

# Research on heat dissipation technology of power batteries for new energy vehicles

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### Abstract:

The thermal management system of power batteries plays a key role in improving the performance and safety of electric vehicles and extending the battery life. This paper summarizes the heat dissipation technology of batteries that produce energy for contemporary energy vehicles, analyzes the importance of heat dissipation of batteries that produce energy for contemporary energy vehicles, discusses the application of heat dissipation technology for batteries that produce energy for contemporary energy vehicles, and looks forward to the development direction of heat dissipation technology for batteries that produce energy for contemporary energy vehicles, so as to boost the development of heat dissipation technology for power batteries for new energy vehicles.

**Keywords:** New energy vehicles, Power batteries, Heat dissipation technology, Thermal management system

## 1. Introduction

The rapid growth of the emerging energy vehicle sector has necessitated increased standards for battery heat dissipation technology. The reliability, stability and service life of battery performance are closely related to its internal temperature. Consequently, the pivotal role of heat dissipation technology lies in maintaining the battery's functionality within a secure temperature spectrum, thereby preventing performance decline due to significant temperature disparities. Common heat dissipation methods for new energy vehicle power batteries include air cooling, liquid cooling, heat pipe cooling, phase change material cooling and hybrid cooling, etc. Each method has its unique advantages and application scenarios. With the emergence of new materials and new processes, the development of power battery heat dissipation technology in the future will tend to higher thermal

conduction efficiency and smarter temperature control to meet the use requirements of new energy vehicles in different environments. This article discusses the heat dissipation technology of power batteries, aiming to furnish a scientific foundation and technical assistance for the ongoing advancement of novel energy vehicles.

## 2. A summary of the latest technology for cooling power batteries in vehicles.

The core of power battery heat dissipation technology is to maintain a stable temperature during battery operation to prevent excessive temperature from causing battery performance degradation or safety accidents. Generally, the heat dissipation process involves a variety of physical phenomena, such as

conduction, convection, and radiation. Heat dissipation primarily occurs through conduction, involving the direct movement of heat from a high-temperature zone to a low-temperature zone within a solid.; convection involves fluids, such as air or liquid, through which heat is carried away; and radiation is the emission of heat from the surface in the form of electromagnetic waves. Technologies for dissipating heat fall into two distinct types: active and passive heat loss. The process of active heat dissipation depends on outside forces to facilitate the transfer of heat., such as using devices such as fans or pumps to increase air or liquid flow to accelerate heat dissipation. Passive heat dissipation mainly relies on the natural flow of heat, such as using heat sinks to increase heat release by expanding the surface area. With the advancement of innovative energy vehicle tech, the advancement of power battery technology for heat dissipation persists. For example, the use of new materials such as graphene enhances thermal conductivity, and the application of microchannel cooling technology makes liquid cooling systems more efficient. Furthermore, extensive research has been conducted on heat pipes and phase change substances, owing to their superior ability to transfer heat.

### **3.Importance of heat dissipation for power batteries in new energy vehicles**

Rapid development characterizes the emerging energy vehicle sector, with the demands for power battery efficiency steadily rising. As an energy storage device, lithium-ion batteries are composed of positive electrodes, negative electrodes, electrolytes, diaphragms and shells. Power batteries primarily generate heat through methods like chemical reaction heat, Joule heat, polarization heat, and side reaction heat. Heat from chemical reactions within a battery, known as chemical reaction heat, serves as the primary heating source for power batteries. Upon charging the battery, the chemical interaction between the positive and negative electrodes produces significant chemical heat; Joule heat refers to the heat produced by the current flowing through the battery during operation. The production of this heat correlates with the battery's operational condition. For example, when the battery load is large, the current passes through the battery for a longer time, and the Joule heat generated is also greater; polarization heat is the polarization phenomenon of the chemical substances inside the battery amidst the influence of the electric field. The amount of this heat is related to factors such as the operating voltage, current and the battery's working environment temperature; side reaction heat is that in addition to the above three heat generation methods, some

side reactions may occur during the use of the battery, and these side reactions will also release heat. In general, the heat generation mechanism of power batteries is complex and needs to be considered comprehensively according to the specific use environment and conditions.

