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Thermal Performance Analysis of Lithium Battery Thermal Management System for New Energy Vehicles

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Abstract: The battery of new energy vehicle is the core part of the whole vehicle.By analyzing the thermal management system of lithium battery,the service life, safety and performance of lithium battery can be effectively improved. The thermal management of lithium battery is related to its temperature, which also determines the battery capacity, heat consumption rate, battery state working voltage and other important parameters of lithium battery. Therefore, the thermal management of battery is particularly important for the performance of sexual energy vehicles.This paper will introduce the composition of the battery system,analyze the current research situation of the thermal management system of lithium battery packs in new energy vehicles for civil use, and look forward to the future development direction of the thermal management system of lithium battery packs in new energy vehicles.

Keywords: Lithium Battery; Battery Thermal Management System; New Energy Vehicles

Introduction

In 2020, the domestic market share of new energy will be about 13%,and will break 16% in 2021. Its market share will reach 25.6% in 2022.According to the innovation diffusion theory, when the market share reaches 16%, the new energy vehicle products will be mature.From 2023,new energy vehicles will no longer be a niche choice.As the carrier of China's dual carbon goals, new energy vehicles play an important role,and the thermal management system of electric vehicles is the core technology that affects the endurance. Lithium battery is the type of power battery used by new energy vehicles at present. The performance, service life, cost, safety and other factors of the battery largely determine the development of new energy vehicles.[1]

1. Composition of lithium battery and definition of battery management system

1.1 Composition of lithium battery

The composition of lithium battery mainly includes five parts,namely,positive material,negative material,diaphragm,electrolyte and shell.

The positive active material is generally lithium manganate or lithium cobalate or nickel cobalt lithium manganate. Use thickness10~20uM of electrolytic aluminum film lithium.Battery cathode material is a part of lithium ion battery materials, which directly affects the performance of lithium ion batteries, accounting for a large proportion.The mass ratio of positive and negative electrode materials is 3:1 ~4:1.The negative active material is graphite with a thickness of 7-15μm.The cathode material of m electrolytic copper foil is the battery. During the charging process, the carrier of lithium ion and electron plays the role of energy storage and release, which mainly affects the first efficiency and cycle performance of lithium battery.Diaphragm is a specially formed polymer film. The film is microporous structure, which allows lithium ions to pass freely. The diaphragm is one of the key inner layers. The performance of the film determines the interface structure and internal resistance of the battery, which directly affects the capacity, cycle and safety performance of the battery. The high-performance diaphragm can improve the comprehensive performance of the battery, and plays an important role.Organic electrolyte is dissolved with carbonate solvent of lithium hexafluorophosphate,and gel electrolyte is used for polymer.The electrolyte of lithium battery is the carrier of ion transport in the battery, and it is the guarantee for lithium ion battery to obtain high voltage, high specific energy and other advantages. The types of shells mainly include steel shells,aluminum shells,nickel plated iron shells,aluminum plastic films, etc.The main function of the shell is to protect the internal materials of the lithium ion battery from damage.

1.2 Definition of battery management system

The thermal management system is simply to control the temperature in the car by managing the flow of heat.

Why do batteries need thermal management?For example, in winter in the north, the temperature can reach minus 20 C or even lower. At this temperature, the lithium battery will self discharge, leading to a reduction in discharge capacity. The worst case is that the battery cannot discharge electricity, which will lead to the failure of electric vehicles to start.In summer, the temperature in cities in the south is too high.In addition, the battery will generate heat during charging and discharging, and the battery pack is in a confined space, so the heat is difficult to dissipate. In this way, the battery temperature will further increase, which will affect the battery performance and surrounding parts. Therefore, it is particularly important to control the temperature of batteries and motors, and battery thermal management has emerged as the times require. Thermal management plays the role of heating and cooling in the battery system. It mainly manages the heating film, heating harness, liquid cooling pipes, liquid cooling materials and heat conducting materials.

1.3 Development history of thermal management

The early thermal management system is relatively simple. Basically,it only needs to adjust the cold and heat in the cabin, while the battery and motor only exchange heat with the surrounding air, that is, the early thermal management system for air-cooled cooling. This process is relatively simple. Basically, it only needs to adjust the cold and heat in the cabin, while the battery and motor only exchange heat with the surrounding air, that is, air-cooled cooling.Both the battery and the motor will generate heat when they work, and if the heat cannot be discharged, the temperature will be too high, which will directly affect the safety of the tram. However, the advantage of electric vehicles is that there will be a large amount of air into the battery and motor after driving. The heat generated by the battery and motor is discharged through air cooling to reduce the temperature. However, the design of the air-cooled heat dissipation system does not consider insulation. In winter, the air-cooled battery will not work because it cannot reach the operating temperature.

With the increase of motor and charging power, air cooling has no way to meet the cooling demand, so the thermal management system has evolved into the liquid cooling era.The most obvious benefit of liquid cooling heat dissipation is naturally that the heat dissipation efficiency will be improved. In order to protect the heat dissipation efficiency, the battery system has added a thermal insulation design, and the battery will perform better in winter. More importantly, the liquid cooling system can directly control the direction of heat, and can actively conduct heat management.For example, in winter, the heat generated by the motor can be directly transferred to the battery for heating or the air conditioning system can be used to cool the battery and motor.

