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The research of the contribution of big data in enhancing power battery safety

Yufan Wang

Faculty of Business and Management, Beijing Normal University-Hong Kong Baptist University United International College, Guangzhou, 511400, China

p930024242@mail.uic.edu.cn

Abstract: The use of oil and gas is the main cause behind the increased impact of severe weather over the past two decades. In the use of oil and natural gas, fuel powered vehicles account for a large part. Therefore, at present, countries are vigorously promoting the settlement of new energy vehicles. With the support of national policies, new energy manufacturers are springing up. There are also many large factories with good qualifications, but there are also many small factories mixed with other factories. With the increase of new energy vehicles, more and more traffic accidents caused by new energy vehicles, especially the self-destruction of new energy vehicles caused by power batteries. Therefore, this paper attempts to make suggestions and analysis on the production, charging, driving and handling of power batteries after accidents through big data monitoring.

Keywords: New energy car; Power batteries; Big data; Car security.

1. Introduction

Under the domestic policy of an active electric vehicle, the Chinese government is promoting many development policies, and manufacturers of large and small manufacturers are involved in the manufacture of electric vehicles. Due to the participation of large and small manufacturers, the production quality of electric vehicles is uneven, 30% to 40% of the cost of production of electric vehicles are very serious technical barriers and are most concerned with accidents if accidents occur. In this paper, we attempt to reduce the safety problem of power batteries through multiple data monitoring and feedback. This paper will first analyze the industrial chain and reduce the defect rate and improve the purity of raw materials through big data monitoring of raw materials of power batteries. The next step is to analyze real-time data while the car is running to prevent battery accidents caused by important problems such as water floods. In addition, when the vehicle is charged, the charging state of the power battery can be monitored to prevent overcharging.

2. Analysis of power battery during production

There are four main components of positive electrode materials, anode materials, electrolytes and diaphragms for production of power cells. Among them, the reaction heat of the positive electrode material is reduced by large particles and rational wrapping quantity, and the electrolyte is adjusted, and the film additive is added to protect the negative electrode material.

2.1. The anode material

When the cathode material of the lithium ion battery is unstable in the high charge state, it gradually decomposes and discharges oxygen. In the process of releasing the reactive heat after combustion by the organic electrolyte, the active material of the cathode material reacts directly with the electrolyte and is also an important reason for the fire and explosion of the lithium-ion battery.

Main treatment of cathode material processing is core shell structure, surface coating and doping to improve the safety of the battery. The researchers used differential scanning calorimetry to test the particle size and coating of the cathode material and analyze its thermal stability. Through big data simulation, the use of large particle materials is found to reduce the reaction heat between cathode material and electrolyte. Using an appropriate coating amount can reduce the heat of the cathode material reaction, but also can effectively increase the reaction starting temperature. For doped materials, relevant researchers use accelerated calorimeters to study the thermal behavior of anode materials at 50~250℃. After doping, the starting temperature gradually increased from 140℃ to 150℃. This factor is a determinant to determine the safety of the battery. The exothermic reaction heat is lower than that of the undoped material. The adiabatic temperature evaluation of undoped materials was 61℃, while the adiabatic temperature appreciation of the doped material is only 41℃, which has a positive influence on the stability of the cathode material.

2.2. Anode materials

The main safety effects of anode materials are the generation of lithium dendrites and thermal decomposition during charging and discharging. In commercial graphite, for example, in actual use, commercial graphite anode during the first charge and discharge process, the graphite anode materials and electrolyte reaction during work and insulation protective film, and under the temperature of 80 ℃ ~ 120 ℃, the protective film will appear decomposition phenomenon, then the internal lithium will contact with the electrolyte, the exothermic reaction. In view of the safety of the anode material, the researchers have carried out corresponding in-depth research, solved the problem of lithium dendrite in the anode material, adjusted and optimized the electrolyte, and added film forming additives to improve the stability of the protective film.

