Design and Implementation of Automatic Test System for Air Tightness of Clean Angle Valve

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Abstract: Aiming at the air tightness test requirements of a clean Angle valve, an automatic valve air tightness test system based on virtual instrument technology is designed and developed. This system adopts the direct pressure method and the difference pressure method to carry on the redundant design, which makes the system has strong reliability. Furthermore, the system uses LabWindows/CVI as the software development platform, which makes the system has strong expansibility. The actual test shows that the system can realize the automatic detection of the valve tightness.

1. Introduction

Cylinder valves are widely used in daily life with high safety requirements. Therefore, they must go through a series of type tests including durability test and air tightness test before being put into production, and even in the case of the design document or main manufacturing process being changed, or stop production time for more than 6 months, the same series of type tests must be performed before restarting production. Air tightness test can effectively prevent unqualified cylinder valves from causing safety hazards in daily life. At present, there are only relevant standards and no practical test methods for air tightness test.

With the continuous development of automatic testing technology, virtual instrument technology gradually occupies the leading position in the testing field[1]. Taking virtual instrument technology as a software platform, using the characteristics of its graphical programming, a set of good human-computer interaction interface test system can be quickly set up according to the different requirements of virtual test panel[2]. In this paper, a set of valve air tightness automatic test system is developed based on virtual instrument technology according to the air tightness test requirements of the clean Angle valve.

2. Air Tightness Test Scheme Design for Clean Angle Valve

2.1 General Method for Valve Tightness Test

At present, the tightness detection equipment used in industrial production is mostly designed according to the gas flow formula. According to the different measured parameters, the methods of air tightness detection based on gas flow formula are mainly divided into direct pressure method and internal differential pressure method [3], and the both methods use the internal pressure or differential pressure of the tested valve to calculate the leakage flow of the valve.

2.1.1 Air tightness test method based on direct pressure method

Direct pressure method is a kind of air tightness test method which calculates the product leakage rate through the pressure variation. In this method, a certain pressure gas is filled into the sealed workpiece. After the pressure is stabilized, the pressure is maintained for a period of time, and the

pressure sensor detects whether the pressure drops. This detection method has the advantages of high efficiency, strong universality, high detection rate and no damage to the tested products. For the reason that the accuracy is not high, it is mainly used in the test of products with low sealing requirements.

2.1.2 Air tightness detection method based on differential pressure

Differential pressure air tightness detection method based on differential pressure is also called comparative method. The leakage amount of the workpiece under test is obtained by detecting the pressure difference between the standard container and the workpiece under test, so this method requires a standard leak-free product or a sealed tank with tiny difference between the internal volume of the workpiece and the detected product volume[4]. The basic principle of the differential pressure detection method is shown in figure 1. The two ends of the differential pressure sensor are connected to the standard vessel and the workpiece under test respectively. When the air source and valve 1 are opened, the compressed air enters the chamber of the standard vessel and the workpiece under test respectively through valve 2 and valve 3, thus forming a closed balance system. When the test begins, valve 2 and valve 3 are closed simultaneously, and the standard chamber and the chamber under test form two separate Chambers. If there is no leakage in the standard container cavity and there is leakage in the workpiece under test, the differential pressure will be generated between the two sealed cavities, and the leakage amount can be calculated according to the pressure difference.

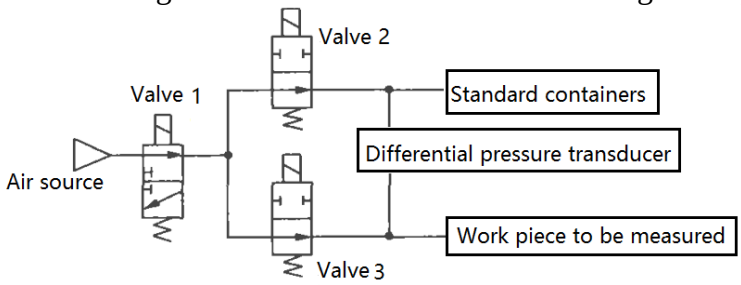

Fig. 1 The basic principle of the differential pressure detection method

The air tightness detection method based on pressure difference has high detection accuracy, but it is not universal and requires two fixtures. The detection cost is twice as high as that of the pressure-drop detection method. Furthermore, If the standard parts have problems, the results of the differential pressure air tightness test are not the same, so the standard parts need to be verified regularly. Because the range of differential pressure test method is small, it is not suitable for the test of workpiece with large leakage. This method is mainly used in the occasions with high test pressure and high resolution.