However, one of the key nodes at this stage is the cabin heating.In the era of fuel vehicles, the residual temperature of the engine can be used to heat the cabin, but electric vehicles can only use PTC (Positive Temperature Coefficient) as the heat source. The working principle of PTC for heating the cabin is similar to that of a hair dryer, which uses resistance wire to heat and directly supply its heat to the cabin. In this case, all electric energy is converted into heat energy, but in winter it consumes huge energy.In order to solve this problem, the thermal management system has entered the era of heat pump. The heat pump is not complicated in principle. The air conditioner absorbs the heat inside the vehicle, and then transfers the heat outside the vehicle through the compressor.The heat pump directly reverses this process, that is,transfers the heat of the air outside the car directly to the car.At room temperature, the heat energy generated by the heat pump is about three times that generated by PTC mode when the same electric energy is consumed.The energy consumption of the heat pump is directly related to the temperature. The lower the temperature, the higher the energy consumption of the heat pump. As far as the current heat pump technology is concerned, the working efficiency of the heat pump is very low when the temperature is below - 10 degrees. The power consumption and PTC are basically the same level. With the heat pump, the heat conduction path between the cabin battery and the electrode is fully opened, and the heat management system can achieve more functions.

For example, in winter, cabin heating can not only rely on the heat pump to absorb heat from the outside air. The heat in the battery and motor can also be used to heat the cabin. If the cabin does not need so much heat,the heat of the motor can be directly supplied to the battery, so that the battery has better performance. If the car stops, the heat in the car will not be wasted, and the heat will be transferred to the battery. Because the battery has heat preservation, it can be stored for a longer time.The next time the vehicle is started, the heat will be directly transferred from the battery to the vehicle.The increase of thermal management function means that the heat transmission path will be very complex, and the vehicle performance will be more excellent.

2. Design of lithium battery thermal management system

2.1 Build battery pack

When the new energy vehicle starts, the power battery thermal management system starts to play a role.The basic principle of the thermal management system for lithium battery of new energy vehicles mainly includes the heat transfer mechanism of heat conduction, heat convection, heat radiation, and the structure and function of the thermal management system.Heat conduction refers to the process of heat transfer from high temperature zone to low temperature zone, which is determined by heat conduction coefficient;Thermal convection refers to the process of heat transfer from high temperature zone to low temperature zone, which is determined by thermal convection coefficient;Thermal radiation refers to the process of heat transfer from high temperature zone to low temperature zone, which is determined by thermal radiation coefficient.The structure of thermal management system mainly includes heat source, heat transfer device, heat controller and heat exhauster.Its function is to control the transfer and discharge of heat to maintain the heat balance of the system.

In order to promote the use effect of lithium battery thermal energy vehicles.To achieve continuous optimization,first of all, the battery cooling structure model should be confirmed,and based on the actual situation, a reasonable optimization scheme should be designed: Scheme 1, place the microchannel cold plate on the side wall of the battery;In the second scheme, microchannel cold plates are placed at the bottom and side walls of the battery.

2.2 Heat system based on heat pump technology

The heat management of heat pump system has the following processes:first, the heat in the air is absorbed into the heat pump system from the environment.Then, the air is compressed and heated. In this process, the air is lifted, that is, the unit air is heated.This heat is used to heat the cold air in the car and make it warm up.After the heat exchange, the air is decompressed,and the heat is converted into low-temperature heat and discharged outside the vehicle. The heat pump system needs to take into account both heating and cooling conditions.The in car evaporator in the cooling mode is used as the condenser in the heating mode, and the external condenser in the corresponding cooling mode is used as the evaporator in the heating mode.

The heat pump air conditioner can realize the conversion of refrigeration and heating when using four-way solenoid valve. On the basis of not increasing too much cost, it can realize the improvement of heating efficiency (COP). This method is the best solution under the environment of minus 10°C to 5°C.However, if the ambient temperature is too low,the COP will also become low due to the low ambient temperature. At the same time, the evaporator will be frosted at low temperature, which will lead to the decline of the heat exchange surface and further affect the heating capacity. At this time, supplementary heating can be carried out by means of PTC heating, motor stall and electric pool pulse heating.

Heat pump air conditioning is an option for new energy vehicles,especially pure electric vehicles, but it is not the only option. It can solve the problem of low-temperature heating through predictive heat management technology, battery insulation technology and battery pulse heating technology.

3. Outlook

As the basic power source of new energy vehicles, the quality of lithium batteries is closely related to the overall performance of vehicles. Therefore, it is of great significance to explore the optimization of the thermal management system of power batteries.The power battery thermal management system of new energy vehicles studied in this paper is based on the relatively mature air conditioning system technology in the current related fields. After further improvement of this technology, a thermal management system with high reliability, high maturity and stable performance is generated, which can be effectively applied in a variety of power battery thermal management systems of new energy vehicles.

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