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Development and Application of Electronic Fuel Injection and Ignition in Automobile Electronic Technology

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Abstract

Electronically controlled fuel injection technology and electronically controlled ignition technology are two milestone technology applications in the development of modern automotive electronics. The development of these two technologies has promoted the revolutionary development of modern internal combustion engines and achieved the goals of high efficiency, high reliability, cleanliness and energy conservation of internal combustion engines. This paper mainly describes the basic composition, principle and working process of these two technologies, and introduces the research progress of the relevant scholars on the electronically controlled fuel injection technology and electronically controlled ignition technology, so as to lay the foundation and provide theoretical guidance for further in-depth study of electronic engine control technology.

Keywords: Automotive electronics; Electric control oil injection; Electric ignition

1. Introduction

With the advent of the digital, electrification and intelligent era, automobiles, as an important means of transportation for people, are bound to undergo major updates and technological upgrades with the progress of the times to meet the growing transportation needs of people. The application of automotive electronics [1] is undoubtedly a revolutionary breakthrough, with the advantages of light weight, small size, high sensitivity, fast response and high accuracy compared to traditional purely mechanical mechanisms. This is a big improvement for the performance improvement of the car, the light weight of the car, the operation intelligence and the emission cleanliness. Li Hong Yi ,Cao Zhi Wan et al [2-3] have provided an outlook on the current status and future development direction of modern automotive electronics applications. Wenying Zou [4] et al. proposed a new method of designing an automotive electronic control system based on Simulink/RTW in order to meet the diversity and rapidity of real-time control system development by combining the model-based design method and automotive code generation technology. The research process includes designing algorithms in Matlab/Simulink, building control system models, and then automatically generating embedded code by RTW to realize the development of automotive real-time control system under OSEK/VDX operating system environment.

This paper mainly compares and explains the application of modern automotive electronics in internal combustion engines, and takes electronically controlled fuel injection technology and electronically controlled spark plug ignition technology as examples to illustrate the significant role of the application research of electronics in improving the performance of internal combustion engines.

2. Modern electronically controlled fuel injection technology

2.1 Basic principle

Electronically controlled injection system mainly consists of air supply system, fuel supply system and electronic control system three major components. Its working process is the air supply system will be clean and have a certain flow rate of fresh air from the intake tract through the intake valve into the cylinder of the internal combustion engine. The fuel supply system through the injector will have a certain pressure of fuel according to the ECU signal to open and close the injector needle valve to achieve the injection process, and the ideal injection law is the first open slowly, and later break fuel quickly that is, first slowly and then sharply. Each engine work process, there is an optimal injection advance angle, and the best injection advance angle refers to the speed and fuel supply under certain conditions, the maximum power and minimum fuel consumption rate of the injection advance angle.

The injection control system takes the air flow signal and engine speed signal as independent variables, determines the basic injection time by querying the MAP table of injection time in the ECU storage system, and then corrects the injection time according to the corresponding sensor signal to get the accurate injection time and injection volume, and transmits the signal to the injector, and then realizes the opening and closing of the injector. Among them, if the injection advance angle is too large, will make the stall period increases, the maximum pressure rise rate increases, the engine works rough, and idle bad, difficult to start, and will significantly increase the negative compression work, so that fuel consumption increases, power decreases; and if the injection advance angle is too small, will make the fuel cannot be burned quickly near the upper stop, afterburning period increases, although the pressure rise rate and combustion pressure is low, but the exhaust Temperature increases, cooling system heat loss increases, thermal efficiency drops significantly

2.2 Current State of Research

Many scholars have studied the performance of electronically controlled fuel injection systems in different ways to optimize them and promote the development of electronically controlled fuel injection technology. Liang Chen et al [5] sorted out and analyzed the development of electronic fuel injection system and high-pressure common rail fuel injection system for diesel engines, and summarized that the electronic fuel injection system for diesel engines has undergone three important upgrades, which are position-controlled system, time-controlled system and time-pressure-controlled injection system. In addition, the research hot issues of high-pressure common rail system are introduced, including high-pressure sealing of the system, uneven injection caused by small fluctuation of common rail pressure, optimization of three-dimensional control data of the system and manufacturing of high-speed precision solenoid valve. Kexun Zhang et al [6] studied the logic optimization of the logic driving circuit of the electronically controlled fuel injection solenoid valve of an internal combustion engine and found that if the voltage of the driving circuit of the solenoid valve was increased to 36 V, the solenoid valve could be accelerated and the energy consumption was reduced. In addition, by designing the control sequence with reconfigured current feedback and using interrupt nesting, the real-time performance of fuel injection can be improved, and the anti-interference capability and reliability can be enhanced. Chang zhen Lien et al [7] studied the way of high-speed solenoid valve driving for electronically controlled fuel injection, mainly analyzed from two aspects: solenoid structure design and circuit driving technology, and proposed a boost driving circuit based on DC-DC charge pump to achieve precise fuel injection by appropriately modifying the circuit hardware parameters to match the solenoid valve response characteristics. Yuan Chang et al[8] studied the drive control technology of the injector solenoid valve in the high-pressure common rail system by analyzing the working principle of the injector solenoid valve and the influencing factors affecting the response speed of the solenoid valve, and cleverly designing a high and low voltage time-sharing drive circuit based on current feedback control by using BOOST voltage conversion technology. During the operation of the drive circuit, by comparing the difference between the reference voltage and the sampling voltage and optimizing the automatic control of the peak current and the drive current waveform, the corresponding speed of the drive circuit can be significantly accelerated, in which the current in the injector solenoid valve rises from zero to the required value in only 0.045 s.

