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Research Article

Development of Replace Controller for Diesel Particulate Filter with Carbonized Micro Wood Fiber Filter Core

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Abstract: To solve the problem that the diesel particulate filter with carbonized micro wood fiber filter core (CMWF DPF) must be replaced when the amount of captured particulate material is up to a certain level, the working principle and controlling requirements of the filter of carbonized micro wood fiber was studied and a replaced controller for CMWF DPF based on AT89C52 was designed. In this study, the signal acquisition, data calculation and analysis were introduced.

Keywords: AT89C52, Carbonized Micron Wood Fiber (CMWF), Diesel Particulate Filter (DPF), photoelectric isolation

INTRODUCTION

Diesel vehicle, has not only good dynamics and stability, but also good fuel economy and could reduce carbon oxides emitted by engines greatly, which is paid more and more attention, but, compared with gasoline car, its particulate emission are 30 to 80 times (Nguyen and Worrarat, 2010). The particulates emitted by diesel vehicles are incomplete combustion solid carbon particulates and sulfates, hydrocarbons and metallic oxides which are adsorbed on its surface. So they could pollute the environment seriously (Gong *et al*., 2011). In particular, micro-particulate and polynuclear aromatic hydrocarbons which is a kind of carcinogenic substance, have a great harm on the environment and human health. Diesel Particulate Filter (DPF) is one of the most effective and simple ways to control the emission of Particulate Material (PM) (Wu *et al*., 2002). Carbonized Micro Wood Fiber (CMWF) DPF is connected to the exhaust pipe, collected PM in the DPF when the exhaust flow through it Guo *et al*. (2011). With the increase of the running time, the PM in the filter increases gradually, filtration efficiency decreases and exhaust back pressure rises, which could influence the power and the fuel consumption of the engine. So, in order to make the DPF sustained and effective and increase its service life, the particulate would be removed when DPF in use for some time.

In this study, a controller that could prompt to replace CMWF DPF based on AT89C52 microcontroller is developed.

THE WORKING PRINCIPLE OF THE CONTROLLER

The controller is applied to a real time supervision of the pressure and temperature in CMWF DPF and it will send the alarm signal to prompt the driver to replace CMWF DPF when the engine back pressure value exceeds a set one. The overall design of system is shown in Fig. 1.

THE HARDWARE DESIGN OF SYSTEM

The System Structure: The hardware system block of the controller to replace the CMWF DPF is shown in Fig. 2.

So, the entire system centers on AT89C52, coordinated control the acquisition circuit, real time clock circuit and memory circuit. The display panel and the upper computer processing software are used to display the monitor results in order to achieve the purpose of alarm. Because its severe working condition, the anti jamming ability of every modules in the design must be considered so that the system could work in a stable and reliable condition.

Exterrnal Expansion Data Storage Uint: AT89C52 has little memory for storage, only 8 K flash memory, but the experiment needs a large number of data records, so there must be a external expansion data storage module matching AT89C52 which could store the information of temperature, pressure and speed, which could be transferred in the main program.

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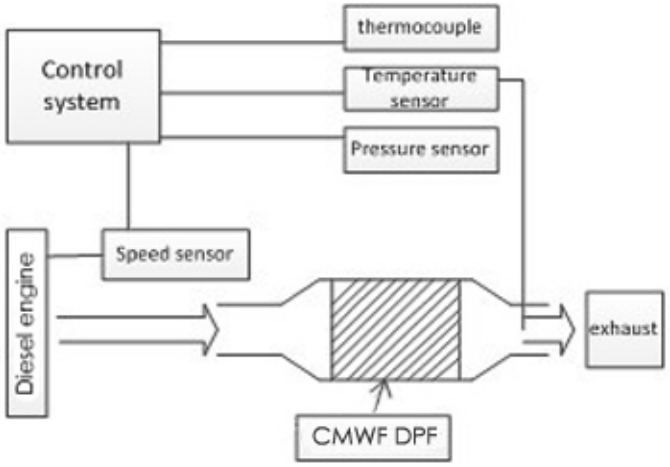

