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Research Progress of Test and Evaluation Technology for Battery Management System

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Abstract: *With the development of new energy vehicles, the battery management system is an important support for the safety and long life of new energy batteries. Its reliability affects the service life of new energy vehicles. Therefore, this article will take the battery management system as the starting point. Analyze the research progress of battery management system test and evaluation technology.*

Keywords: *battery management system, test evaluation*

1. Introduction

In 2019, the Ministry of Transport, the Ministry of Propaganda and other 12 ministries and commissions jointly released the "*Green Travel Action Plan* (2019-2022)", by 2022, the initial completion of a reasonable layout, eco-friendly, clean, low-carbon, intensive and efficient green travel service system, green travel environment significantly improved. The Ministry of Transport promote the large-scale application of green vehicles, further increase the promotion and application of energy-saving and new energy vehicles, solve the problem of new energy vehicle range, guide green travel multi-pronged approach, and explore a variety of measures. In recent years, China's new energy vehicles have been promoted and applied on a large scale under the impetus of national policies, markets and technologies. As shown in Figure 1, by the end of 2020, the number of new energy vehicles in China reached 4.92 million, accounting for 1.75% of the total number of vehicles, and the number of pure electric vehicles was 4 million, accounting for 81.32% of the total number of new energy vehicles. Sales of new energy vehicles exceeded one million units for three consecutive years, showing continuous rapid growth and ranking first in the world for six consecutive years, becoming an important driving force in the transformation of the global automotive industry into electric.

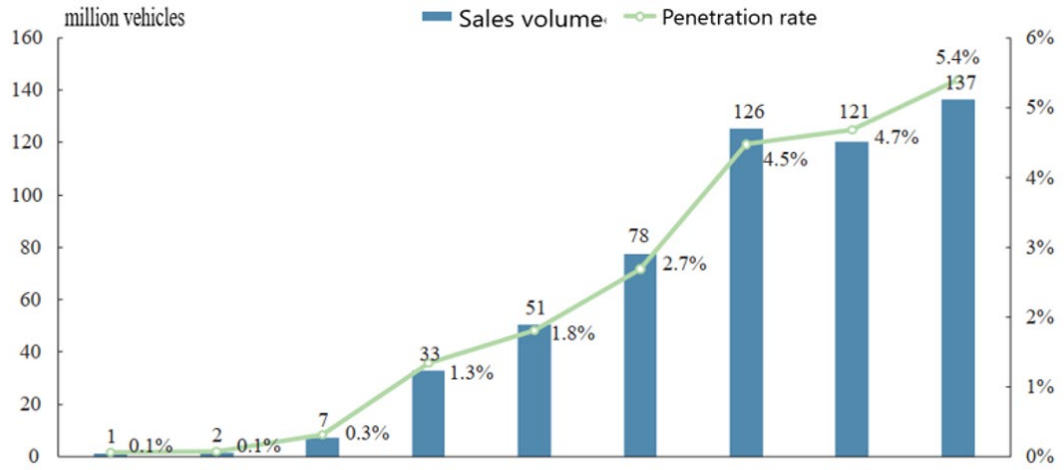

Figure 1: New energy vehicle sales and penetration rates

BYD and Geely entered the top ten global sales of new energy passenger vehicles, further increasing their global influence. Power battery companies such as Ningde Times, BYD, AVIC Lithium, Guoxuan Hi-Tech and YIWI Li-energy ranked among the top 10 in the world in terms of installed capacity and became important global suppliers.

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2. Current status of battery management system research

The battery management system (Battery Management System, BMS) is a comprehensive system for power battery monitoring of electric vehicles and high-voltage power management. As the link between the power battery and the vehicle controller, BMS is to solve the key issues of safety, availability, ease of use, and service life in the lithium battery system [1]. The main function is to improve the utilization rate of the battery, prevent the battery from being overcharged and over-discharged, extend the service life of the battery, and monitor the state of the battery. The main function is to improve the utilization rate of the battery, prevent the battery from being overcharged and over-discharged, extend the service life of the battery, and monitor the state of the battery.

The battery management system is an indispensable component of electric vehicles, and together with the battery system and the vehicle control system constitute the three core technologies of electric vehicles. With the rapid development of the new energy industry and the increase in consumer recognition, the market has increasingly higher requirements for BMS. Safety is the top priority for electric vehicles and requires accurate BMS fault diagnosis and analysis, plus the rise in electric vehicle fires in recent years has greatly reduced consumer confidence in power battery products. Foreign BMS have been developed earlier and are more mature. Some of the more representative battery management systems are: the BADICHEQ system developed by the team led by Mentzer Electronic GmbH and Werner Retzlaff from Germany and the BATTMAN system designed by B. Hauck; the battery management system used in the Toyota Pruis hybrid electric vehicle produced by Toyota Motor in Japan and the battery management system developed by Tesla in the USA. The Aomori Industrial Research center in Japan has been working on practical applications of BMS for a long time; Villanova University in the USA and US. Nanocorp are jointly developing SOC fuzzy logic predictions for various battery types [2].

