window in **Figure 2**. Select the corresponding charging rate and charge the current until the highest voltage V of the monomer is 4.29V cutoff or the highest temperature Tmax of the monomer reaches 55°C, and the corresponding test data is obtained.

4.4. Guarantee measures

Fast charging cooling: request water temperature 20°C; Technical requirements: the water cooling unit needs to control the water temperature T1 at 15–25°C.

Fast charging heating: request water temperature 45°C; Technical requirements: the water cooling unit needs to control the water temperature T1 at 40–50°C.

If the water temperature T1 is lower than 10°C for a certain period of time (2min), the water temperature is too low fault will be issued, and the fault will be recorded and reported to the equipment. Fault removal: 15°C, lasts for 5S, fault handling: do not do any processing [11];

If the water temperature T1 is higher than 55°C for a certain period of time (2min), the water temperature is too high fault will be issued, and the fault will be recorded and reported to the equipment. Fault removal: 50°C, lasts for 5S, fault handling: request to turn off thermal management;

The minimum temperature of the battery core is less than or equal to -30°C, and charging, discharging, and thermal management are not allowed;

The minimum temperature of the core is greater than -30 °C and less than or equal to -20 °C, allowing discharge heating according to the discharge power meter, but not allowed to charge.

The maximum temperature of the battery core is greater than or equal to 55°C will trigger level 6 fault, and the discharge, charging, and thermal management functions are not allowed to start.

5. Thermal management battery fast charge method evaluation

5.1. Comparison of test data of thermal management fast charging with and without opening at different temperatures

For the comparison of SOC fast charging test at battery temperature of -10°C and 40°C with and without thermal management, the consistency issues such as SOC calculation deviation and accuracy were not considered for testing on the same sample and the same equipment, respectively. The results are shown in **Figures 5**, **6**, **7**, and **8**.

