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Dynamic Temperature Test for PTC Material Used to Heat Diesel

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Abstract. This paper gives a way which utilizes the PTC (positive temperature coefficient) materials to preheat diesel in the injector in order to improve the cold start performance and emissions of engine. Combining high performance data acquisition system based on MSP430F149, a dynamic temperature testing system was developed to test fuel temperature heated by PTC in injector. The software and hardware electrocircuit were expounded in detail. The temperature varying law of diesel fuel heated with PTC ceramics was measured under different voltage. A conclusion can be draw that diesel fuel may be heated to self-defined temperature around Curie point when diesel fuel was heated with PTC material.

Introduction

The cold start of diesel engine is one of the important performance indices. It is not only related with efficiency, but also influences emission index and fuel consumption [1]. Emission of diesel engine is very high during cold start. HC and CO of 50% ~ 80% are produced in the course of cold start.

From 1990s, in abroad very deep research have been done on HC emission under cold start condition [2, 3]. Huang Z.H et al studied HC emission under cold start and its influencing factors [4, 5]. According to real testing of HC emission from gasoline engine cold starting to catalyst converter igniting, the temperature and dynamometer when exhaust pipe was in different locality, Cheng Y et al explored the influences of HC emission aroused by different spark advance angle in the course of gasoline engine cold start and warm up[6].by using method based on cycling control, Li L.G et al analyzed the igniting stability effect done by first cycling injection pulse width in gasoline engine cold start[7].

The cold start performances and emission under cold start are related with many factors, the fuel spray is one of important factors. From the basic study of the fuel spray, He L.Y et al thought that the higher environmental temperature and surface temperature of spraying injecting flow is, the bigger increasing rate of disturbing wave, and the easier spray breaks and atomizes [9].

In order to decrease the emission of cold start, Yao C.D adopted regenerator-box and properly enhanced inhaling temperature to find decreasing emissions of HC and CO. when the air is heated to 70°C in inhaling chief pipe, the emission of HC may decrease 36% and CO may decrease 13%[10].Frank Zimmermann settled heating device inside injector. The flow inside this injector is between 0.1g/s and 0.7g/s. the temperature of fuel oil may be heated to 65°C in 5 seconds and the jarless temperature may keep between 70°C and 90°C. In this condition, fuel oil around 50% became gas state in inhaling pipe, the engine decreased emission of HC to 80% in idle speed of 20s [11]. Seoksu Moon thought that the injecting penetration would decrease and injecting width would increase by the enhancement of temperature of the slit injector. The swirl injector is adverse at the same situation [12].

From above literatures, the cold start emission of gasoline engine may be effectively decreased by enhancing temperature of fuel oil or inhaling air, so does the emission and performance of cold star. Because the mass of fuel oil is far fewer than that of inhaling air, less heat energy may enhance temperature of fuel oil needed in course of cold start and warm up. An effective method enhancing temperature of fuel oil is to settle PTC material inside injector.

PTC material is rapidly developed and is widely applied in recent years. PTC material will obey negative temperature law that its resistance value decrease along with the augment of temperature before the temperature arrives at Curie point. Its resistance value will sharply ascend after the temperature arrives at Curie point. Before work temperature arrives at Curie point TC, the resistance value of PTC component has a little change, so its current value will aggrandize along with aggrandizement of its voltage value. The current arrives at its maximum value as soon as the temperature is at TC. If voltage value is continuously aggrandized, the resistance value will rapidly ascend because the temperature of PTC composite is above at TC. This is the characteristics of static state of PTC composite. PTC composite was used to heat diesel oil of injector in this paper. Needed energy is very little and the temperature heated may be controlled in the scope mounted.

Before PTC material can be successively applied in injector, a great deal of basic studies needs to be conducted and many technical problems need be solved. PTC material based on Ceram was used to heat diesel oil in this paper. Combining with MSP430F149 high-performance data collecting system, a set of dynamic temperature test system was developed to test the dynamic temperature variety law when PTC material is used to heat diesel. The elementary test on ceramic PTC was also conducted.

Test system

2.1 hardware design of the test system

The hardware parts are made up of PTC material, temperature sensor, amplifier, and data collecting system. PTC material is used to heat diesel oil. Then temperature of the heated diesel oil is measured with temperature sensor and is translated to electrical signal. After the electrical signal is amplified, it will be collected by data collecting system and sent to computer to process and analyze through A/D. In this paper, INA118 and UA741 were chosen as chief components of amplifier and MSP430F149 as kernel of data collecting system.

