DESIGN OF LONG CANISTER MACHINERY PRODUCT MULTIFUNCTIONAL MEASUREMENT SYSTEM BASED ON LABVIEW

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ABSTRACT
Dimensional tolerance and geometric tolerance are the most important technique indicators associated with the function of a machinery product. This article introduced a measurement system, which was developed for a long canister machinery product which needs 100% detection. The inspecting mode, still dependent on a coordinate measuring machine or any other precision measuring instrument, leads to low speed of detection and low accuracy. Aiming at solving the problem, an automatic measurement system is built based on virtual measuring technology, based on LabVIEW virtual instrument platform to develop the main control program to build the peripheral hardware which was founded on some key technique: fixing appliance, sensor applications, exact arithmetic, system integration. Furthermore, it is essential to carry out the research of generalized design. Through using hardware modular unification, interface design standardization, software functionality and configurable hierarchical, achieved the goal of measuring dimensional tolerance and geometric tolerance on the same instrument. Experimental results show that inspection accuracy of the proposed system reaches 99.80%, and the measurement error is less than 0.043mm. The measurement result satisfies the requirement of the long canister technique indicators. The synthetical measurement efficiency reaches three times that of the former method.
Keywords: dimensional tolerance and geometric tolerance, LabVIEW, fixing appliance, sensor, precision.

1 INTRODUCTION

In this paper, a multifunctional measurement system is used for measuring the dimensional and geometric tolerance of long canister. The precision of some dimensional tolerance and geometric tolerance of long canister are very high, which will directly affect the product quality of subsequent fittings. These parameters mainly include diameter, roundness, thickness uniformity and so on. In the early stage of product development, the precise measurement method which can meet the requirement of measuring precision is established, which is mainly achieved by measuring the coordinate measuring machine and special locating fixture. However, with the gradual expansion of the production scale of tubular parts, the defects of the original detection methods gradually appear, as shown in Table 1. Therefore, it is necessary to develop a special detection device to achieve accurate and efficient measurement of products.

The canister is made of special process, which is difficult to fixed because the inner wall is smooth and the outer surface is rough. For the outer diameter, it is particularly important to design a reasonable signal acquisition unit, in order to meet the accuracy of the mining point and avoid scratching the wall. At the same time, the design of measurement system and data processing are the key factors that affect the accuracy of system. This paper introduces the design and development process of the special testing system.

2 THE OVERALL DESIGN IDEA OF SYSTEM

According to the measurement requirements of the canister, the paper develops the selection of measuring sensors and the research of measuring positioning tooling, which is embedded

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Table 1: Insufficient performance of the original detection method.

Parameter name	Detection method	Defects
Outer diameter	CMM	Low detection efficiency
Inner diameter		
Roundness		
Uniformity of wall thickness	Micrometre	Fewer points and low detection accuracy
Vertical degrees	Positioning device and dial indicator	Complex process and inefficient

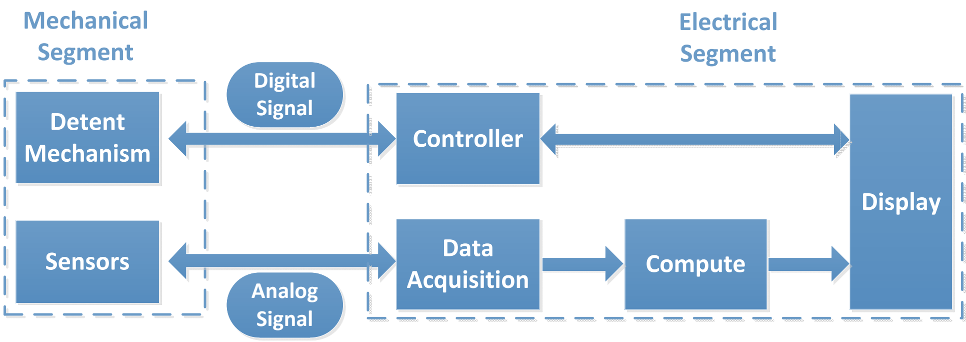

Figure 1: System structure diagram.

in the mechanical part of measuring platform after measuring sensor and electrical control component. The control and data processing hardware integrates the PXI system to form the electronic control part hardware, and realizes the communication with the special measuring program developed by LabVIEW, which constitutes the measurement and control part of the measuring platform, and finally establishes the special measuring platform of canister through the combination of the hardware and software of the mechanical part and the control cabinet. The system composition of the measuring platform is shown in Fig. 1.