The study conducted by Xing chun Zhang et al. [9] on the drive of piezoelectric high pressure common rail injector focuses on designing a piezoelectric injector drive circuit using current and voltage for accurate closed-loop control and energy recycle of piezoelectric injection, and designing and proposing a new control strategy to match it, and the optimal control strategy is obtained through testing and optimization. Tests show that when the trapezoidal charge and discharge current is used to achieve the charging of piezoelectric injectors, the charging time is about 120 us, and the corresponding discharge time is 100 us, which obviously achieves the high-speed charging and discharging requirements of the injector. At this time, although the energy required to drive the piezoelectric injector is greater than the energy required to drive the capacitor of equal capacity, the single injection energy demand is less than that of the solenoid valve type injector, and the working process is more stable and consistent, so that multiple injections and precise injection can be realized.

2. Modern Electronically Controlled Spark plug Ignition Technology

2.1 Basic Principle

The electronically controlled ignition system is mainly based on the crankshaft sensor signal, engine load sensor, throttle position sensor and other related sensor signals to determine the operating status of the engine, determine the corresponding ignition angle by querying the ignition data in the MAP table, and then ignite the mixture through the spark plug discharge to achieve the fuel combustion process, through continuous optimization of the ignition angle can be achieved to improve engine power, economy and good emissions. The purpose of improving the engine power, economy and good emission is achieved by continuously optimizing the ignition angle. In general, the electronic ignition system has closed-loop control and open-loop control. When a detonation sensor is installed in the control system, the ECU will continuously optimize the ignition advance angle in real time according to whether detonation occurs during the engine operation, which becomes the closed-loop control of the ignition advance angle.

In addition, there are many factors affecting the ignition advance angle, mainly with the engine speed, load, excess air coefficient and intake pressure, temperature, and this is generally through the engine ignition advance angle adjustment characteristics curve test to determine, which ignition advance angle adjustment characteristics curve is to maintain the engine throttle opening, speed and mixture composition is certain, its power, fuel consumption rate and exhaust temperature with the ignition advance angle change relationship. If the ignition advance angle is too large, after the ignition delay period, it will make the highest combustion pressure in the compression stroke before the upper stop, the highest pressure and pressure rise rate is too large, the piston up the compression work consumed increased, the engine is easy to overheat, the effective power decreases, the degree of work detonation increased; if the ignition advance angle is too small, after the ignition delay period, the piston has moved a certain distance to the lower stop when combustion begins. so that the combustion of the mixture in a larger volume, making the combustion of the fixed degree of decline, and hot gas and cylinder wall contact area, heat loss increased, the highest combustion pressure is reduced, and expansion is not sufficient, the exhaust temperature is too high, the engine overheating, power down, fuel consumption increased. During the continuous development of electronic systems, many scholars have optimized electronic ignition systems and the design of control strategies.

2.2 Current State of Research

Xue feng Zhao et al [10] mainly developed and tested the hardware design of the direct injection gasoline engine electronically controlled injection system, selected MC51 microcontroller as the control chip of ECU, and carried out the design and development of system circuit, signal processing circuit and actuator circuit, the overall technical scheme needs to meet the requirements of GDI engine control speed and accuracy, realize in-cylinder rarefied fuel injection control, and support the upper computer interface field debugging and data calibration functions. The test shows that the hardware design of the electronic control system has good anti-interference ability and reliability. Mingwen Wang et al [11] developed based on the parameters and characteristics of natural gas engines to achieve engine control by detecting and determining the ignition sequence and ignition angle, and conducted bench tests and simulations to prove its feasibility. Hong guang Zhang et al [12] studied the ignition energy of electronically controlled spark plugs, mainly by serially using a voltage regulator as an analog load and collecting the voltage signal at both ends of the resistor by a digital oscilloscope. The test results showed that when the engine speed was lower than 2500r/min, the ignition coil closing time was 6ms. When the speed was between 2500-5000r/min, the ignition coil closing time was 3ms. When the speed was higher than 5000r/min, the time was shortened to 2ms, and the quantification of the ignition energy was achieved, which is beneficial to improve the cold start performance, power and emission reduction. Hui Zhu et al [13] studied the control of ignition coil and injector in electronically controlled gasoline engine in detail, and proposed a control strategy based on programmable timing/timer microcontroller to realize the control of the signals by analyzing the timing relationship between the two signals, and analyzed and evaluated the advantages and disadvantages points of the method. Among them, the timing of ignition coil mainly controls two parameters of ignition advance angle and ignition coil closing angle; the timing relationship of control signal of injector mainly controls two parameters of injection pulse width and injection advance angle. The experimental results show that this control method has good reliability and stability, high control accuracy, simple programming, and wide application range.

Jingbo Wu [14] et al. studied the ignition energy of ignition system of gasoline engine, and the causes affecting the minimum ignition energy were systematically analyzed by using simulation test software, and the change law of ignition energy was summarized. After that, a minimum ignition energy control method was proposed and its feasibility was demonstrated. Wei Hong [15] et al. investigated the ignition timing adaptive control strategy for natural gas engines, using the ignition timing fluctuation method to find the optimal control factor, and using the high degree of speed fluctuation of natural gas engines as an evaluation index to form a closed-loop ignition timing control strategy, which in turn achieves the goal of optimal fuel economy. Finally, the authors carried out a combined hardware and software system design and practical application to fully demonstrate its feasibility.

3. Conclusion

In summary, the application of electronically controlled fuel injection and electronic ignition technology has greatly promoted the development of the automobile engine industry and indirectly promoted the development of the automobile industry in the direction of energy saving, environmental protection, high efficiency and high reliability. In the future, in order to further improve the performance of the engine and the overall comfort and convenience of the car, automotive electronic control technology will certainly be widely developed and applied. In addition, the degree of electronic control in the automotive industry will also become a synonym for the degree of sophistication, guiding the development of the automotive industry progress.

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