2.3. Battery inconsistency analysis and fault diagnosis

Battery inconsistency refers to the differences in voltage, internal resistance, capacity and other parameters of batteries of the same specification and model [1]. Battery inconsistency is one of the main factors affecting the performance of battery system, and it is also an important reason to induce battery failure. Many early studies on battery inconsistency have shown the relationship between inconsistency and the service life of power battery packs [2-3]. WANG et al. [4] elaborated a voltage fault diagnosis method based on fuzzy improved Shannon entropy, and proposed a safety management strategy based on Z-score method. According to the operation data of electric taxi, the abnormal voltage battery in electric taxi has been found successfully. ZHAO et al. [5] used machine learning algorithm and 3σ multiple screening strategy to detect the monomer with abnormal voltage change in battery pack based on the operation big data of new energy vehicles, and successfully verified it in real vehicles.

3. Power battery safety

In general, battery related causes of new energy vehicle accidents can be summarized as a mechanical induction, electrical induction, car immersion factor and power battery spontaneous combustion coefficient. The common accident investigation and analysis method of the new energy vehicle can be classified into "traceability analysis+ accident recurrence method" and "induction sorting+ process inference method". The former identifies the possible accident source by collecting the field data, and simulates the defect in the test room to reproduce the accident processing. From the point of view of an accident with no apparent clues, the latter classifies the reasons that could lead to battery failure and inferences from the propagation, evolution, accident initiation rules, and reasonable predictions.

3.1. BMS

The BMS system is primarily used to monitor the running conditions of electric vehicles and effectively manage energy storage batteries such as battery temperature monitoring, monitoring of charging processes, and power estimation.

The main monitoring and management tasks have the following aspects:

1)Avoid battery packaging and battery damage due to various factors;

2)Work properly under proper temperature and voltage of the battery;

3)Provides a protective barrier for operation of an electric vehicle based on ensuring stable operation and safety of an electrical pool;

We use BMS system to perform cloud processing over a vehicle or machine port can bus and collect and process BMS system feedback via big data at the same time.

It is possible to record the seriousness of the damage in the timely after the large data machine learning, and to record the rescue speed after the accident by the machine learning.

3.2. Mechanical inducements

Mechanical causes such as bumps, squeeze and pinch can damage the shape or body of the battery. The most frequent power battery accident is a crash. The deformation of the power battery system caused by the collision is three typical situations, the deformation of the X direction battery pack caused by the frontal collision or the trailing edge collision, the deformation of the battery pack in the Y direction due to side impact, and includes deformation or punching of the battery pack in the z-direction due to vehicle collisions. Typical failure modes of the battery pack under this external force result in thermal runaway:

(1) The shell of the battery system is deformed, resulting in direct contact between the high voltage live portion and the electrically conductive shell in the battery system, resulting in direct wrapping or electrical gap/ creep distance breakdown;

(2) The cell is squeezed or disconnected to cause the shell damage, the leakage of electrolyte, the internal diaphragm damage and the external deformation of the external force, thereby causing an internal short circuit;

(3) The cooling pipe of the battery pack thermal management system is broken and coolant leakage occurs;

A typical accident was a battery pack of pure electric passenger cars and fired after hitting a hard object on the road in 2013; in 2019, the brand pure electric passenger car pushed the triangle iron while driving; in 2021, a pure electric passenger car caught fire after its chassis hit a curb on a bend.

From the above, we can know that accidents caused by power batteries are mostly caused by short circuit, and after short circuit, due to violent chemical reactions, a lot of heat is released and the car spontaneously burns. From the perspective of big data, we can increase the measurement of current voltage and temperature data in the BMS system. For example, HONG et al. [6] proposed a battery thermal runaway diagnosis method based on the operation big data of new energy vehicles and the entropy judgment theory. This method realizes the prediction and diagnosis of thermal runaway, and can accurately predict the occurrence time of thermal runaway of battery packs and the location of thermal runaway cells. HONG et al. also proposed a battery thermal safety management strategy based on Z-score method.

