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Study on Activation System of Thermostatic Preheating Engine

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Abstract: Innovatively addressing the challenge of difficult winter starts for vehicles in northern regions, this study has developed a Thermally Controlled Preheating Engine Activation System. This system ingeniously integrates a thermal insulation kettle, an efficient water pump, precision valves, and temperature sensors, all closely linked with the engine's coolant circulation system. In cold environments, the system automatically initiates a preheating mechanism by circulating and heating the coolant, significantly enhancing engine startup efficiency and reducing wear caused by cold starts. The anticipated outcome of this research is to substantially improve the operational reliability of vehicles in cold climates, extend their lifespan, promote energy conservation and emissions reduction, and drive the automotive industry towards greener, more efficient, and intelligent technologies, thus laying a solid foundation for industry upgrades and transformation.

Keywords: Thermostatic preheating engine system; Cooling cycle; Circulating heating; Energy conservation and emission reduction; Industry upgrading

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1. Introduction

In winter in northern China, it is very common that the cold makes it difficult to start a car. At low temperatures, the battery performance is weakened, the lubricating oil becomes thicker, and the fuel is difficult to volatilize, especially for diesel engines [1]. The constant temperature preheating engine activation system studied in this paper aims to optimize energy storage and reuse and strengthen the low-temperature starting ability of automobiles.

Given the urgent global demand for environmental protection, energy conservation and emission reduction has become a key issue. The system innovatively uses engine waste heat for storage, automatically releases heat energy for preheating in a low-temperature environment, can achieve remarkable energy saving and emission reduction effects without an external power supply, actively responds to the call for green travel, and promotes

sustainable development. In addition, the system effectively maintains the optimal working temperature of the engine, making the driving experience more comfortable and secure [2].

2. Research background

The severe cold during winter in northern China poses a severe challenge to the starting performance of automobile engines. In a low-temperature environment, problems such as the weakening of battery power supply, the increase of lubricating oil viscosity, and the decrease of fuel volatility significantly reduce the starting efficiency.

The Action Plan for Energy Conservation and Carbon Reduction for 2024-2025 set the goals of low-carbon transportation infrastructure construction, low-carbon transformation of transportation equipment, and optimization of transportation structure. Constant temperature preheating engine activation system aims to achieve the goal of energy saving and emission reduction and alleviate the difficulty of starting cars during winter in northern China. The practice has proved that this new achievement can effectively push the transportation field towards green, low-carbon, and high-efficiency, and contribute to achieving the goal of sustainable development.

Domestic research on engine preheating systems has made progress and has been applied to advanced automotive and engine products. China First Automobile Works (FAW) has innovated heat exchanger design and developed a patent for an “engine preheating system” that effectively shortens the preheating time for engine oil, enhances engine start-up efficiency and performance, and ensures the use of vehicles in cold environments. At the same time, Weichai Power has introduced a diesel engine with a thermal efficiency of 53.09%, which is a significant breakthrough in diesel engine thermal efficiency. These technological advancements have enhanced the international competitiveness of China’s automotive industry and are driving the global automotive industry towards environmental friendliness, efficiency, and intelligence.

Simultaneously, many scholars in this field have studied this specific issue. For example, Li Wanmin and Zhao Gengyun introduced electromagnetic induction heating technology for cold engine preheating and designed a wireless control system for cold engine start preheating system based on NewMsg_RS2401 [3]. Jiang Yuliang, Gu Pinglin, and Liang Dong jointly studied an engine cooling water preheating device based on STC8A8K64S4A12 single-chip microcomputer control, with the central lock as the control signal and the current engine cooling water temperature as the control basis. Through manual/automatic mode, the heating module and electronic water pump were controlled to work, and the engine was preheated by the heated cooling water [4]. The vehicle-mounted engine glow plug controller researched by Sharla Cheung and others accurately controlled the glow plug to heat intermittently or continuously through control logic, which effectively improves the cold start performance, it effectively improves the cold start performance and combustion stability of diesel engines at low temperatures and reduces the emission effect [5].