Compared to foreign countries, domestic BMS is a late starter, with a less than perfect ecological environment and a certain gap with foreign countries. The initial barriers to entry for BMS are comparatively low, but as the market becomes more competitive; the technical barriers become higher and higher and without core technology will be eliminated. With the support of domestic guidance and subsidy policies in recent years, electric vehicles have been developing rapidly and the size of the domestic BMS market has also increased rapidly. In addition to the traditional car companies that have created some new car-making forces, such as Weilai Automobile, Xiaopeng Automobile, Ideal Automobile, etc., since the decline of state subsidies in 2019, the new energy market has fallen sharply. BMS still holds an important position for vehicle manufacturers and battery manufacturers. Companies have independent research and development of representative such as BAIC New Energy, BYD New Energy, CATL. From the analysis of the domestic market competition pattern, the mainstream current third-party BMS market share is also steadily increasing, such as Kelee, Neusoft Reach, Yinneng Electronics, Juyson Electronics, etc.

Specialized third parties are expected to have an even greater advantage in the future as the industry is driven by technology improvements and cost reductions due to specialized division of labor. Despite the rapid development of BMS, there are still some key technologies that need to be broken through. Such as improving the accuracy of acquisition and state estimation, avoiding the leakage of high-voltage voltage and current, and improving the compatibility of the battery management system. At present, we need to improve the safety, life, accuracy, and specific energy on the basis of the existing battery is the challenge we face. The main direction of future research is how to be safety-oriented, and early warning of faults on the basis of the battery system fault initiation mechanism, to improve system safety and to reduce the risk of false alarms and state false switches in the BMS.

3. The development status of automotive electronic functional safety

The release of the automotive electronics industry standard ISO 26262 "Functional Safety of Road Vehicles" has given people a deep understanding of functional safety and provided a reliable process guarantee for assessing and avoiding these risks. The international standard ISO 26262 was derived from IEC61508 after 6 years and was officially promulgated in November 2011. It is specifically used for electronic and electrical components in the automotive industry. The development of electrification, intelligence, networking, and sharing has forced the need for high integration and high safety of automotive electronics and electrical appliances, which increasingly reflects the importance of design based on standard systems. The ISO 26262 standard has become mainstream and many efforts have

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been made both domestically and internationally to produce automotive electronics under this standard. European, Japanese and Korean manufacturers were awarded tenders on the basis of compliance with the ISO 26262 standard and the relevant independent third-party certification. Infineon Technologies has developed the PRO-SIL range of safety products. The Safe Assure security solution from NXP Semiconductors [3].

The ISO 26262 standard has received a great deal of attention, especially in the automotive industry in Europe and the United States, while it is still in its infancy in China. In recent years, new energy vehicle manufacturers such as Changan, BYD, and BAIC, as well as domestic suppliers such as Hengrun Technology, Neusoft, and Keli Electronics, have also established functional safety-related design and development processes and corresponding review mechanisms. For example, Changan New Energy has obtained ISO 26262 process certification and certificates related to new energy electronic control unit products; BAIC New Energy has obtained ASILD-level functional safety process certification. The State Standardization Administration Committee's Chinese National Standards Announcement No. 26 of 2017, GBT/34590-2017 "Road Vehicle Functional Safety" standard will be officially implemented on May 1, 2018, promoting the development of domestic automotive electronic functional safety and providing an institutional process development standard for new energy vehicle research. In summary, compared to foreign countries, the development of functional safety for new energy vehicles is still in its infancy for China, and we still have a long way to go. The introduction of the ISO 26262 standard for battery management BMS is not only in line with the development needs of the technology trend, but also can really bring qualitative changes to the BMS, which is conducive to the healthy development of the industry in the long run [4].

4. Current status of BMS test and evaluation technology

The national/industry standards related to BMS testing and evaluation are QC/T 897, GB/T31467.3, GB/T27930, GB/T32960.3 and GB/T38661 "*Technical Conditions for Battery Management Systems for Electric Vehicles"*, GB 38031 "*Safety Requirements for Power Batteries for Electric Vehicles"* and GB/T 39086"*Functional Safety Requirements and Test Methods for Battery Management Systems for Electric Vehicle"*. There are also group standards under development, thermal management system performance test methods, and electric vehicle battery management system state of health (SOH) estimation error test methods. QC/T 897 test items, routine functional tests such as state parameter accuracy, SOC estimation accuracy, battery fault diagnosis, electrical environment adaptability, etc., environmental adaptability performance such as temperature environment, vibration, electromagnetic compatibility, etc. QC/T 897 environmental testing includes high and low temperature, temperature change, damp heat, salt spray environment, overvoltage, undervoltage, reverse polarity and other electrical adaptability evaluations.