3 MECHANICAL PART DESIGN

3.1 External positioning mechanism

The device is used for external positioning of the canister. Canister is positioned on the V-shaped rack, and lifted up to the measuring position by cylinder.

3.2 Internal positioning mechanism [1]

The internal positioning mechanism is a three-point structure, which is consisting of two fixed bearings and an active bearing, as shown in Fig. 3. The fixed bearings are used for positioning the canister, and the active bearing will lock it by a compressive force F from

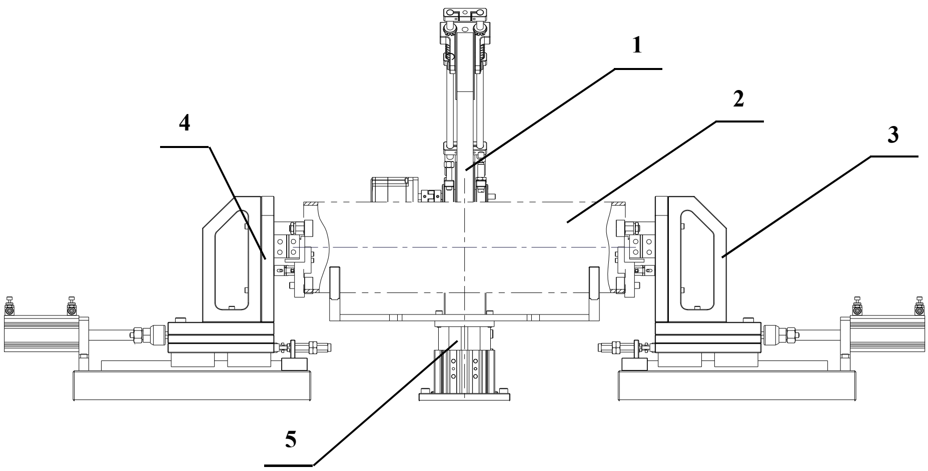

Figure 2: Structure Chart of measuring positioning mechanism. 1 – friction drive mechanism; 2 – tubular parts; 3, 4 – internal support positioning mechanism; 5 – external support positioning mechanism.

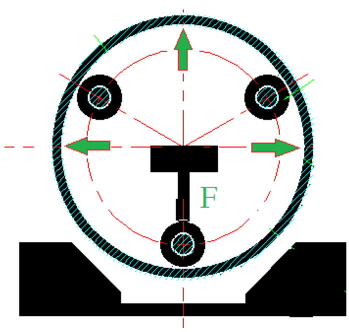

Figure 3: Measuring positioning mechanism.

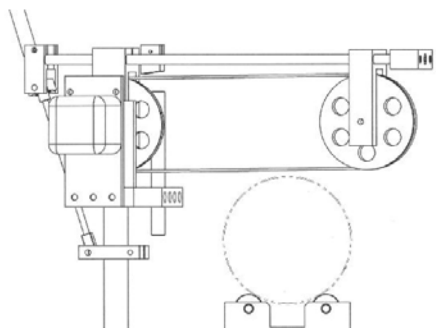

Figure 4: Friction Drive mechanism.

microcylinder. This mechanism can make the digital signal more stable, while avoiding the measurement error.

3.3 Driving mechanism

The driving mode is friction drive, as shown in Fig. 4, the friction belt is driven by cylinder to the right position. The friction belt that driven by motor clad around the outer surface of the canister. As result, the sensor will get signal stably because the canister rotates constantly.

4 MEASUREMENT PART DESIGN

In order to meet the requirement of signal acquisition of measurement parameters, a total of 12 measuring sensors were set up in the corresponding position of the canister, as shown in Fig. 5.

