Research on Performance Optimal Control of New Energy Vehicle Cooling System

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Abstract: The application and popularization of new energy vehicles have become the strategic trend of the development of China's automobile industry. The cooling system of new energy vehicles is used to maintain the temperature of the vehicle system in a reasonable range to prevent the high temperature from affecting the life of the vehicle or causing faults and accidents. This paper introduces the present situation of the cooling system of new energy vehicles, studies the calculation model of battery cooling, and optimizes and simulates the liquid cooling structure of power lithium battery pack, which verifies the calculation model well and accumulates a lot of practical data.

1. Introduction
In recent years, with the advantages of electric vehicles in energy utilization and environmental protection, more and more people are devoted to the development and research of electric vehicles. Electric vehicles are considered as the future development trend of automobiles. In the pure electric vehicle, the motor replaces the traditional internal combustion engine to provide electric energy for the motor. The motor can provide electrical energy to the whole vehicle by converting electrical energy into mechanical energy to drive the vehicle. This process will produce loss, which dissipates in the form of heat. If the heat cannot be discharged out of the body in time, it will seriously affect the performance and service life of vehicle equipment. Cooling system is one of the core technologies of vehicles, and its technical level and working condition directly affect the performance indicators of vehicles. In addition, the cooling system control of electric vehicle is affected by many factors such as driving conditions and driving environment. It is a relatively complex control object. The cooling system indirectly consumes the energy of the power battery of the vehicle. The control method of the cooling system also affects the energy utilization rate of the pure electric vehicle. Therefore, it is of great practical significance to study the performance optimization control of new energy automobile cooling system.

2. Development status of cooling system for new energy vehicles

2.1 Thermal management of power lithium batteries
Lithium batteries generate a lot of heat during charging and discharging. In such a narrow and enclosed space, if there is no efficient thermal management system to take away the heat in the enclosed space in time, the efficiency, capacity and stability of lithium batteries will be affected. Battery thermal management system is used to prevent thermal runaway of power batteries and ensure that lithium batteries work in a reasonable temperature range. The ideal temperature range for lithium battery operation is 15 C ~ 35 C. If the temperature of the battery is lower than this, the ion transport...
in the battery will be bad and the performance of the battery will be reduced. If the temperature is higher than this, the dissipation rate of recyclable lithium and active materials will be increased. At present, the mainstream battery thermal management system is mainly divided into three categories, namely air cooling, phase change material cooling and liquid cooling, as shown in Figure 1 below.

Figure 1. Battery cooling methods

2.2 Thermal management of new energy vehicle driving motor
Driving motor is also the core component of pure electric vehicle, and as the main component of electric energy consumption of pure electric vehicle, the driving motor generates a lot of heat, so it needs special cooling system to cool the motor. The cooling methods of motor are mainly divided into air-cooling, oil-cooling and water-cooling. Compared with air-cooling, liquid-cooling has better cooling effect, so liquid-cooling has been widely used in motor cooling. In recent years, the cooling research of driving motor has been very mature, and the most widely used is the liquid cooling structure encapsulating snake-shaped cooling channel, micro-channel, cooling channel with spoiler structure on the motor shell, as shown in Figure 2.

Figure 2. Liquid cooling jacket structure

3. Calculating model of lithium ion battery cooling
The temperature rise of lithium-ion batteries in new energy vehicles has a direct impact on their service life and safety. In order to design an efficient thermal management scheme for power batteries, it is crucial to master the thermal principle and characteristics of lithium-ion batteries. The numerical simulation method has the advantages of fast calculation speed and short time-consuming. Therefore, it is of great value to analyze the working principle of lithium ion batteries and to study the simulation model of single batteries and battery modules.

3.1 Structure and basic working principle of power lithium ion battery

3.2 Thermal simulation model of lithium batteries
The lithium iron phosphate battery is composed of battery module, and the cooling structure based on micro-channel cooling plate is designed. The cooling plate is placed at the bottom of the battery pack, which can cool the power lithium battery pack without occupying space. The cell module and its cooling structure are meshed by changing the z-direction mesh size of the cell group and the coolant fluid calculation domain, respectively. As shown in Figure 3, the validation data are selected as the average surface temperature of a single cell.
3. Structure optimization and simulation analysis of liquid cooling
The main factors affecting the heat dissipation performance of the cooling structure are determined by analysis, and the optimization scheme of the cooling structure is designed, as shown in Figure 4.

In this scheme, the micro-channel cooling plate is placed on the side wall of the battery pack to wrap the battery pack in the middle. This optimization scheme will greatly increase the contact area between the micro-channel cooling plate and the battery core body. Each cooling side plate has a uniform distribution of micro-channels. The thermal management performance and temperature distribution of power lithium battery module were studied by CFD simulation analysis.

Figure 5 shows the data curve of the maximum temperature $T_{\text{max}}$ of the battery with time. During the initial discharge period of 200 seconds, the maximum temperature of the battery core rises rapidly to 28.9 °C, and then with the continuous discharge and cooling process, the maximum temperature $T_{\text{max}}$ rises slowly and basically stabilizes at about 31 °C. At the end of the discharge, the temperature of the battery core rises rapidly. At the end of the discharge, the maximum temperature $T_{\text{max}}$ of the battery pack does not exceed 34.7 °C, which is just in line with the optimum operating temperature of the power lithium battery. The above results show that the cooling structure can control the temperature rise of batteries well even under the condition of continuous high rate discharge.
5. Conclusions
According to the working principle of lithium batteries for new energy vehicles, the heat generation mechanism of lithium batteries is analyzed, the geometric simulation model and calculation model of thermal effect of power lithium batteries are established, the optimization model is simulated and calculated, the simulation analysis of the heat generation characteristics of the model and the image processing of the temperature field distribution of batteries are carried out. The results show that the optimized structure has good thermal management performance and provides a reference for future cooling performance simulation research.

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