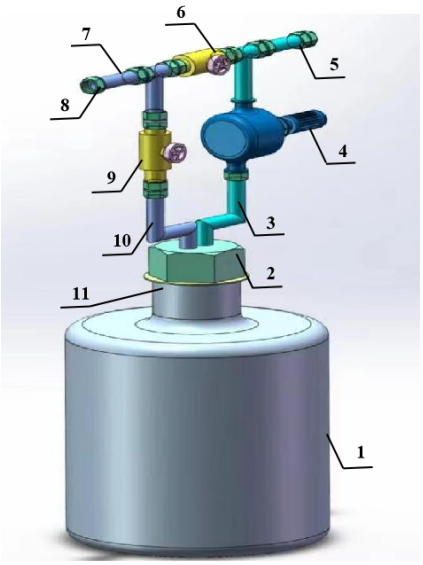
Hongtaosun *et al.* used the self-contained storage battery on the construction machinery and equipment as the power supply for the heating element of the system. Heating elements were respectively installed in the diesel pipeline and outside the diesel filter element in the diesel tank to heat the oil circuit as a whole, which could prevent the diesel oil in the tank from freezing and waxing and hardening the oil pipe [6]. Li Dongyang *et al.* used SEM-EDS and a thermal conductivity analyzer to analyze the microstructure, composition elements, and thermal conductivity of the electrothermal alloy and Positive Temperature Coefficient (PTC) thermistor

used in the two preheating devices and built an experimental platform to conduct low-temperature preheating experiments on the two tubing preheating devices. The results show that the electrothermal alloy material has high thermal conductivity and a good experimental effect [7].

However, despite the remarkable progress, the rapid development of thermal system technology has made great achievements, but it still encounters bottlenecks such as low start-up efficiency at low temperatures, insufficient system integration, and increasingly stringent energy-saving and environmental protection standards. In order to overcome these challenges, the industry urgently needs to explore cutting-edge technologies. Based on such problems, we have studied a thermostatic engine preheating system, which can be optimized and innovated from the perspectives of energy saving and convenience.

3. System composition structure

3.1. Structural composition



1. Supervisor
2. Main valve
3. Outlet connecting nut
4. water pump
5. Liquid outlet pipe
6. Sealing cover
7. Insulation thermos pot
8. Liquid inlet pipe
9. Branch valve
10. Inlet connecting nut
11. Temperature sensor

Figure 1. Structural diagram

As the key to heat storage, the thermos effectively locks the high-temperature coolant, significantly reduces the heat loss, and provides a stable heat source for the preheating process [8].

The efficient water pump ensures the rapid circulation of coolant, thus accelerating the preheating process of the engine and improving the overall efficiency.

Precision valves can accurately adjust the flow of coolant according to actual needs. The temperature sensor monitors and feeds back the temperature information in real-time to ensure that the preheating process is neither excessive nor too little, which further improves the energy utilization efficiency.

The on-board management system integrates an intelligent control function, which can automatically adjust the preheating strategy according to the vehicle state, external environment, and other factors, making the system operate more efficiently and safely [9].

3.2. Thermos pot

The thermos pot is made of 316 and 304 stainless steel with corrosion resistance and high-temperature resistance to ensure the integrity of the equipment in harsh environments. In design, the heat loss is reduced by the large volume vial port structure. The internal vacuum layer further improves the thermal insulation effect and reduces heat conduction. Stainless steel bottle cap and high-temperature gasket ensure sealing and work stably even at high temperatures. This series of thermos pots is designed to provide users with a quality thermal insulation experience and help the car engine start quickly in cold weather [10,11].

3.3. Efficient water pump

As one of the core components of the engine activation system with constant temperature preheating, a high-efficiency water pump undertakes the important task of circulating coolant. It adopts an advanced hydrodynamic design, which can realize high-speed and uniform circulation of cooling liquid with low energy consumption and ensure that all parts of the preheating system can reach the ideal temperature quickly.

This high-efficiency cycle not only accelerates the preheating process of the engine in a low-temperature environment, and improves the starting performance, but also effectively reduces energy consumption, which conforms to the design concept of energy saving and environmental protection. Therefore, the application of a high-efficiency water pump is very important to improve the overall performance and efficiency of the preheating system.

3.4. Precision valves

The precision valve plays an important role in the preheating activation system, and it realizes intelligent management of the coolant flow path through precise control of the electric actuator. This innovative design enables the valve to receive accurate signals from the control system and quickly convert them into precise actions of the valve plate, which can achieve extremely high accuracy and response speed whether it is opening, closing, or fine adjustment [12].

This precise control not only optimizes the efficiency of the preheating process but also ensures that the engine can get the best preheating effect under different working conditions. Concurrently, the application of electric actuators also simplifies the operation process, improves the automation level of the system, and provides strong support for the green and sustainable development of modern transportation.