Fig. 1: The overall design of the system

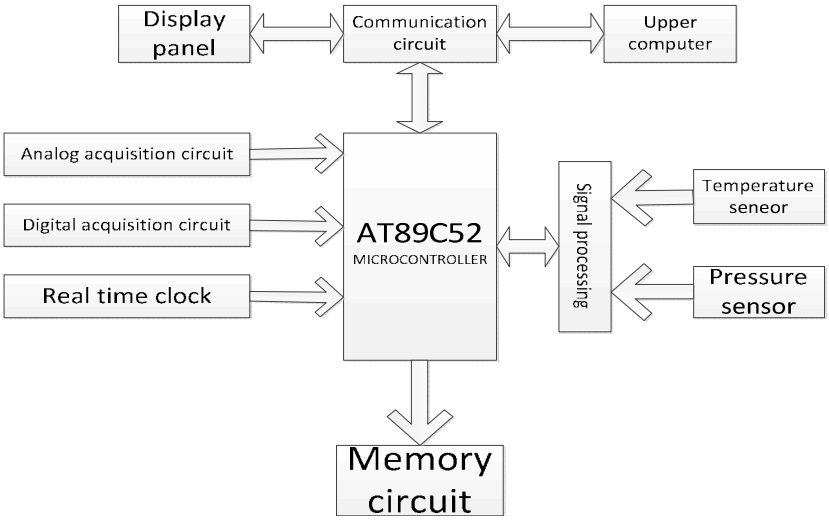

Fig. 2: The structure block of system

The data storage unit used AT24C1024 chip, which provides 1,048,576 bits of serial Electrically Erasable And Programmable Read Only Memory (EEPROM) organized as 131,072 words of 8 bits each. The chip's main characteristics are as follows: connect with incompatible equipment AT24C128/256/512 with the wires; the 1024K is internally organized as 512 pages of 256 bytes each; random word addressing requires a 17-bit data word address; low-voltage operation (VCC = 2.7V to 5.5V); data could be saved for 40 years; the Write Protect (WP) input, when connected to GND, allows normal write operations. When WP is connected high to VCC, all write operations to the memory are inhibited. If the pin is left floating, the WP pin will be internally pulled down to GND, switching WP to VCC prior to a write operation creates a software write-protect function; bidirectional data transfer protocol; random and sequential read modes; self-timed write cycle; the device's cascadable feature allows up to two devices to share a common two-wire bus.

Analog Data Acquisition module: In order to achieve the real time monitor to CMWF DPF, the analog data acquisition module must meet the requirement of channel selection, signal amplification and isolation processing. We choose BP-7017 eight-channel analog data acquisition circuit because it has universal function including communication module, data acquisition module, control module, multi-channel module and multi-function module. RS485/422 interface communication mode was used; complete protection measure for power, communication and input part was applied; the design of the module structure is

Table 1: The parameters of sensor and transmitter

Parameter sensor	Pressure sensor	Temperature sensor	Speed sensor
Model	AK-4	JWB	THG19
Range	0~1MPa	0~300℃	0~4500r/min
Accuracy	0.5%	+0.1%	----------
Principle	Strain gauge style	Catalytic combustion	Photoelectric
Production place	China	China	China

reasonable so that it is easy to install and debug and suitable for the signal acquisition of sensor and data transmission with the host computer.

Power module: Various modules are used in the system so the demands for the power are different. Stable and reliable power supply is the guarantee of that the system could work properly. From the point of anti-interference and electrical isolation, reliable and low power design is used to improve the stability of the system. The power supply design is shown in Fig. 3, the power supply module can not only filter the power signal, but also has a protection function for the external power and DC/DC power converter is used to meet the different requirements for power. The regulator chip is used to let the external 24 V voltage be 5 V, at the same time supply stable input voltage for the communication circuit to improve the effect of voltage isolation and transform.

Transducer: The transducer is a device which convert physical or chemical signal into electrical signal. The signal detected by the sensor always changes with time and the sensor should be able to track the input signal so as to obtain an accurate output signal. In order to obtain dynamic real time monitor to CMWF DPF, the parameters of the sensor we selected are shown in Table 1.