The protection tests of over-temperature, over-charge and over-discharge in GB/T 31467.3 are related to BMS. BMS is required to function when doing over-temperature, over-charge, and over-discharge protection tests. The main purpose is to check whether the BMS can make corresponding actions in time when a fault is detected, so as to prevent the occurrence of dangerous accidents. GB/T27930, Communication protocol between non-vehicular conductive chargers and battery management systems for electric vehicles, focuses on managing the charging process, including the physical connection of the charger, low-voltage auxiliary power-up, charging handshake, charging parameter configuration, charging, and end of charging. GB/T3296.03, Part 3 of the Technical Specification for Electric Vehicle Remote Service and Management System: Communication Protocols and Data Formats. It mainly specifies the BMS communication protocols, which need to be unified when the electric vehicle interacts with the enterprise platform and public platform of the vehicle company for information without barriers. GB/T technical conditions for battery management systems for electric vehicles, focusing on safety requirements, unified recommended test methods for items such as equalization functions, without specific indicators.

This increases the assessment of the electromagnetic compatibility performance requirements of the BMS to ensure that the BMS works reliably in the complex electromagnetic environment of electric vehicles. Compared with QC/T 897, the test methods of electrical environment adaptability, electromagnetic compatibility test and SOP estimation accuracy test have been added; meanwhile, the test methods of total voltage, total current, temperature environment test, mechanical performance test and SOC estimation accuracy have been supplemented and enriched. In the Automotive Standardization Committee on functional safety technology and standards research planning, GB/T "*Road Vehicle Functional Safety*" in which "*BMS Functional Safety*" is an important part of the main

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four safety objectives to prevent thermal runaway caused by over-discharge, over-current, over-temperature and over-charge of the battery unit. GB Safety requirements for power batteries for electric vehicles, in which overcurrent, over-discharge, overcharge and overtemperature protection, thermal dispersion test and BMS are relevant. Compared to GB/T, there is an additional overcurrent protection test, which requires the battery management system to function during the test.

The Electric Vehicle Industry Technology Innovation Strategy Alliance has published T/CSAE 184-2020 "*Electric Vehicle Power Battery Health Status Evaluation Index and Estimation Error Test Method*". The basic battery data test section is mainly used to obtain the true values of the battery health status characterization parameters for the BMS estimation error test. It specifies test methods for obtaining capacity, energy, peak power and DC internal resistance battery characterization parameters. During the BMS health state estimation test, the cycling conditions under which the power cell reaches different health states, the test conditions of the BMS and the test scenarios need to be considered. In order to better implement the battery health status assessment and obtain accurate parameter indicators, this standard regulates the power battery system cycle conditions, BMS test conditions and BMS health status estimation test procedures. As the actual application conditions of power batteries vary, in order to better ensure the operability and relevance of the test, this standard does not provide uniform regulations on the cycle test conditions, which can be selected from the standard cycle conditions, typical charge and discharge conditions or other conditions negotiated between the vehicle manufacturer and the vehicle manufacturer to charge and discharge the battery system to achieve different health states. At the same time, as different manufacturers' BMSs have different methods of estimating the health status of the battery, depending on the actual conditions and application models, the health status of the BMS can be estimated by testing the battery system at the recommended test temperatures given in Appendix A using fast charging, slow charging, typical charging and discharging conditions or other conditions negotiated between the vehicle manufacturer and the OEM. Finally, the accuracy of the health state estimation of the BMS is calculated from the true and estimated values of the battery health state indicators obtained from the basic battery data test.

5. Conclusions

In the future, there will be an increasing number of electric vehicles, and at the same time the safety of electric vehicles will become an increasingly important issue. Compared to traditional consumer lithium batteries, power batteries used in new energy vehicles are significantly more complex in structure, the number of cells they carry, and the overall requirements for safety performance, which makes the battery management system (BMS) even more important. And it's one of the core competencies of new energy vehicles. The BMS is a core component for ensuring the safety and improving the life of the power battery, and is responsible for the accurate estimation of several control strategies while realizing the energy management of the entire vehicle. A high-performance and highly reliable BMS is therefore the key to ensuring safe, reliable and long-life operation of the battery system, and scientific measurement of the BMS is of great significance.

If the management system is not managed properly, it will directly reduce the efficiency and cycle life of the battery, and even affect the safety of the battery system. Therefore a scientific measurement and accurate evaluation of the BMS will ensure the safety of the battery system in complex environments, the accuracy of the BMS throughout its life cycle, and its efficiency during service. Currently the main functions of the BMS are: battery status monitoring, battery power estimation, battery energy balance management, battery system thermal management, battery fault diagnosis and early warning, battery health status estimation, etc.

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