2.2 Test Scheme Proposed in This Paper

2.2.1 Test requirement

This type of clean Angle valve is often used in the high pressure applications where sealing is strictly required. The test procedure for the leakage rate of the valve is as follows:

step1: When the pressure of blowback gas reaches 6bar, measure the leakage rate before the valve start action;

step2: After the valve act for 10,000 times, then stop, and measure the leakage again;

step3: Repeat step2 for 5 times and record the leakage rate each time.

2.2.2 The proposed test scheme

In order to ensure the accuracy and reliability of test results and prevent the failure of a sensor in the test process, the data acquisition module of this test system adopts redundant design. Namely simultaneously installs the pressure transmitter and the difference pressure transmitter to carry on the signal acquisition. The leakage rate test method is as follows: After the opening and closing of the cleaning Angle valve, stop supplying air to the blowback gas cylinder, and measure the change of the

air pressure of the blowback gas cylinder with time. By collecting the sensor value in the pressure maintaining pipeline, the pressure drop value in unit time under the pressure maintaining state is calculated, and then the leakage rate is obtained.

3. Measurement and Control System Design for Clean Angle Valve Air Tightness Detection

3.1 Hardware Design

As shown in figure 2, the measurement and control system is implemented by means of embedded computer with configuration of data acquisition module, counter module and digital I/O module. The data acquisition module completes the acquisition of differential pressure, pressure, temperature and other signals. The counter module carries out cylinder switch time test through the stroke switch. The digital I/O module drives the solenoid valve after power amplification through the power amplifier plate. The selected embedded computer is an industrial-grade computer with working temperature -20 ℃ ~ 55 ℃. Its configuration is Intel Core i3 processor, memory 2G, hard disk 500G. The multi-function card selected is 16-channel single-terminal analog acquisition with 16bit resolution, 250kS/s sampling rate, and has 4 channels of analog output, 8 channels of digital IO, 5VTTL, 3 timing counters, and a maximum frequency source of 10MHz.

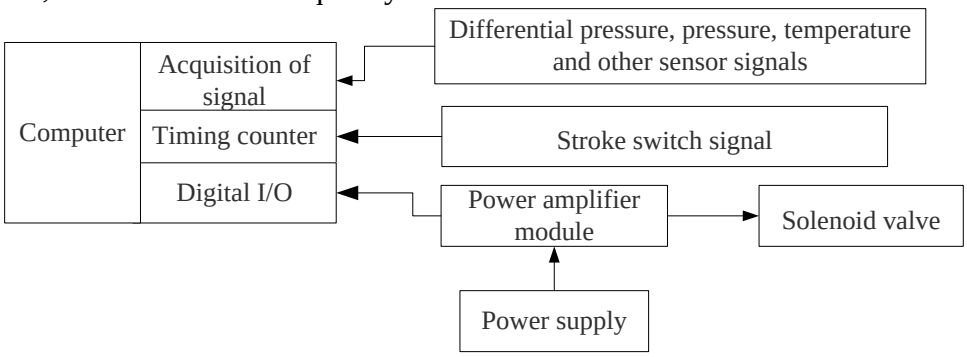

Fig.2 The component module of Measurement and control system

3.2 Software Development

The measurement and control system software is developed with LabWindows /CVI, a special software development tool for virtual instruments of NI company in the United States. The application development process is shown in figure 3.