The Other Modules: The system also includes several other auxiliary function modules, such as digital acquisition module, whose main function is acquisition of the input signal of the thermocouple, the pressure sensor, the temperature sensor and the speed sensor; real time clock circuit which provides the current date and time information to the system; memory module is used to record the data generating in the running process, the data include time, temperature, pressure and alarm information; display panel as used to supply the man-machine communication interface and display the current situation of the system; the host computer

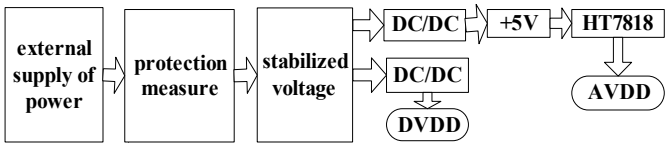

Fig. 3: The power supply design

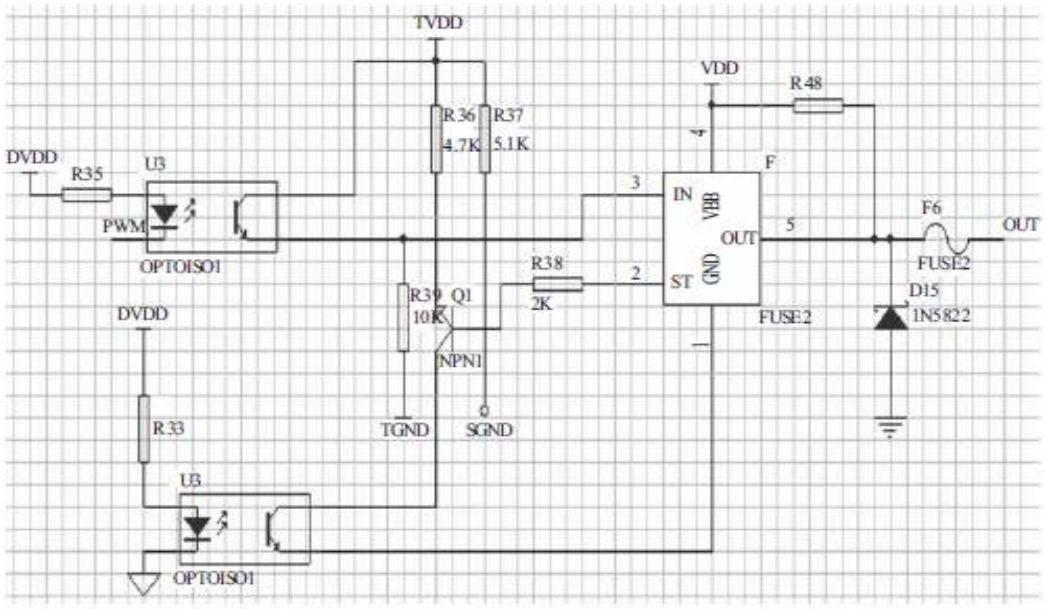

Fig. 4: The running principle of the output signal

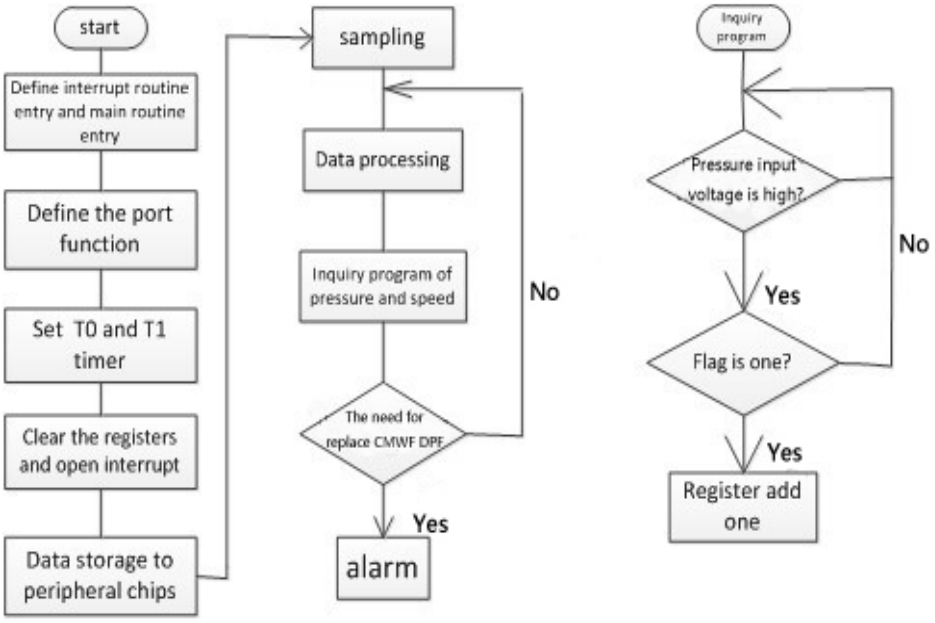

Fig. 5: The control flow chart of the generation program of CMWF DPF

which could download and save the data and real time monitor to the system running situation in the system debugging state; drive module which could send the control signal issued by MCU through opto-isolation to the drive chip to drive the solenoid valve. The running principle of the output signal is shown in Fig. 4.

Alarm control system: The alarm control system program includes main program, subroutines and interrupt routines, which are all written with C language. The program control flow char is shown in Fig. 5.

The control system is mainly used to control the opening and closing of the alarm valve, which consists of a solenoid valve and a relay. The solenoid valve and relay need relative large current to drive so they cannot be driven by the control panel directly, but can be driven by the GS6300 drive chip. The square wave generated by MCU, after opto-isolation could be send to the drive chip to control the solenoid valve and relay. MCU would adjust the valve position according to the feedback signal from GS6300.The control and alarm for replacement system need control the back pressure within the setting range when it starts. It would prompt to replace CMWF DPF when the back pressure exceeds the setting value.

The alarm system achieves control with PI algorithm and the specific algorithm is as follow:

