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**Research Article**

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# Fuel cell vehicle thermal management ideas

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**Abstract** With the development of society and economy, the problem of energy crisis and environmental pollution has become increasingly prominent, fossil fuel consumption, greenhouse gas emissions, resulting in global warming, glacier melting and other status quo, a serious threat to the human survival of the environment. New energy commercial vehicles with hydrogen energy as the main power are developing rapidly and will gradually replace traditional fuel commercial vehicles, but the thermal management system of traditional fuel vehicles is not suitable for new energy vehicles. The optimization and improvement of vehicle thermal management system design control strategy has become a key research issue in the new energy vehicle industry.

**Keywords** hydrogen energy, thermal management system, control strategy

## 1.Development background of new energy vehicles

During the "two sessions" in 2021, China will "peak carbon" and "carbon neutrality" has become an important national strategy, and is committed to achieving the peak of carbon dioxide emissions before 2030, and strive to reach carbon emissions before 2060 [1]. Among them, hydrogen energy is a resource that can replace petroleum energy in the future. Countries all over the world have formulated technical route planning for the development of hydrogen energy and have invested active research in the field of fuel cells for the development of hydrogen energy [2][3]. With the support of the national government and the development strategy of automobile enterprises to transform into new energy vehicles, the technology and research of fuel cell vehicles have made breakthrough progress [4]. China's existing industrial hydrogen production capacity is about 25 million tons/year, which can provide low-cost hydrogen sources for the initial stage of the development of hydrogen energy vehicle industry. At this stage, the production of gray hydrogen can be moderately expanded according to the initial development needs of the hydrogen energy automobile industry; Using abundant coal resources combined with carbon dioxide capture and storage (CCS) technology to provide blue hydrogen. However, the future independent hydrogen energy supply must focus on the development of green hydrogen, including valley electricity, renewable energy electrolytic water and nuclear hydrogen production. China is the world's largest renewable energy power generation country, only every year wind power, photovoltaic, hydropower and other renewable energy abandoned electricity is about 100 billion KWH, if these abandoned electricity used for electrolytic water hydrogen production, can increase hydrogen energy of about 2 million tons. By further improving the cost competitiveness through technological progress, it is expected that hydrogen production from renewable energy will become the main way of hydrogen supply in China in the future.

In the 2023 Hydrogen Energy Annual Meeting held by Xianghuanghui Research Institute and Antai College of Economics and Management of Shanghai Jiao Tong University in Shanghai, Academician Ling Wen of the Chinese Academy of Engineering mentioned that China issued the "Medium and long-term Plan for the development of hydrogen energy Industry (2021-2035)" in March 2022, which means that hydrogen energy is officially incorporated into China's energy strategic system. According to the statistics of Xiangorange Institute, from 2020 to 2023, the production and sales trend of fuel cell vehicles in China is shown in Figure 1, and the

production and sales volume of fuel cell vehicles are on the rise. In 2023, the production and sales of new energy vehicles in China will be 9.587 million and 9.495 million, respectively, an increase of 35.8% and 37.9%. Among them, the production and sales of fuel cell vehicles were 5,631 and 5,791, an increase of 55.3% and 71.9%, respectively, which shows that the growth rate of fuel cell vehicles exceeds the total growth rate of new energy vehicles, and fuel cell vehicles have gradually become the mainstream trend of the development of new energy vehicles.

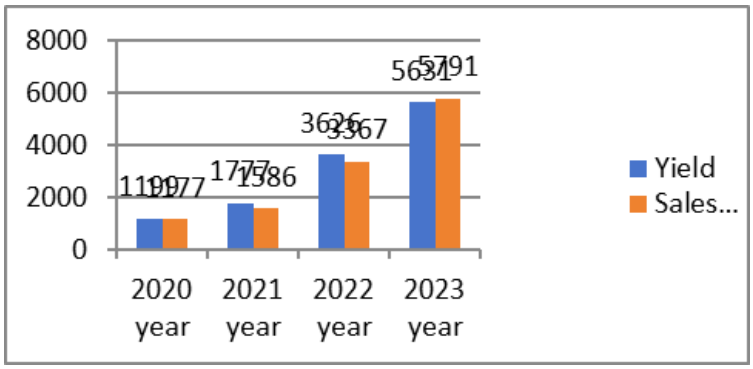


*Figure 1: Sales of fuel cell vehicles*

**2. Impact of thermal management system on new energy vehicles**

At present, in the field of new energy development and application, China has achieved more remarkable results. Among them, the energy conversion efficiency of new energy fuel cell vehicles is much higher than the 30% conversion efficiency of traditional fuel energy, which has won the financial support of the state and local government, and more and more commercial vehicle users have begun to buy fuel cell vehicles with car subsidies to replace traditional fuel vehicles.