3.5. Temperature sensor

The temperature sensor adopts advanced high-temperature platinum resistance technology, which can accurately capture the temperature change in the face of a high-temperature coolant environment of thousands of degrees to ensure accurate data. Its high accuracy and stability provide reliable temperature feedback for the system.

When the preheating system starts and the coolant temperature experiences significant fluctuation, these key data will be immediately transmitted to the onboard control unit. As the intelligent center, the single-chip microcomputer quickly analyzes and processes this information, and then sends accurate opening and closing instructions to the valve to realize intelligent regulation of the preheating process. This process not only improves the response speed of the system but also ensures the efficient operation of the engine in the optimal temperature range, thus escorting green travel [13].

3.6. Vehicle management system

The onboard management system integrates intelligent algorithms, accurately receives data from temperature sensors, and dynamically regulates valves and pumps, thus realizing seamless linkage between onboard and preheating systems [14].

The system control platform takes intelligent management as the core and integrates data acquisition, transmission, processing, and analysis. The software platform has a friendly interface, and users can easily monitor the vehicle status and give control instructions. At the same time, an efficient data exchange mechanism can ensure the real-time synchronization of information between the vehicle and the preheating system, optimize communication protocols and interfaces, and reduce delays and failures.

In terms of hardware selection, the Programmable Logic Controller (PLC) and its supporting equipment are carefully selected to accurately meet the needs of vehicles. Through the integrated management software of Application Programming Interface (API) and Software Development Kit (SDK), the seamless flow of data between systems and the instant transmission of control instructions are realized, laying a solid foundation for intelligent travel.

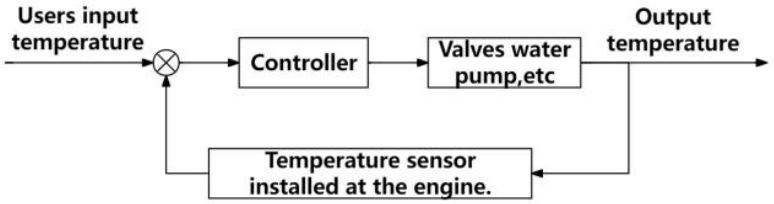


Figure 2. Feedback flow diagram for controlling preheating temperature

4. Working process

4.1. Heat storage process

As a key component in the system, the thermos pot is responsible for storing high-temperature coolant. Its design aims to effectively reduce heat loss and ensure that the coolant can still maintain a high temperature for a period of time after the vehicle is turned off.

When the vehicle is not working or after the engine is turned off, the high-temperature coolant in the incubator will naturally cool down, but the cooling speed is relatively slow due to its excellent thermal insulation performance. Before the next start of the vehicle, the stored heat will be used to preheat the engine, and the working process is shown in **Figure 2** [15].

4.2. Preheating process

After starting, the pump pushes the coolant circulation to ensure its fast and stable flow. The precision valve adjusts the coolant flow according to the temperature sensor information to maintain the engine temperature and save energy. The vehicle management system determines whether to start the preheater according to the temperature and the preset algorithm and intelligently adjusts the preheating process to optimize energy saving. The whole process is controlled through a closed loop, the temperature sensor provides real-time feedback, and the on-board system controls the control commands such as pump speed and valve opening to accurately control preheating. When the coolant temperature reaches the set value, the system automatically stops

preheating and turns off the equipment to save energy.

4.3. Self-protection mechanism

To ensure the safety and reliability of the system, the vehicle management system also has built-in self-protection mechanisms. For example, when the system detects abnormal conditions (such as coolant leakage, water pump failure, etc.), it will automatically cut off the power supply and give an alarm to remind the driver to check or repair.

5. Conclusion

The constant temperature preheating engine activation system developed in this study, through the innovative constant temperature preheating mechanism and intelligent control technology, significantly improves the starting performance of the engine in a low-temperature environment, reduces the wear of the engine during cold start, and improves the safety and comfort of drivers. And effectively reduces the energy consumption of the engine in the cold start stage, and significantly improves fuel efficiency.

Simultaneously, the technology also optimizes the working state and temperature management of the engine, greatly reduces harmful gas emissions during cold start, and contributes to improving air quality. This achievement not only reflects our deep concern for environmental protection but also our unswerving commitment and practice to the sustainable development strategy. Future research will further optimize the system design and improve its applicability and reliability. In the future, with the development and application of the system, it will bring new development opportunities to the automobile industry, promote the development of the automobile industry in a more environmentally friendly, efficient and intelligent direction, and provide strong support for the upgrading of the automobile industry.

Disclosure statement

The authors declare no conflict of interest.

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