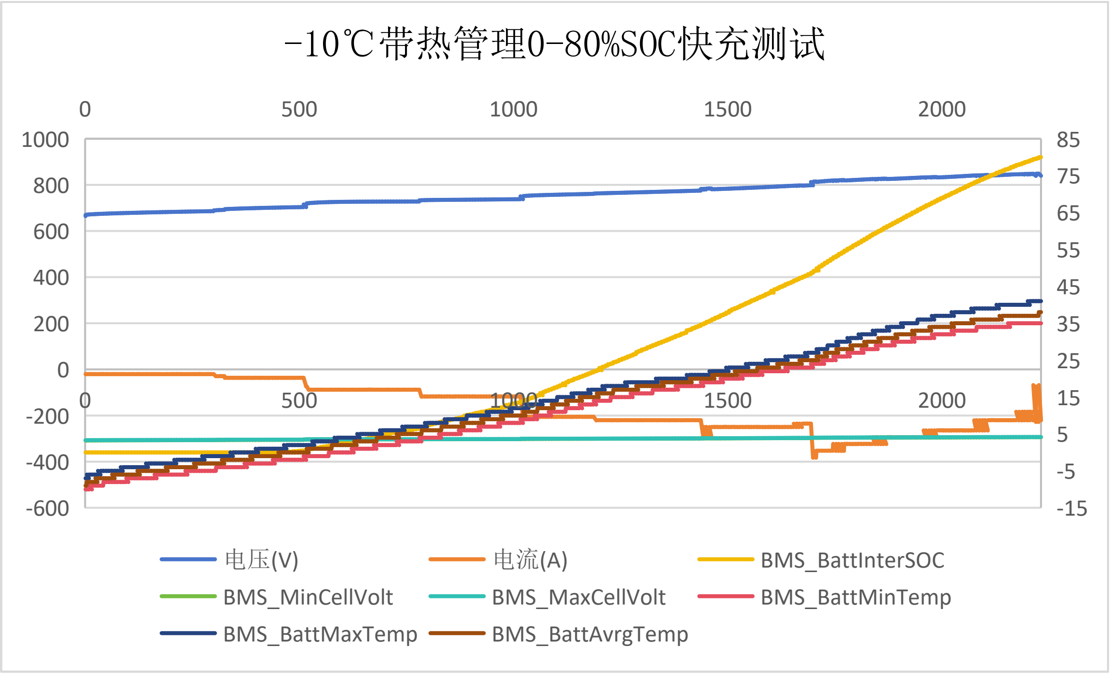

Figure 5. 0–80% SOC fast charge time 37min11s

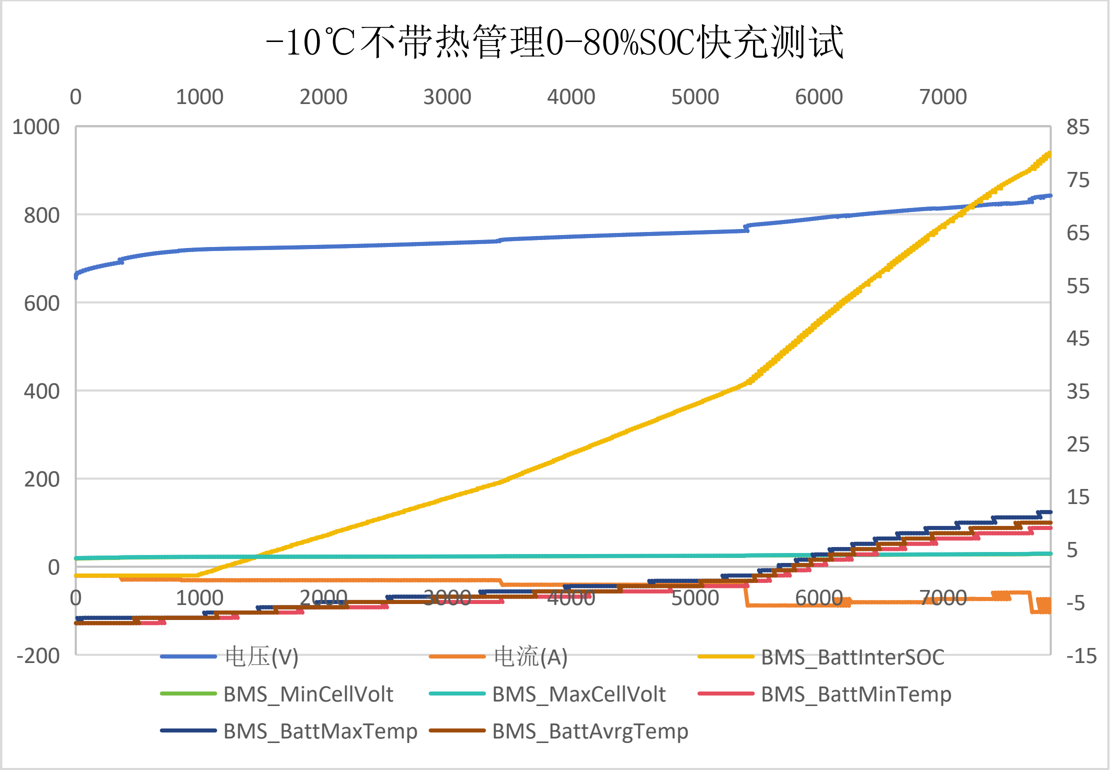

Figure 6. 0–80% SOC fast charge time 2h11min8s

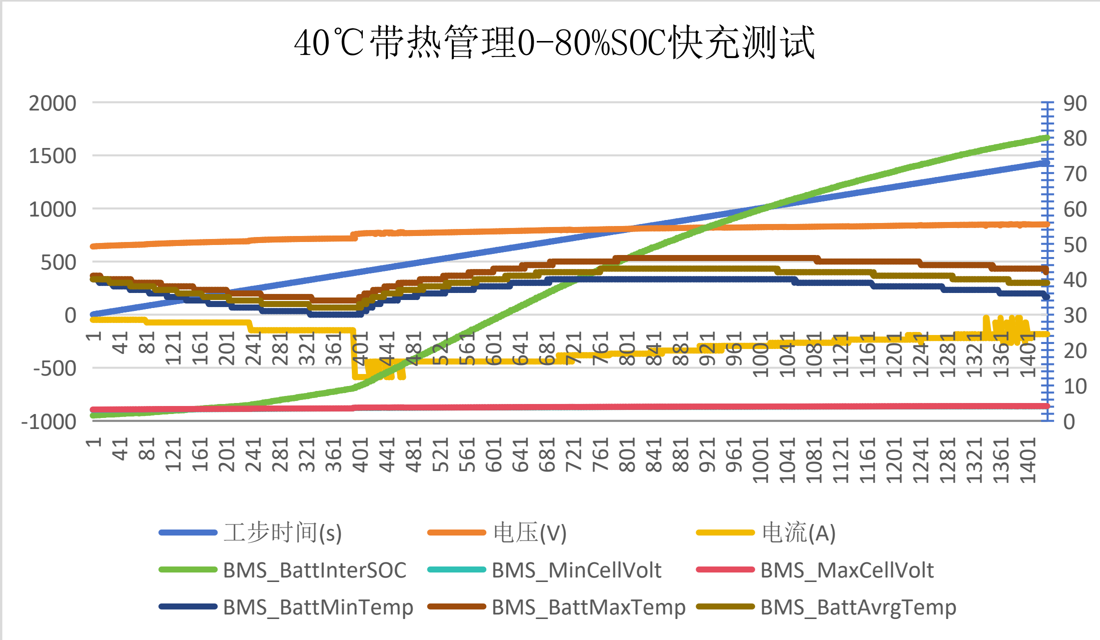

Figure 7. 0–80% SOC fast charge time 22min21s

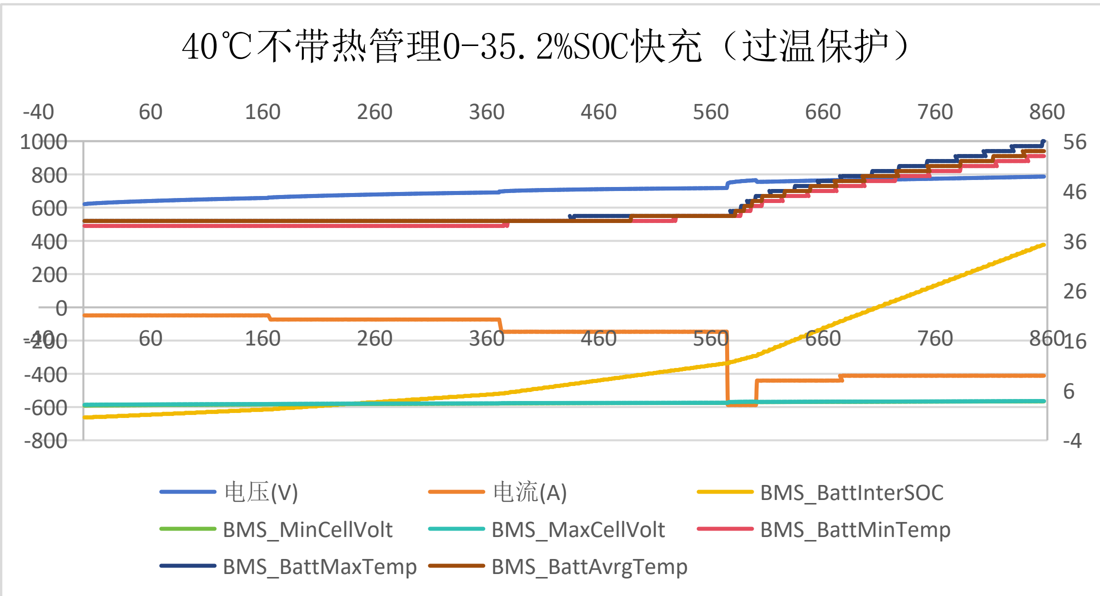

Figure 8. BMS_BattMaxTemp56℃ when fast charging 14min17s to SOC 35.2%

5.2. Data analysis

From the data analysis, it can be seen that the fast charging time of 0–80% SOC with thermal management 2231s is shorter than that of 0–80% SOC without thermal management 7868s at -10℃. At 40℃, when the maximum temperature of the monomer reaches BMS_BattMaxTemp56℃, it will trigger a level 6 fault, which is not allowed to discharge and charge, and there is a security risk [12].