1. Measuring internal diameter. Four inductance sensors (1#, 2#, 3#, 4#) are arranged inside the canister, as shown in Fig. 5.
2. Measuring external diameter. In order to overcome the influence of the rough surface of the canister on the signal acquisition (5#, 6#, 11#, 12#), as shown in Fig. 5. Two different types of sensors are used to measure the external diameter. One is the use of DCM (displacement conduction mechanism). The measurement part of DCM is a column structure, as shown in Fig. 6. It can effectively avoid scratches on the cylinder surface and improve measurement precision of inductance sensor. The other way is laser sensor, as shown in Fig. 7. The measuring value of the wall thickness is obtained through the calculation of internal and external diameter.
3. Measuring end-face verticality. Four sensors (7#, 8#, 9#, 10#) are used for End-Surface measurement, as shown in Fig. 5.

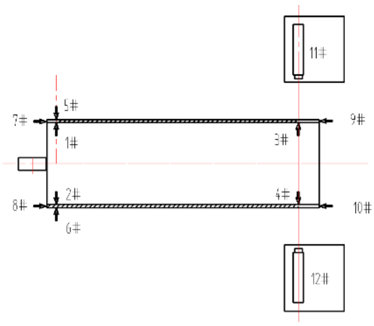

Figure 5: Sensor position schematic diagram.

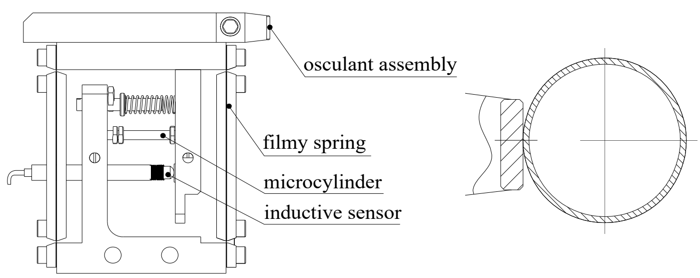

Figure 6: DCM structure schematic diagram.

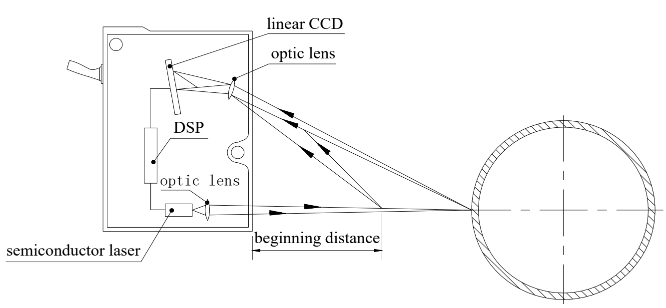

Figure 7: Laser sensor measurement schematic diagram.

5 DESIGN OF MEASUREMENT AND CONTROL SYSTEM

5.1 System hardware design

The system hardware is designed with NI Company's PXI platform. It has good timing and synchronization performance which can improve the accuracy of measurement. Based on the research of the hardware design requirements of the system, the main hardware models are determined, as shown in Table 2.

The control part of the system adopts modularized design, which is including the data acquisition module, I/O module and motor control module. The system overall architecture is shown in Fig. 8.

5.2 System software design [2]

The system software adopts LabVIEW development platform, which is also developed by NI Company, it is a good choice of hardware compatibility. The advantage of this integration approach are stability and expansibility. So, it can create a good software environment for the subsequent secondary development and reorganization. The software functional architecture is shown in Fig. 9.

Table 2: Hardware configuration.