2.1.1 Data acquisition system

The kernel is MSP430 microcontroller in data acquisition system. It is a super-low power consumption flash MCU whose instructs set is 16 bits RISC. This MCU has powerful processing ability, abundant On-Chip external module and convenient development facility. The developed data acquisition was shown as figure.1:

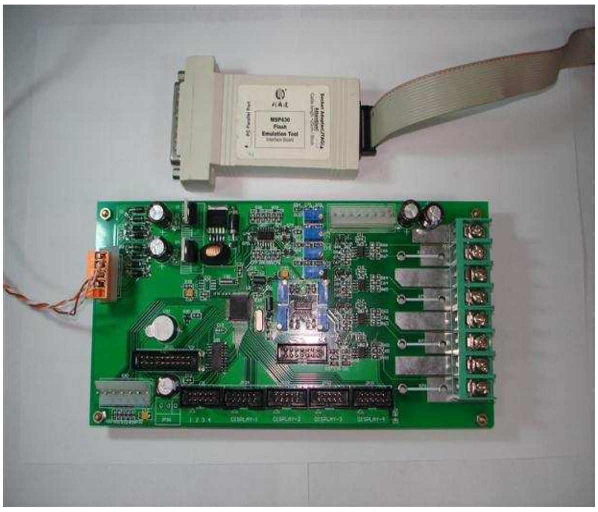

Fig.1 Amplification and Data Acquisition System Circuit

2.1.2 Error compensation for temperature

The reference temperature of Thermocouple sensor adopted in this paper is zero Celsius. Because the environmental temperature is room temperature, the acquired input signals will generate error. In order to solve this problem and to enhance resolution of the sensor, we use software to realize temperature error compensation.

At first, the temperature of cold end is measured with a sensor embedded in thermocouple. Then, the output signal of sensor is sent into MCU through amplification and data acquisition system circuit. After acquisition ends, the program which compensates temperature is run.

2.2 software design

The software includes two parts, one is main program and another is interruption program. The main program realizes initialization, setup of WD and AD acquisition time, clock, channels and so on. The interrupt program run when interrupt flag is set up as 1. The flow chart of main program is shown as figure.2

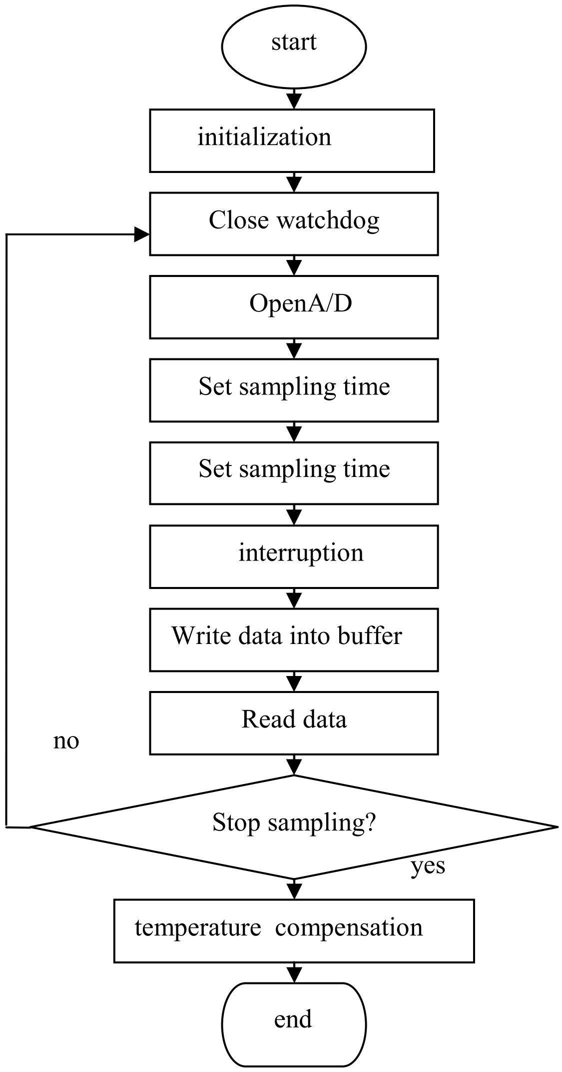

Fig.3 Main Program Flow Chart

2.3 realization of the test system

Diagram of the test equipment is shown as figure.4. In this test equipment, K thermocouple was adopted and the Curie point of ceramic-based PTC material is Celsius 75. The MSP430F149 was used to realize data acquisition and process functions. 0# diesel oil was used as heat media in test.