6. Application prospect of thermal management battery fast charging method

6.1. Application analysis of electric vehicle industry

With the rapid development of the electric vehicle industry, battery fast charging technology has become the key to improving user experience and promoting industry progress. As an emerging technology, the thermal management battery fast charging method has the potential [13] to solve the bottleneck of traditional fast charging. With the rapid development of the new energy vehicle industry, fast charging has become one of the key technologies for the popularization of electric vehicles. However, rapid charging puts forward higher requirements for the battery thermal management system. Problems such as heat accumulation, thermal runaway risk, shortened life, and unstable performance of batteries in the process of fast charging have become increasingly prominent. This paper mainly analyzes the thermal management problems of new energy batteries under fast charging conditions and discusses the application of innovative technologies such as efficient heat dissipation materials, intelligent thermal management system, active cooling technology and thermoelectric effect technology in detail, in order to provide effective technical support and solutions [14] for new energy battery thermal management.

6.2. Prediction of technology development trend

At present, the thermal management of mature liquid cooling and PTC heating is still the preferred scheme for many electric passenger vehicles. With the improvement of people's requirements for new energy vehicles, the charging time is shorter and shorter under the premise of battery safety, and the endurance is increased; the future battery charging power will be larger. More new materials and new technologies will be applied, such as direct cooling or oil cooling immersion, and higher [15] technical requirements will be required.

Disclosure statement

The authors declare no conflict of interest.

References

[1] Feng Z, 2022, Test and Analysis of Power Battery Thermal Management for New Energy Electric Vehicle. Special Purpose Vehicle, 12.

[2] Bi Y, Huang J, Li Y, 2024, Thermal Management of New Energy Battery under Fast Charging Conditions. Energy and Energy Saving, 06.

[3] Wang S, Li J, Li Y, et al., 2022, Lithium Ion Battery Charging System Low Strategy. Energy Storage Science and Technology, 05.

[4] Hu M, 2024, Research Progress of Fast Charging Technology for Power Battery of New Energy Vehicle. Auto Pictorial, 07.

[5] Zhou D, 2025, The New Energy Automotive Power Battery Heating Control Strategy Optimization. Journal of Automotive Technology, (02): 84–88.

[6] Wang S, 2025, New Energy Vehicles Thermal Runaway Detection and Power Battery Thermal Management Strategy. Auto Pictorial, (02): 17–19.

[7] Du S, 2025, New Energy Vehicles Is Analysed Influence of Large Power Charging the Battery Thermal Management System. China's Auto Market, (01): 51–52.

[8] Zhang YX, 2025, Research on Battery Management System Based New Energy Vehicle Endurance Optimization.

Automotive Knowledge, 25(01): 4–6.
[9] Qin S, 2024, New Energy Vehicles Power Battery Cooling System Optimization Study. Automotive Test Report, (21): 47–49.
[10] Zhao K, 2024, Application and Prospect of High Power Fast Charging Technology for Electric Vehicles. Product Reliability Report, (07): 91–93.
[11] Fan C, Yin K, 2024, New Energy Vehicles Power Battery Thermal Management System Design Study. Journal of Auto Test Report, (9): 44–46.
[12] Shi Y, 2024, Discussion on Power Battery and Charging Technology of Pure Electric Vehicle. Times Auto, (01): 100–102.
[13] Cai T, 2023, Research on Thermal Behavior and Thermal Management Optimization of New Energy Vehicle Power Battery, dissertation, Nanjing University of Posts and Telecommunications.
[14] Huang Y, Xie M, Zhao Z, et al., 2023, Analysis on Thermal Management Technology of New Energy Vehicle Power Battery. Energy & Conservation, (06): 20–27 + 134.
[15] Jiang H, 2023, Research on Optimal Heating and Charging Strategy of Lithium-Ion Battery in Low Temperature Environment, dissertation, Central South University.