Selection requirements	Type	Model
High speed data storage and computation, a variety of mechanical movements control and information gathering	Chassis	PXI-1042
	Controller	PXI-8115
16 group sensor signal Source, range ± 0.5mm, output voltage ± 5V, board measurement accuracy than 1mV	Data Acquisition Card	PXI-6289
16-input, 14-output, high and low-Potential, drive motors	Digital I/O Card	PXI-6528

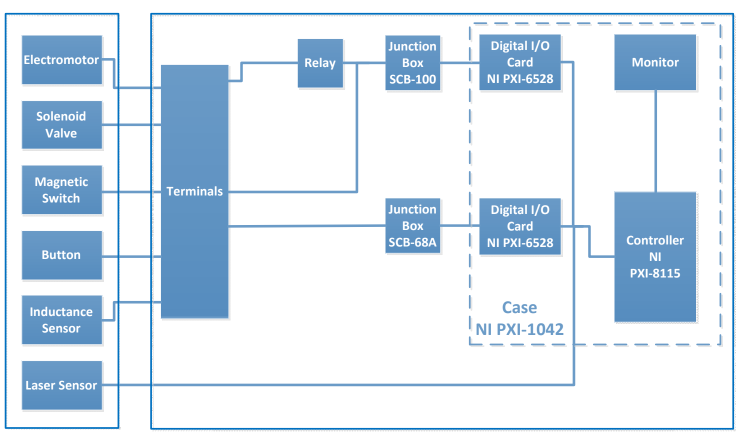

Figure 8: System Hardware architecture diagram.

5.2.1 Data acquisition program design

LabVIEW provides a perfect interface program for collecting cards. The NI-DAQmx VI function module is mainly used for instrument, data acquisition and control application. It can realize the different kinds of data completes the processing function simultaneously by collect or sent in a single or batch form. The program as shown in Figs 10, 11 and 12.

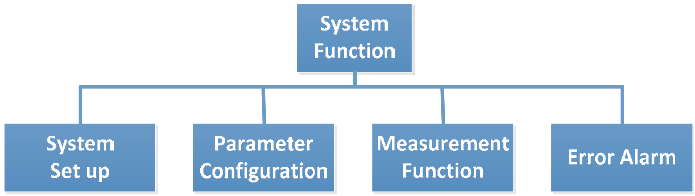

Figure 9: System function diagram.

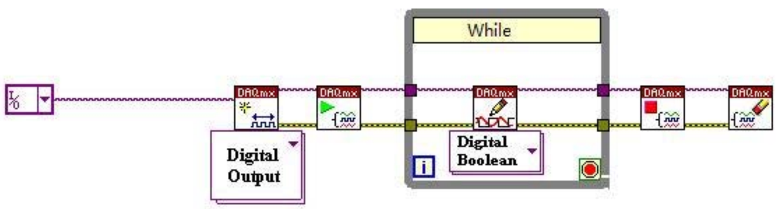

Figure 10: Digital signal Acquisition program code block diagram.

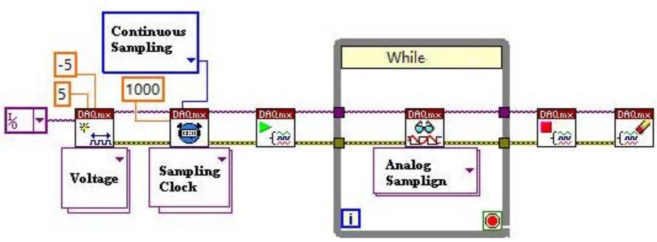

Figure 11: Analog Signal Acquisition program code block diagram.

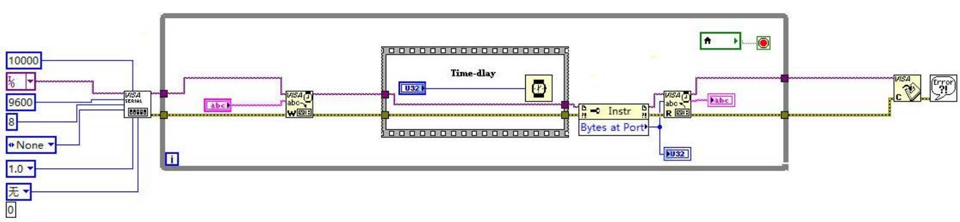

Figure 12: Serial data Acquisition program code block diagram.

5.2.2 The program design of sensor linearity correction

As we know, the actual linearity of the sensor usually has some deviation with the nominal linear level. So, the calibration and correction is necessary. Through calibration and calculate the correction coefficient formula for:

$$y = ax^4 + bx^3 + cx^2 + dx + e \tag{1}$$

Then write the Sub VI for correction compensation, which include the sensor number and optimized data. The revision program as shown in Fig. 13.

