Optimization Design of Cooling System for Mine Truck Engine

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ABSTRACT

Taking the engine cooling system of mine truck in research as an example, aiming at the mine vehicle working in the mining area under the bad environment, and the current engine cooling system cannot guarantee the engine running in the best condition of the problem. The optimal design of the cooling system is realized by designing the real-time control system of the electric water pump. It can solve the problems that existed in the cooling system of mine truck engine, and provide an effective and reasonable way for the optimization design of engine cooling system.¹

KEYWORDS

Mine Truck; Engine; Cooling System; Electric Water Pump Control System

INTRODUCTION

At present, the mining vehicle engine adopts more compact design and larger unit volume power, and the degree of strengthening is higher and higher. The heat flow generated also increases obviously by the engine. In the mining area, the vehicle working conditions, load changes, the engine is more prone to overheating, which causes the oil deterioration and loss, high fuel consumption, increased wear parts (such as the piston and the piston ring cylinder thermal fatigue crack bite, etc.). These conditions can cause the engine to boil, causing the engine power, economy and reliability deterioration, reduce vehicle fuel economy, influence the mine car

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life, while the traditional cooling system cannot satisfy the mine car engine that operated in the condition of optimum working temperature.

In view of the above problems, an electric water pump control system is designed. The temperature sensor of the cooling system is monitored and fed back to the ECU by setting up temperature sensors. ECU collects, judges and processes the feedback water temperature signals. Then, the corresponding regulation instructions are given to the electric water pump, so as to achieve the real-time response, adjust the supply quantity of cooling water, satisfy the good operation of the engine in the changing working conditions, and effectively improve the cooling system.

ENGINE COOLING SYSTEM OF MINE VEHICLE

The engine cooling system is designed to take away the heat absorbed by the high temperature parts of the engine while they are working, so that they can be kept in the proper temperature range [1]. Most domestic vehicle engines adopt the traditional forced circulation cooling system. The water circulation cooling system of a mine car engine mainly includes the engine, radiator, fan, cooling water pump, cooling water pump, inlet pipe, thermostat and inner and outer pipeline of the engine, etc. as shown in figure 1. The cooling water at the water outlet of the radiator enters the engine under the pressure of the cooling water pump, takes away the excess heat absorbed by the heating element, and flows to the radiator through the thermostat. Under the action of the water pump, the cooling liquid forms a circulating flow to achieve the continuous cooling effect[2]. The engine crankshaft is driven directly by belt drive cooling fan to heat the radiator by the high temperature liquid of the radiator. The system is designed in term of the maximum heat load of the engine, engine cooling cannot satisfy the needs of automatic adjustment, and will also increase fuel consumption, the noise increases, seriously affect the engine performance and fuel economy, affect the driver's comfort[3].

![Figure 1. The Sketch Map of Engine cooling system of a mine vehicle.](image-url)
OPTIMIZATION DESIGN SCHEME OF COOLING SYSTEM STRUCTURE

For mining vehicles, due to low speed, load changes, prone to overheating of the engine, resulting in the vehicle cannot run properly. At present, the closed loop cooling system is widely used in the engine cooling system of heavy duty mining vehicles[4]. The research of cooling system in our country is based on the amount of cooling water circulation, which directly influences the effect of cooling cycle system. The greater the cooling water circulation, the better the engine heat dissipation performance, but the conventional cooling water pump speed is directly proportional to the engine speed, the speed of the pump is limited by the engine speed. The cooling capacity of the cooling system cannot be adjusted automatically with the heat dissipation of the engine. When the load is large, it can satisfy the cooling demand. When the load is too small, the cooling capacity is too large, which will affect the operation of the engine, resulting in unnecessary waste of fuel[5].

In view of the above problems, an electric water pump control system is designed. As shown in figure 2. The whole system is equipped with a temperature sensor on the basis of the traditional cooling system, and the electric water pump is used instead of the mechanical water pump. The temperature sensor is mounted on the engine outlet temperature acquisition. ECU collects, judges and processes the feedback water temperature signals. The system of the electric water pump electric pump speed regulating a work instruction, so as to achieve the purpose of controlling the coolant flow, realize the real-time control of the temperature of engine cooling system. It solves the mine car in climbing, heavy load and slow speed during the operation of internal engine temperature too high, to satisfy the normal requirements of the engine in the complex working conditions, improve the efficiency of the cooling system, save energy consumption.
ECU is the CPU, RAM, ROM, I/O interface circuit, timer / counter, and serial communication interface components made on an integrated chip to form a complete electronic controller[6]. The principle is shown in figure 4.

This microprocessor is STC's high-grade 8 bit microcontroller STC89C51. It can be fully compatible with 51 full word series products, using CMOS manufacturing process, low power consumption. There are internal clock circuit, reset circuit, drive module, D/A conversion module, A/D conversion module and so on. The object of this design is the coolant temperature, and the temperature measurement device (mainly temperature sensor) is one of the most important components of the control system, and the MSTT type integrated temperature conversion device is adopted. A temperature sensor collects temperature signals of the engine coolant. The temperature conversion device amplifies and processes the signals output by the temperature sensor directly. The temperature signal is converted to voltage analog signal, and the converted voltage signal is sent directly to the A/D conversion module. The A/D is converted by ADC0809, and the result is processed by the microcontroller. After the D/A conversion module, the D/A conversion is carried out by DAC0832, and the digital quantity is converted into current according to the instruction, and then the electric water pump is driven to provide reasonable cooling liquid for the cooling circulation system at different rotating speed.

The single-chip microcomputer control system interface circuit of this system is shown in Figure 5. The system components mainly consist of STC89C51, ADC0809, DAC0832, MSTT, DS18B20, LM324, 74LS04 and other components.

The software of the control system divides the whole program into modules according to the function. Each module can be designed, programmed and debugged
separately, and then combined to make it a practical program. The software of the electric control system mainly completes the functions of circulating sampling, processing and driving motors for the cooling liquid temperature signals. The main program flow is shown in figure 6:

Figure 4. The hardware schematic diagram of electric control auxiliary control system.

Figure 5. The interface circuit diagram of Singlechip control system.
EXPERIMENTAL RESULTS AND CONCLUSIONS

At the same speed, the fuel consumption of the original system and the new system is compared (two sets of speed are listed here, 1300r/min and 1900r/min respectively). As shown in figure 7. The test shows that the fuel consumption with this cooling system is obviously lower than that before and after the improvement. The performance of the cooling system is obviously improved, and the fuel consumption and noise can be reduced more effectively, and the fuel economy and the fuel economy of the whole vehicle can be improved. Because of the particularity of the system working environment, the anti-interference ability of the system should be further strengthened so as to better match the heavy duty mining vehicles.
Figure 7. The chart of comparison of fuel consumption between old and new systems.

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REFERENCES