During the process of supplying energy, batteries produce thermal energy. Should the heat remain undissipated over time, it could impact operational efficiency, longevity, and potentially lead to safety issues. Consequently, efficient heat release is crucial for enhancing the efficiency and safety of batteries. Within the realm of new energy vehicles, the consistent performance and enduring dependability of the battery pack directly correlate with the overall vehicle's performance metrics, especially under high load and continuous operation. The heat dissipation problem is more prominent. To meet this challenge, a variety of heat dissipation technologies have been developed and applied. These technologies need to take into account the overall structural design, managing the vehicle's energy usage and expenses, while maintaining the battery pack's efficiency in thermal regulation. The activity of the battery pack's electrochemical reaction is significantly impacted by temperature. Choosing the right temperature for operation can enhance battery efficiency, prolong its lifespan, and cut down on maintenance expenses. The creation of a power battery heat dissipation system that is efficient, dependable, and cost-effective stands as a principal subject in the ongoing research on power batteries for new energy vehicles. As materials science and thermal management technology evolve, along with sophisticated simulation and computing technologies, scientists can refine the heat dissipation system's design, enhancing thermal management efficiency, crucial for the safety, cost-effectiveness, and comfort of new energy vehicles.

### **4.Application of heat dissipation technology for power batteries in new energy vehicles**

#### **4.1 Air Cooling**

Compared with other cooling methods, air cooling is simpler and easier to implement for battery cooling. The principle of air cooling is to use air to conduct convection heat exchange with the battery pack with higher temperature to cool the battery. Cooling air is categorized into two types: natural convection cooling and forced convection cooling. The purpose of natural convection cooling is to reduce the battery's temperature solely through the flow of natural air. Due to its extremely low cooling efficiency, most studies use forced convection cooling with forced ventilation

devices.

Thermal management systems for air-cooled batteries are categorized into two types based on their ventilation technique: series and parallel ventilation. Yang and colleagues<sup>[1]</sup> developed a thermal model for a battery pack with 32 individual batteries, utilized a series ventilation cooling technique, and examined how longitudinal and lateral spacing affects the battery pack's cooling efficiency. Chen and colleagues aim to enhance the cooling efficiency of the parallel air-cooled BTMS.<sup>[2]</sup> suggested a method for optimizing the distribution of battery space to ensure a consistent airflow rate across the cooling channels. Pesaran and colleagues<sup>[3]</sup> employed the finite element technique to evaluate the cooling efficacy of both series and parallel ventilation systems. Findings indicate a 4 °C and 10 °C decrease in the peak temperature and temperature variance of the parallel ventilation model compared to the series model, suggesting its superiority over the series ventilation.

The division of the air-cooled battery thermal management system into unidirectional and reciprocating flows is based on the direction of gas flow. While the majority of air-cooled battery thermal management systems operate in a one-way flow, research indicates that the reciprocating flow system offers more consistent temperature control. Mahamud<sup>[4]</sup> implemented a back-and-forth airflow mechanism in the air-cooled battery thermal control system to enhance the battery pack's temperature consistency. In contrast to unidirectional flow, reciprocating flow has the potential to decrease the battery system's temperature variance by approximately 4 °C and lower the battery pack's peak temperature by 1.5 °C. He and colleagues<sup>[5]</sup> implemented a back-and-forth airflow and an active battery thermal control system, enhancing the battery pack's temperature consistency while significantly decreasing the intake flow. Compared with unidirectional airflow cooling and passive control, the battery pack temperature uniformity and coolant savings increased by 76% and 38% respectively.

## 4.2 Liquid Cooling

As an important component of power battery temperature control, the liquid cooling system achieves effective cooling of the battery through the heat transfer performance of the fluid. The system mainly uses cooling liquid with high heat capacity to pass through the battery module, and transfers the heat generated by the battery to the coolant by means of heat conduction and convection, and then discharges the heat to the outside of the vehicle through the circulation system. Different from the traditional air cooling heat dissipation method, the liquid cooling system has