5.2.3 Data compensation program design

During the system debugging, it was found that the roundness measurement error cannot be amended by a fixed value. Experimental data analysis shows that the measurement difference between measuring system and CMM is mainly caused by different sensor triggering modes. The compensation empirical formula is fitted through statistical analysis of many specimens, such as:

$$y = ax^2 + bx + c \tag{2}$$

The roundness calculation results are optimized and the correction of the system measurement error is realized.

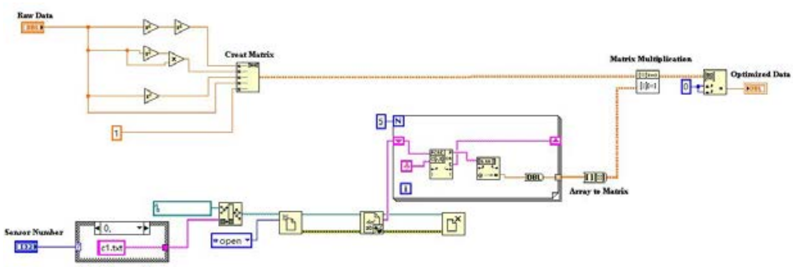

Figure 13: Sensor linear correction program code diagram.

Table 3: Statistical tables for measurement of repetitive results.

Parameters / Specimen	Left				
	Outer diameter	Inner diameter	Roundness	Vertical degrees	Thickness
1#	99.90%	99.92%	99.95%	99.92%	100%
2#	99.95%	100%	99.90%	99.92%	99.92%
3#	99/90%	99.92%	100%	99.95%	100%
4#	99.95%	99.92%	99.95%	99.95%	99.95%
5#	99.95%	99.95%	100%	99.9%	99.95%
Parameters / Specimen	Right				
	Outer diameter	Inner diameter	Roundness	Vertical degrees	Thickness
1#	99.95%	99.95%	100%	99.95%	99.90%
2#	99.95%	99.95%	99.95%	99.92%	99.95%
3#	99.90%	99.90%	99.80%	99.92%	99.95%
4#	99.95%	99.95%	99.92%	99.92%	100%
5#	99.95%	100%	99.95%	99.95%	99.95%

Table 4: Statistics of measurement accuracy results.

Parameters / Error	Left(mm)				
	Outer diameter	Inner diameter	Roundness	Vertical degrees	Thickness
δ_{max}	0.007	0.008	0.034	0.013	0.037
Parameters / Error	Right(mm)				
	Outer diameter	Inner diameter	Roundness	Vertical degrees	Thickness
δ_{max}	0.008	0.012	0.043	0.013	0.029

6 TEST RESULTS

6.1 Repetition [3]

Select 5 test specimens, and each of them is measured 10 times continuously, and each measurement requires the reload of the canister, calculate the results of the 10 measurement of the standard deviation (S_g), data statistic results as shown in Table 3.

6.2 Accuracy

Recording each parameter value of 30 selected test samples, marked as $X_{i.}$ And calculate the indication error δ, which was the deviation between X_i and X_m (calibration values). Measurement data and calculation results as shown in Table 4.

6.3 Detection efficiency

Based on this system, the single detection time is reduced to 6 minutes by 15 minutes of the original method, and the detection efficiency is nearly 3 times higher.

7 CONCLUSION

a) This thesis solved the problem of the canister detection positioning. At the same time, the special signal acquisition unit can meet the measurement accuracy requirements and overcome surface roughness impact. So that, it was achievable which measure the dimensional tolerance and geometric tolerance simultaneously.
b) The function of mechanical control and signal acquisition of the measuring platform is realized by building a control system based on PXI platform, and the modular hardware measurement and control system are established.
c) Special measurement program based on LabVIEW is designed to solve the data transmission, numerical computation, fitting compensation software functions, and achieve the accurate measurement of the canister parameters. The measurement results show that the system repeatability and accuracy index can satisfy the system precision requirements.

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