Research on Electronic Throttle Performance Test System

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***Abstract*—The flow of air entering engine cylinders is controlled by the electronic throttle, which is an important part of automotive engines and has a direct effect on the fuel efficiency and the security of automobiles. For the demand of quality sampling, an electronic throttle performance test system, which met the manufacturers' requirements, was designed to achieve the test of the opening performance of electronic throttle on the bases of C++ Builder, NI's PCI-6259 data acquisition card and PID throttle controller. At present, the system has been put into use in the electronic throttle factory. Compared with original test devices, the system is of more stability and higher accuracy; furthermore, more than 40% of the test time is saved.**

Keywords--electronic throttle, test system, response time

I. INTRODUCTION

Electronic throttle, which adjusts the flow of air into the engine and directly affects the performances of vehicles, such as power, reliability, comfort, convenience and fuel thrift etc, is an essential control part of automotive engines [1]. A few figures can be adopted to make the evaluation of electronic throttle, such as the response time, the location accuracy, the synchronization error and the linearity of position sensors, the drive motor torque, the durability as well as reliability of return spring.

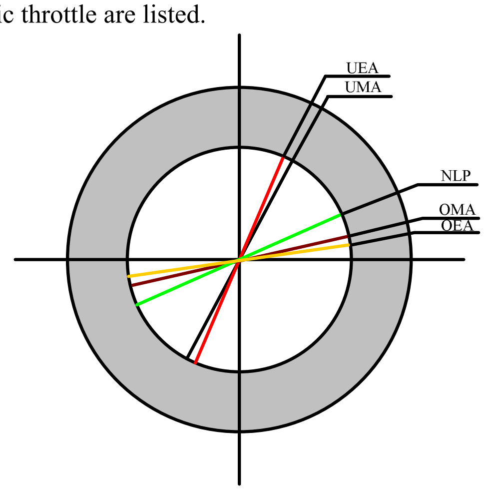
Based on virtual instrument technology, an opening time parameter and impulsion performance test system of electronic throttle is introduced in literature [2]; a position sensor, idle speed actuator and valve test system of electronic throttle is designed in literature [3]; and a durability performance test system is developed in literature [4]. In order to ensure the quality of electronic throttle, manufacturers urgently wish to make the quality evaluation of the overall product performances. To satisfy the demand, a new system is proposed and developed. In this system, under C + + builder environment, PID controller and NI PCI-6259 data acquisition card are gathered to achieve the performance detection and the quality evaluation of electronic throttle.

II. AN OPENING PERFORMANCE TEST METHOD OF ELECTRONIC THROTTLE

The electronic throttle consists of drive motor, reduction gear, return spring, throttle valve and position sensor etc [5]. Functioned by ECU driving signals, the drive motor adjusts the opening of electronic throttle through reduction gears; the return spring keeps the opening of the valve plate in a very small neighborhood to ensure the safety of driving. The position sensor, commonly a linear sliding potentiometer, is located to detect the opening of electronic throttle and obtain the value. The resistance of the potentiometer linearly changes with the position of electronic throttle, and then the corresponding voltage signal, which is produced by the sensor and symbolizes the value of the opening, is sent into ECU [6].

There are five positions to locate the valve plate of electronic throttle: the minimum mechanical cutoff position OMA, the highest mechanical cutoff position UMA, the lowest electrical cutoff position OEA, the highest electrical cutoff position UEA and the initial position NLP. The position distribution is shown in Figure 1.

The roundtrip response times (UEA to OEA, OEA to UEA, NLP to OEA, OEA to NLP, UEA to NLP) under three different temperature environments (- 40 °*C* , -48 °*C* , and 120 °*C*) absolutely reflect the comprehensive performances of the position sensor, the drive motor, the return spring and the mechanism. Therefore, the response times can be reckoned as criteria for determining whether an electronic throttle is qualified. As is shown in table 1, standard roundtrip response times of certain type of electronic throttle are listed.



Fingure 1 Positions of the throttle valve

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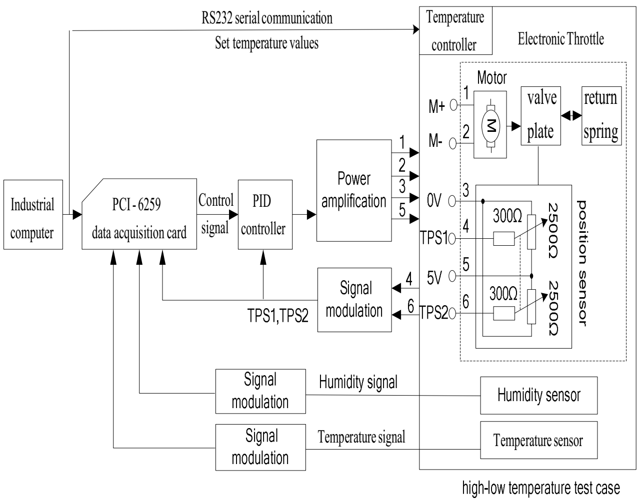
Table 1 standard roundtrip response times of certain type of electronic throttle