3.3. Electrical inducements

Statistics are made on the use state of the vehicle at the time of the accident, and the analysis results are shown in the figure 1. It can be seen that 30.7 percent of the vehicles were running, 36.2 percent were charging, and 33.1 percent were resting at the time of the accident. This indicates that the safety of power battery in charging state needs special attention.

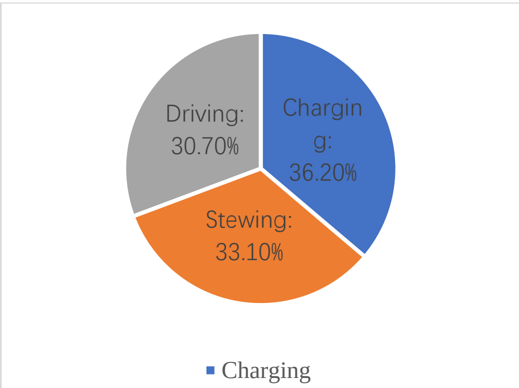

Fig.1 Analysis of running state of accident vehicle [6]

Accidents caused by charging may include the following reasons:

(1) Due to poor cell consistency, some monomers are overcharged;

The battery charging control strategy does not match the safe usage boundary of the battery, for example, lithium is generated in the battery during low-temperature charging;

Functional safety failure, resulting in the charging system and battery system cannot work together, resulting in battery overcharging, etc.

Among them, functional safety failures led to overcharging of batteries, exemplified by a fire on an electric bus in 2013. Through the collection of operation monitoring data, it was found that the vehicle had been charged several times before the fire, but the battery management system did not cut it off in time, the vehicle controller did not alarm, and the monitoring platform did not give feedback and hints, which eventually led to the fire of the rechargeable bus. By analyzing the battery operation data of the monitoring platform, some of the above accidents can be traced and arranged. However, some vehicles caught fire during charging or during rest after charging, but the cause of the accident could not be found in the operation data. After using big data methods, RICHARDSON et al. [7] used Bayesian parametric estimation method based on Gaussian process regression to estimate battery capacity decline.

In addition to conventional current, voltage and temperature variations, the researchers readjust the measurements to produce a new data label such as temperature and current profile to make the prediction model more efficient and accurate. And data is derived from a realistic random charging process. And it can simulate battery health better during charge.

3.4. Ingress Protection and Power battery spontaneous combustion

3.4.1. Ingress Protection

There are two main causes of accidents caused by poor design or failure of Ingress Protection:

(1) When the vehicle is immersed in water, the liquid enters the battery pack, causing the external short circuit of the battery. The insulation alarm and even smoke and fire of the battery system are still problems that need to be paid attention to at present;

(2) When running for a long time under a high-temperature and humid environment, a water mist is introduced through the connection of an anti-fog valve or a structural component, causing corrosion of an internal part of the battery pack, an electric short circuit and a decrease in the insulation resistance;

3.4.2. Power battery spontaneous combustion

Spontaneous combustion of power batteries without apparent external inducers account for most accidents in normal drives or parked vehicles. Such accidents usually occur suddenly, and the actual causes often disappear in battery combustion, so it is difficult to find the cause accurately and reproduce the process of such accidents.

4. Conclusion

This paper describes the cause and analysis of the power battery accident from various viewpoints, and proposes the relief proposal for the accident by combining large data and machine learning. In addition, several large data algorithms are presented for the prediction and analysis of the power of a new energy vehicle with reference to several materials. The purpose of this study is to improve the safety rate of new energy vehicle power batteries after using large data and machine learning. From production, guarantees of positive and negative electrode materials, emergencies encountered in collisions and charging, up to the generation of combustion and water intake at spontaneous onset. Continuous machine learning and large data can reduce the occurrence of these hazardous conditions and enhance the response to them after they happen.

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