Design of Piston Gauge Verification Data Processing System Based on LabVIEW

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Abstract: In order to check the weight of the quality of piston and its connecting parts more conveniently, this paper designs a set of data processing system for piston gauge measurement and verification based on LabVIEW. The system uses LabVIEW development platform to establish a visual human-machine interface. According to the requirements of JJG59-2007 National Verification Regulation of Piston Pressure Gauge, a set of data processing system is designed and completed. The system can accurately and effectively calculate the special weights of Special Weight, Piston and Connecting Parts of Piston Gauge according to the verification data. It greatly improves the work efficiency. The research lays a foundation for adding piston position indication device and automatic generating and exporting of original records in the system.

1. Introduction
Piston pressure gauge is a measuring standard that uses the principle of hydrostatic balance (that is, the fluid pressure acting on the effective area of the piston is balanced with the gravity of its load). It is a high accuracy, high reproducibility and highly credible standard pressure measuring instruments[1-3]. According to the requirements of the national verification regulations of JJG59-2007 "Piston Pressure Gauge", after the instrument completes the effective area verification of the piston, there will be a large amount of raw data to calculate the effective area of the piston, the special weight, the quality of the piston and its joints according to the formula. Due to the complex formula and large amount of data, the calculation is easy to make mistakes and the work efficiency is low. For this reason, the intelligent data processing system can greatly improve the accuracy, reliability and efficiency of the verification results[4-5].

In recent years, with the development of artificial intelligence, virtual instruments have been more widely used. Instead of the control panel of a conventional instrument, the virtual instrument uses a computer's powerful graphical environment to create a graphical soft-faced panel on a computer screen instead of a conventional traditional instrument panel using a visual graphical programming language and platform. The soft panel has knobs, switches, indicators and other control components similar to the actual instrument. During operation, the user operates the soft panel with a mouse or keyboard to verify the communication and operation of the instrument. The development language based on LabVIEW graphics is simple and easy to understand, and it is convenient to adjust and
maintain subsequent software. Therefore, this paper uses LabVIEW virtual instrument development platform to establish a simple and friendly visual human-computer interaction interface, and designs an intelligent piston pressure gauge verification data processing system. The system uses LabVIEW visual programming technology to establish a human-computer interaction interface. Through the raw data processing and analysis obtained by the verification, the piston effective area, special weight, piston and its connector quality are obtained [6-8].

2. Data processing system design
The system uses the LabVIEW development platform developed by NI National Instruments to realize the functions of data display, analysis and processing, which is easy to operate and maintain. The overall design of the system is as follows: the piston and the standard piston pressure gauge to be tested are installed on the same calibrator (or the standard piston pressure gauge and the piston pressure gauge to be tested are connected through the pipeline), and the piston is adjusted. Vertical position. According to the hydrostatic balance method, the area of the piston gauge to be inspected is compared with a standard pressure gauge. Since the standard piston type pressure gauge and the piston system of the tested piston type pressure gauge have basically the same material and shape, the laboratory adopts the initial balance method. After the verification according to the regulations, the detected piston is calculated from the obtained raw data. The effective standard area of the pressure gauge piston, the experimental standard deviation of the effective area value, the piston effective area limit error, the special weight, the piston and the joint quality[9-12]. The overall design of the system is shown in Figure 1:

![Figure 1. Overall system design](image)

In order to realize the function of data processing, the block diagram is divided into two parts. Firstly, the effective area and effective area value of the piston of the piston type of the tested piston are calculated by the obtained raw data and the effective area of the piston of the known standard piston gauge. Experimental standard deviation, piston effective area limit error; secondly, through the piston piston gauge effective area and other known parameters, such as measured pressure value, ambient air density, special weight, piston and connector material density and piston The gauge weight, piston and connector quality are calculated by the gravitational acceleration of the pressure gauge.