temperature	120℃	-40℃	-48℃
UEA-OEA	<100ms	<100 ms	<100 ms
OEA-UEA	<100 ms	<100 ms	<100 ms
NLP-OEA	<100 ms	<100 ms	<100 ms
OEA-NLP	<500ms	<500ms	<300ms
UEA-NLP	<500ms	<500ms	<300ms



Fingure 2 The structure of system hardware platform

To begin with the opening performance test of electronic throttles, simulate control commands and signals of ECU to make the valve plate of electronic throttles commute in several above positions. Then, collect the output signals of the position sensor, calculate the response times in all positions, and compare them with standard roundtrip times of corresponding type of electronic throttle. Then the result of the quality evaluation is obtained.

According to the manufactures' requirements of the products, the major functions and performances of the test system are as follows.

a) Realize the precise control of electronic throttles and measure five response times under certain temperatures（-48 °*C* , -40 °*C* , and 120 °*C* ）.

b) Simultaneously run a test on four different types of products

c) Add a new function that the system can test new types of electronic throttles

d) Display real-time curves and test results, output test results in report forms, and inquire current and historical test data.

e) Test condition: Motor supply voltage is 13.5V±0.1V, Sensor supply voltage is 5V±0.1V.

f) Time accuracy: ±0.1ms.

g) Temperature accuracy: ±1 °*C*

h) Relative humidity accuracy: ±10%.

III. THE DESIGN OF ELECTRONIC THROTTLE PERFORMANCE TEST SYSTEM

A. The achievement of hardware platform

The system mainly consists of the high-low temperature test case, PID controller, PCI-6259 data acquisition card and the industrial personal computer. The structure of system hardware platform is shown in figure 2.

As is shown in figure 2, terminal 1 and 2 of electronic throttle respectively stand for power (+) and (-) of the drive motor. Terminal 3 and 5 are the power terminal and ground terminal of the position sensor in the electronic throttle. Terminal 4 and 6 respectively stand for positive output and negative output (TPS1 and TPS2) of position signals.

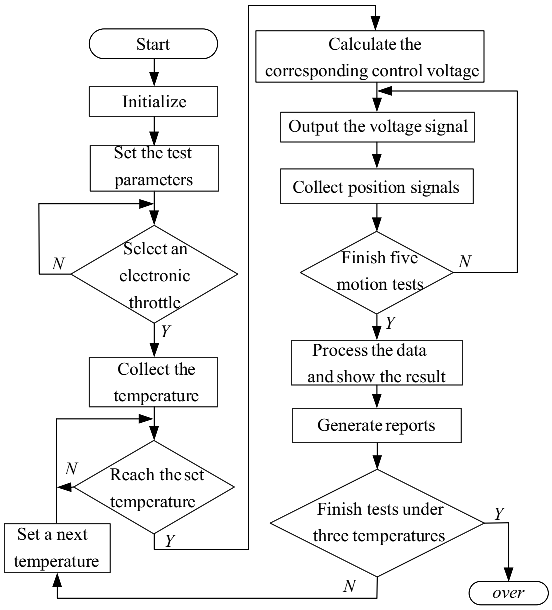
The temperature test case can accurately simulate low temperature, high temperature, high temperature and high humidity, low temperature and low humidity, and variable temperatures, as well as achieving the automatic control of temperature and humidity according to the set value, so as to construct the experiment conditions for the test system.

PID controller, PCI-6259 data acquisition card and the position sensor, altogether make a loop feedback control system[7-9], which aims to keep the opening in the set rang and complete the precision control of the opening.

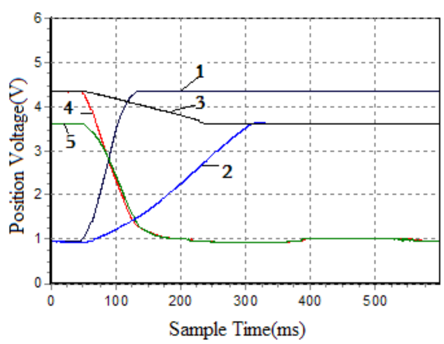
PCI 6259-32 data acquisition card includes 32 analog input channels (16 bit), 4 analog output channels and 48 digital I/O channels. The analog inputs are connected to achieve signal acquisitions of the position sensor, the temperature sensor and the humidity sensor. The analog outputs transmit the set position signals of electronic throttles. The digital I/O channels complete the condition monitoring and the switch controlling.