$$\Delta P(k) = P(k)-P(K-l) = W_p [e(k)-e(k-l)]+W_i e(k) \quad (1)$$

$$P(k) = P(k-1) + \Delta P(k) \quad (2)$$

where,

$P(k)$ = The back pressure value of the k-th control moment;

$e(k)$ = The deviation between the current temperature value and a set initial value of the k-th control moment

W_p, W_i = Proportional and integral coefficients, respectively

According to empirical method, we infer the option range of parameters: W_p was under 1.6~5; W_i was 3~10 min. P_I parameters could be determined with trial-and-error method and experimental method, so that it can control the temperature of the generation stability.

Debugging: The hardware debug used block debug with the principle of from easy to difficult; first local debugging and then total debugging .After hardware debugging, verify that the assignment of the storage space is feasible. In keil 2, under the guideline of top-down design method ,breakpoint debugging and continuous debugging were adopted.

CONCLUSION

In this study, AT89C52 microcontroller is used to design a replacement controller for CMWF DPF, it is proven to meet the requirement of purification of the

diesel exhaust through a large number of experiments. CMWF DPF is a new developing filter for diesel so it has different effects for the different kinds of diesel vehicles. It is to be studied on the filtering mechanism and control strategy of CMWF DPF so that the intelligent control for different vehicles under different conditions can be achieved. This system has advantages such as simple, practical, stable and reliable, so it has good prospect.

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REFERENCES

Gong, J., J. Fu and G. Long, 2011. Study on regeneration strategy for a burner-type diesel particulate filter of automobiles. Chinese J. Environ. Eng., 7: 1603-1608.

Guo, X., D. Du, F. Wang and Y. Ma, 2011. Study on test instrument and filtration theory of the carbonized micron wood fiber DPF. Micropor. Mesopor. Mat., 142: 655-660.

Nguyen, T.K.O. and T. Worrarat, 2010. Compositional characterization of PM2.5 emitted from in-use diesel vehicles. Atmos. Environ., 44: 15-22.

Wu, X., D. Weng, H. Chen and L. Xu, 2002. Progress in research on filter materials for diesel particulate trap. Mat. Rev., 16: 28-31.