a faster thermal response speed and higher heat exchange efficiency, and is particularly suitable for those occasions with extremely high requirements for battery performance and service life. In the structural design of the battery module, the layout of the liquid cooling channel determines the heat dissipation effect. Generally, designers will give priority to the shape and width of the cooling channel to achieve efficient heat dissipation. In addition, the flow rate and temperature of the coolant are also important factors affecting the heat dissipation performance. Too high or too low flow rate may reduce the heat dissipation efficiency. Therefore, monitoring and regulating the flow condition becomes crucial. At the same time, the sealing performance of the liquid cooling system cannot be ignored. Any slight leakage may lead to a reduction in the amount of coolant, thereby affecting the heat dissipation performance of the entire system. In terms of material selection, the coolant is required to have low viscosity and high chemical stability to reduce energy consumption and extend the service life of the system. The design of the heat dissipation cold plate focuses on the design of the flow channel, and the influence on the heat dissipation of the power battery is often achieved by changing the shape and number of the flow channel. The more complex the flow channel design is, the better the heat dissipation effect is generally, but the processing is often extremely complex and the cost is high. Some flow channels cannot even be processed and manufactured in practice. Therefore, the flow channel design should fully consider the difficulty of manufacturing, and then formulate a plan based on the heat dissipation effect. The advantages of liquid cooling technology are obvious. First, it can effectively reduce the operating temperature of the battery, thereby improving the service life and safety of the battery. Secondly, the liquid cooling device has a simple structure and is easy to maintain and replace. In addition, liquid cooling technology also has high reliability and stability, and can work normally in harsh environments. However, liquid cooling technology also has some disadvantages. For example, its cost is high, and it requires a lot of money to be invested in equipment modification and maintenance; at the same time, problems such as liquid leakage also need to be paid attention to.

## 4.3 Heat pipe cooling

Cooling through heat pipes is a novel technique for dissipating heat in power batteries. This exhibits robust thermal conductivity and holds promising potential for application. Heat pipe cooling technology is a technology that uses the heat pipe principle to dissipate heat. It is mainly used for cooling battery systems. A heat pipe is an

efficient heat transfer element consisting of a slender tube and two metal fins connected at the ends. As the battery's internal heat is conveyed to the heat pipe, the liquid in the heat pipe absorbs heat and evaporates, generating a large amount of steam. The steam will flow along the tube and take away the heat inside the battery. Eventually, the steam will condense into liquid in the radiator, releasing latent heat and dissipating the heat. The heat pipe radiator is one of the core components of the heat pipe cooling technology for power batteries. It is mainly composed of heat pipes, fins, fans, etc. The heat pipe's role is to convey the battery's internal heat to the radiator, whereas the fins play a crucial part in expanding the area for heat loss and enhancing its efficiency. The fan is used to accelerate the air flow, thereby improving the radiator's capacity to dissipate heat. In some high-end battery systems, heat pipe cooling technology has been widely used, such as new energy vehicles, drones and other industries. As technology progresses and expenses decrease, it's anticipated that the use of heat pipe cooling technology will expand across various sectors.

#### 4.4 Phase change material cooling

Phase change materials have gradually become an important part of the cooling system of new energy vehicles due to their unique application advantages in power battery heat dissipation. The effectiveness of phase change material heat dissipation technology hinges on the ability of materials to absorb and emit substantial heat energy throughout the phase change, ensuring efficient control of the battery's heat production. In new energy vehicles, the application of phase change materials must take into account complex temperature and load conditions and the matching with the vehicle usage mode. At present, the research on phase change materials not only involves its heat dissipation efficiency, but also includes the thermal stability, thermal conductivity and reliability of the materials in repeated thermal cycles. As materials science progresses, pertinent experts have created an array of phase change substances, encompassing organic, inorganic, and microencapsulated materials. In the field of new energy vehicles, materials that alter phases are designed into modules of different structures and sizes so that they can be integrated into battery packs or battery management systems. For example, some phase change materials are made into heat sinks and placed next to or between battery cells. When the battery generates heat during operation, it can quickly absorb heat and delay the rise of battery

temperature. In addition to studying the performance of single phase change materials, researchers have also begun to explore the possibility of combining phase change materials with other heat dissipation technologies, such as composite applications utilizing technologies like air and liquid cooling, to achieve better heat dissipation effects and higher energy efficiency ratios.

## 5. Conclusion

The research and practice of modern technology for cooling power batteries in vehicles will gradually deepen with the continuous advancement of technology. Ranging from air-cooling to liquid-cooling, encompassing phase-change material and heat pipe cooling technologies, various cooling technologies have shown unique application value and potential. In order to better cope with future challenges, the development and application of high thermal conductivity materials, microchannel cooling technology, intelligent control strategy of cooling system and further research on multi-physics field coupling cooling technology are the key. The integration and optimization of these technologies can not only promote the overall improvement of new energy vehicle performance, but also significantly influence environmental conservation and the sustainable growth of the emerging energy vehicle sector.

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