B. The working principles of the system

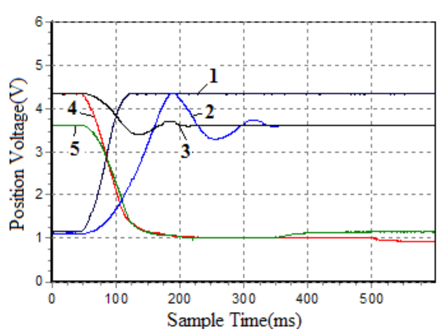
Start the HCI in the host computer, and select an electronic throttle that needs to be tested. Then set the control parameters and send them to the high-low temperature test case through RS232 serial port. The high-low temperature test case automatically changes (heating or cooling) the inner temperature with the received parameters. Meanwhile, the PCI-6259 data acquisition card collects the temperature in the case, and when the temperature reaches the set value for a while, the host computer calculates the control voltages corresponding with the positions according to the set parameters and transmits the voltage values to the PID controller through the PCI-6259 data acquisition card. With the control voltages, the PID controller can accurately dominate the motion of the valve plate. Then the data acquisition card collects the real-time opening signals of the valve plate and the dynamic response curves are shown in the interface of the host computer. After five motion tests (UEA to OEA, OEA to UEA, NLP to OEA, OEA to NLP, UEA to NLP), the software in the host computer analyzes the collected data and calculates the corresponding response times according to the dynamic response curves. Compared



Fingure 3 The main program flowchart of the system



(a) the valve plate opening dynamic response curves in -48 °*C*



(b) the valve plate opening dynamic response curves in 120 °*C*

Fingure 4 Opening performance curves

Table 2 Test result in -48 °*C*

	Standard time	Test data	Test result
UEA-OEA	<100.0ms	78.3 ms	qualified
OEA-UEA	<100.0ms	45.5ms	qualified
NLP-OEA	<100.0ms	76.4ms	qualified
OEA-NLP	<500.0ms	243.3ms	qualified
UEA-NLP	<500.0ms	174.0ms	qualified

Table 3 Test result in 120 °*C*

	Standard time	Test data	Test result
UEA-OEA	<100.0ms	79.9 ms	qualified
OEA-UEA	<100.0ms	37.2ms	qualified
NLP-OEA	<100.0ms	54.5ms	qualified
OEA-NLP	<500.0ms	96.8ms	qualified
UEA-NLP	<500.0ms	49.7ms	qualified

with the standard roundtrip times, whether the electronic throttle is qualified at the current temperature can be judged.

Set a next temperature value and send it to high-low temperature test case, then stop repeating above procedures until all the tests are done, and finally reach a conclusion on the quality evaluation.

C. The Design of System Software

The test system applies C++ Builder6.0 as the development tool. With all the advantages of C++, C++ Builder, which is powerful and effective in the C++ development areas, supports a lot for the system development [10]. The main program flowchart of the system is shown in figure 3.

As is shown in Figure 3, the program completes the parameter setting, the data acquisition and the data processing etc. The parameter setting involves system parameter settings, criteria parameters setting and sensor parameter setting. The data acquisition means the real-time acquisition of position signals, temperature signals and humidity signals. The data processing needs to draw real-time curves of temperature-time and position voltage signal-time. After five response times are analyzed and calculated, whether an electronic throttle is qualified can be judged. Moreover, the data processing has several functions, such as saving test data, selecting current and historical data, as well as generating and printing report.

IV. THE ANALYSES OF THE TEST RESULT

Opening dynamic response curves of the valve plate are generated and shown in figure 4 after doing the tests on certain type of electronic throttle under the temperature -48 °*C* and 120 °*C* .

Based on the time response curves, five response times can be calculated by the software. After comparing the calculated times with the standard round-trip times, whether the electronic throttle is qualified can be known. The quality evaluation results are shown in table 2 and 3.

From the curves and results, it is concluded that this test system can make the precise control of electronic throttle, accomplish the real time collection of position signals, calculate the response times with the collected data, and obtain the result. Therefore, the system can achieve the quality evaluation of electronic throttle.

V. CONCLUSION

(1) The test system can take precise tests of the opening performance, so as to evaluate the quality of electronic throttle.

(2) The human-computer interface is friendly and

intelligent, easy to operate and maintain, and has a short development cycle.

(3) The test results show that the system design is reasonable, easy to use and can be applied in electronic throttle production. From the manufactures' replies, more than 40% of the test time is saved.

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