The software running environment is LabVIEW 8.5 under Windows XP, which consists of a front panel and a block diagram. Using the system's own display controls, input controls, execution of
process control loops, etc. to achieve the experimental standard deviation of the effective area value and the calculation of the special weight, piston and connector quality. The rear panel block diagram is shown in Figure 2 and Figure 3 below:

**Figure 2.** Block diagram of effective area of piston piston gauge

**Figure 3.** Special weight, piston and connector quality block diagram
3. Experiment and analysis

The system has a friendly human-machine interface, realizes raw data input, and displays the data results after analysis and processing in real time, which is convenient for operation and maintenance. The raw data and the calculated data are input and displayed by the control panel to call the program calculation, and the experimental standard deviation of the effective area value and the calculation of the special weight, the piston and the connector quality are realized, and the input and output changes are visually displayed. The control interface is shown in Figure 4 below:

![Figure 4](image)

**Figure 4.** Data processing front panel interface

The verification raw data input through the control panel, the effective area of the standard piston gauge piston, the number of weights, the measured pressure value, the pressure deformation coefficient of the piston-cylinder assembly, the gravity acceleration at the place of use, the ambient air density, the weight material Density, etc., the running program realizes the calculation of the effective area of the piston of the tested piston gauge, the experimental standard deviation of the effective area value, the piston effective area limit error, the special weight, the piston and the joint quality, wherein the white box input is known. The data, gray box visually shows the results. During the inspection of the piston gauge, the raw data obtained can be entered into the data processing front panel during the inspection. After the verification is completed, click the Run button, and the verification result will be displayed directly on the front panel interface.

In the experiment, the calibration data of a piston pressure gauge with an accuracy level of 0.02 and a measuring range of (1~60) MPa was processed. The comparison between the effective area of the tested piston pressure gauge and the 5MPa special weight is shown in Table 1 below. The comparison results are completely correct, and the visualization operation is simple and the work efficiency is greatly improved. The traditional method takes about 30 minutes to complete a calculation on the premise of rich verification experience, and this calculation method only takes 1 second after completing the input of raw data, which greatly improves the work efficiency and reduces the cost Labor intensity.
### Table 1. Comparison of calculation results

| Project                        | LabVIEW calculation | Traditional calculation method |
|--------------------------------|---------------------|-------------------------------|
| **Checked piston pressure gauge effective area** (cm²) |                     |                               |
| 0.10011156                    | 0.10011165          |                               |
| 5MPa special weight(Kg)       |                     |                               |
| 1st piece                     | 5.10796             | 5.10797                       |
| 2nd piece                     | 5.10800             | 5.10801                       |
| 3rd piece                     | 5.10804             | 5.10805                       |
| 4th piece                     | 5.10808             | 5.10808                       |
| 5th piece                     | 5.10812             | 5.10812                       |
| 6th piece                     | 5.10815             | 5.10816                       |
| 7th piece                     | 5.10819             | 5.10820                       |
| 8th piece                     | 5.10823             | 5.10824                       |
| 9th piece                     | 5.10827             | 5.10827                       |
| 10th piece                    | 5.10831             | 5.10831                       |

### 4. Conclusion

In this paper, the data processing system of piston pressure gauge measurement and verification is studied. The LabVIEW development platform is used to establish a visual human-machine interface, and a data processing system is designed and completed. Experiments show that the system can accurately and effectively calculate the effective area of the piston of the piston gauge under test, the special weight, the piston and its joints according to the verification data, which greatly improves the working efficiency. In the next step, you can consider adding multi-channel data acquisition and signal processing to the system hardware design. Adding modules such as ambient temperature detection, piston rotation speed detection, and piston position indication device to the system can complete the verification environment in the piston pressure verification project. The work of the piston rotation duration test, the piston drop speed test and other projects basically cover all the verification items. In addition, the original record automatic generation and export function is added in the system software design, the verification data can be retained, the original issuance and the verification certificate are issued, which will greatly improve the work efficiency and the accuracy of the measurement, and ensure the accuracy and stability of the value transmission.

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