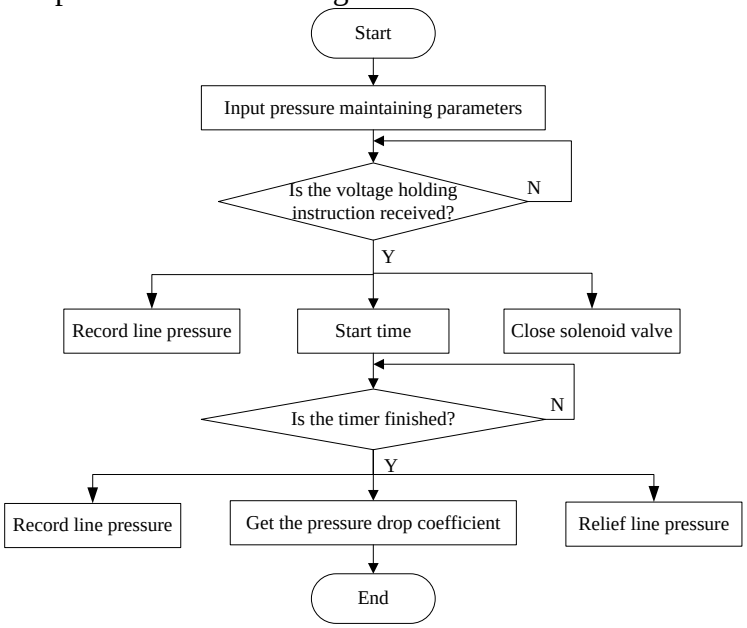

Fig. 3 The flow chart of the application development process

Figure 4 shows the software interface of the leakage rate test developed with LabWindows/CVI. The operating instructions of the panel are as follows:

- Click “Switch” button to turn on the power and complete the hardware initialization, or to turn off the power and to release the device object.
- Click “Start” button to start device and nonsynchronous timer.
- Click “Collect Initial Value” button to collect initial pressure and initial pressure difference of pipeline.
- Click “Test Leak Rate” button to calculate leak rate of pipeline.
- Click “Stop” button to down device and stop nonsynchronous timer.
- Click “Quit” button to release the device object and exit the application.

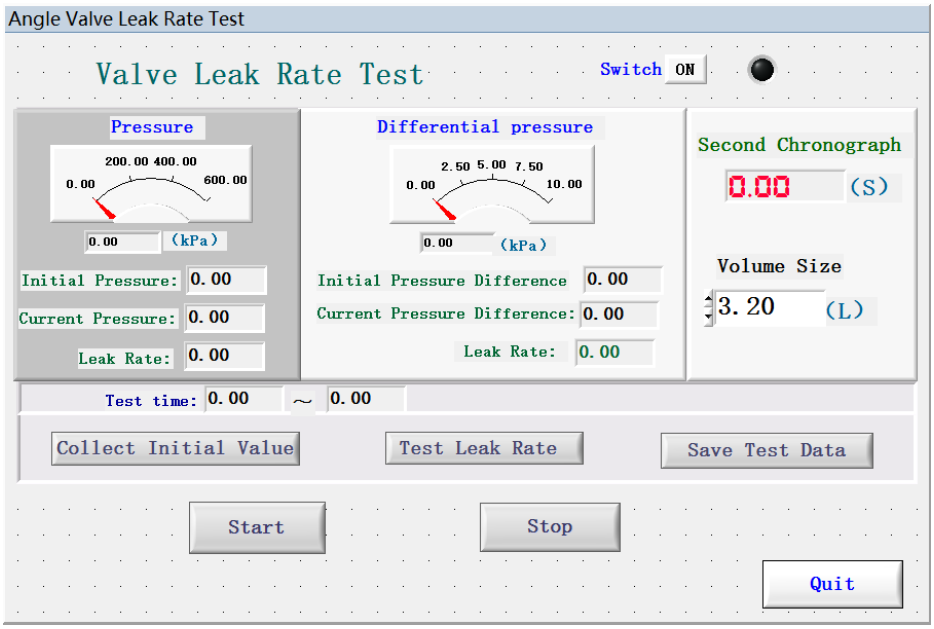

Fig. 4 The software interface of the leakage rate test

4. Conclusions

Valve safety testing is of great significance to ensure product quality, production and life safety. According to the test requirements of the clean Angle valve, this paper adopts the direct pressure method and differential pressure method to design the test scheme, and develops the measurement and control system based on the virtual instrument technology. The test results show that the system can meet the test requirements of the leakage rate of the clean Angle valve.

Acknowledgments

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