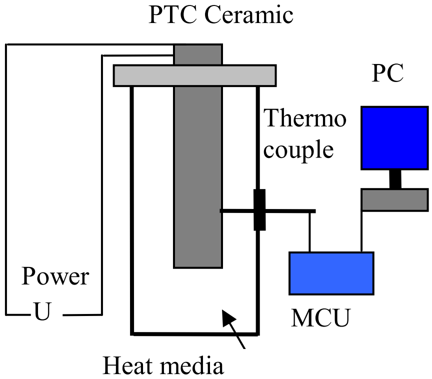

Fig. 4 A Sketch of Experimental Device

Test results and analysis

In order to know temperature and voltage characteristics of PTC material under different voltage, we firstly chose air as heat media and heating voltage is respectively 24V, 48V, 72V and 110V. The distance between thermocouple and PTC is respectively 0mm, 3mm, 5mm and 8mm. the results of test were shown from figure 5 to figure 8.

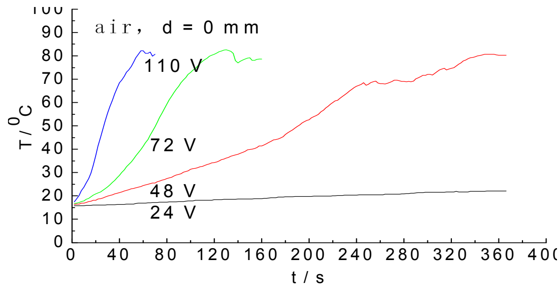

Fig.5 PTC material surface temperature varies with time under different voltage

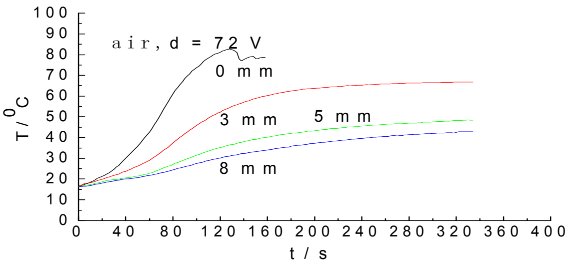

Fig.6 At 72 voltage level, PTC material surface temperature varies with time under different distances

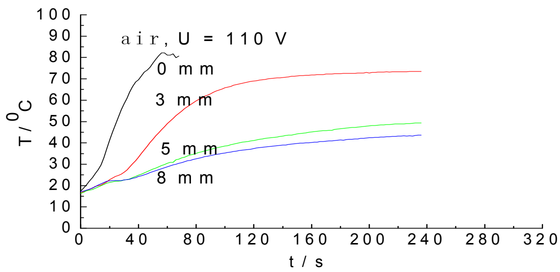

Fig.7 At 110 voltage level, PTC material surface temperature varies with time under different distances

The figure 5 shows that surface temperature of all PTC material rises slowly at 24 voltage level and rises quickly with voltage building up. At 110 vlotage level, The surface temperature of PTC material arrives at Curie point after 1 minute, it need 2 minutes at 72 voltage level. The data of figure 6 and figure 7show temperature change law with time at different distances from PTC material.

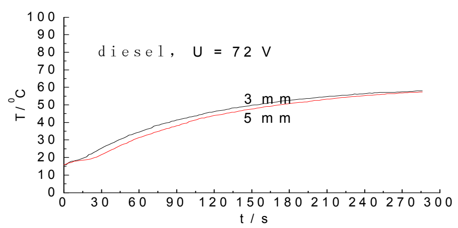

Fig.8 At 72V,diesel temperature heated by PTC varies with time under different distances

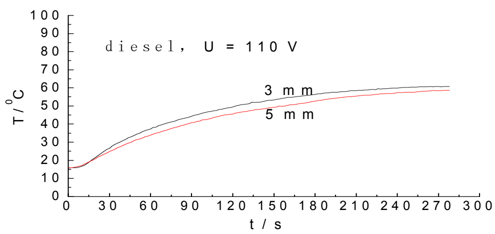

Fig.9 At 110V,diesel temperature heated by PTC varies with time under different distances

The relationship that temperature of PTC composite varies with time at different distances can be obtained from figure 8and figure 9which respectively indicate PTC material is powered by 72V and 110V.The diesel temperature rise quickly in two minutes,then they rise slowly. The diesel temperature can arrive at 60℃ in the 3mm or 5mm away from surface of PTC after being heated 5 minutes.

Conclusions

These data were obtained under still diesel, if PTC materials is settled in injector, before engine is started, the diesel in injector is still too,so fuel can be heated to 60℃ in several minutes.

Acknowledgements

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