Among the types of fuel cells used in fuel cell vehicles, proton exchange membrane fuel cells (PEMFC) are the most widely used fuel cells with advantages such as low cost and fast response speed [5]. Fuel cell vehicles have the advantages of low operating temperature, high reliability, low noise and less environmental pollution. The development, design and production of new energy vehicles are in the initial stage, and the industrialization process is obviously lagging behind. At the same time, there are also many problems in the infrastructure of new energy vehicles in China, such as insufficient infrastructure and capital investment, weak basic research, and insufficient innovation ability [6]. For fuel cell commercial vehicles, temperature has a significant influence on the efficiency of PEMFC engine. In the range of 70° to 95°, the electrochemical reaction inside PEMFC is normal and the output efficiency is the highest. If the temperature range is exceeded, the thermal balance will be unbalanced and the output efficiency will be reduced [7]. In addition, the influence of temperature on the power battery and motor is also relatively large, too high or too low temperature will cause the sharp decline in the service life of the power battery and the hidden danger of the vehicle safety performance [8]. Therefore, in order to further improve the economy and thermal management effect of fuel cell commercial vehicles, the design of a good integrated thermal management system for fuel cells and energy management strategies for fuel cell vehicles combined with thermal management are the focus and difficulty of the current research on vehicle thermal management [9]. For fuel cell commercial vehicles used for long-distance transportation, there are strict requirements for fuel cell endurance, cab temperature adjustment ability, power battery service cycle, and so on. Therefore, the design and control strategy research of integrated thermal management system are of great value and significance.

**3. Development status of thermal management system for new energy vehicles**

Thermal management research includes research on thermal characteristics of key components, design and integrated optimization of thermal management system, analysis and control of vehicle environment, comprehensive utilization of heat energy and other special technologies [10]. However, in existing fuel cell vehicles, cab thermal management, fuel cell thermal management, power battery thermal management and motor thermal management are independently set and managed separately, rather than coordinated and unified

integrated thermal management design, resulting in high energy consumption in overall thermal management of fuel cell vehicles, and some heat energy cannot be recycled, wasting resources [11].

**4. Research progress on control strategy of thermal management system for new energy vehicles**

Research on fuel cell energy management strategies can be divided into rule-based and optimization-based energy management strategies [12]. In the research on rule-based energy management strategy, the energy management strategy designed by Wang Qian to compensate for power battery discharge by fuel cell introduced fuzzy logic control and optimized the total energy utilization rate of the system under vehicle working conditions. Simulation results verified the research on the improvement of vehicle economy by this strategy [13]. Song Yuneedle explored the relationship between energy management strategies and vehicle economy under different rules, and found the internal influence rule and mechanism between the two, providing a new reference for the study of energy management strategies for fuel cell vehicles [14]. The integrated thermal management technology designed by Huang Jiong and the high-efficiency heat pump air conditioner reduce system energy consumption compared with the traditional PTC heating method through the control strategy of key components of thermal management, and effectively increase the low-temperature endurance of electric vehicles in winter [15]. Yang Xiaolong proposed an integrated thermal management system considering all components based on the relative independence of the current automotive thermal management systems, and verified the integrated thermal management system of the vehicle through simulation, which can quickly heat all components of the vehicle. Compared with the PTC heating method, the heat pump air conditioning system can reduce energy consumption and ensure the vehicle's driving ability in winter [16]. In this paper, the heat pump air conditioning system is introduced into the vehicle integrated thermal management system to reduce the energy consumption of the thermal management system and improve the economy of the vehicle. Lu Ran proposed a research on energy cascade management strategy of thermal management system. Based on the one-dimensional simulation model Amesim, thermal analysis is carried out on three heat sources of motor waste heat source, outdoor air heat source and PTC heat source, and the stop valve is controlled by a logic gate to realize flexible switching of different modes and achieve the optimal heating mode [17].

**5. Conclusion**

The components of the vehicle thermal management system, as well as the connection modes and functions of each component are studied, and a one-dimensional vehicle thermal management model is established. At the same time, I am familiar with the working principle of heat pump air conditioning, and analyze and design the topology scheme of vehicle thermal management system based on heat pump air conditioning. Analyze thermodynamic characteristics, design core component parameters and thermal management control strategy. The simulation results of one-dimensional vehicle thermal management model were used to verify the designed thermal management system and control strategy.

1) Topology analysis and design of vehicle thermal management system based on heat pump air conditioning. This paper first analyzes the components of the vehicle thermal management system and the connection forms between different components; Secondly, the composition and principle of the heat pump air conditioning system are understood, and the topological scheme is analyzed and designed according to the structural parameters and ambient temperature parameters of the research object.
2) Parameter matching design of fuel cell commercial vehicle thermal management system. Based on the working principle and heat exchange process of fuel cell, electric motor and power battery, the temperature characteristics of motor and battery are obtained, which provides theoretical basis for the subsequent design and modeling of the integrated thermal management system for the vehicle. According to the composition of the thermal management system of fuel cell vehicles, the functions and temperature control objectives of each subsystem are clarified, the cooling and heating schemes of the integrated thermal management system are designed, the working states of system components and pipeline design schemes under different working modes are determined, and the models are built according to the working principles of key components of the thermal management system. As a basic

model for the subsequent analysis of the rationality and efficiency of the vehicle integrated thermal management system.

3) Design of thermal management control strategy. Vehicle thermal management control strategy based on logic threshold. Firstly, the control strategy of key components in the vehicle integrated thermal management system is introduced. Then, aiming at the thermal management and energy management optimization control problem of fuel cell vehicles, the vehicle thermal management control strategy based on logic threshold is proposed. The minimum equivalent hydrogen consumption of the vehicle is taken as the goal to achieve reasonable power distribution of the power system.

4) Vehicle thermodynamic performance simulation. Based on the vehicle thermal management system model and the control strategy of corresponding components, the influence of different temperatures on the thermal management system is analyzed, and the efficiency and rationality of the proposed scheme are verified.

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