Design of flow measurement system based on LabVIEW

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Abstract. The traditional flow meter is installed in the pipeline, not only to increase initial investment and cause stress loss to the system, but also to use a large amount of manpower and material resources in the data recording. In some areas that are not easily measured, such as buried in the ground, it can be difficult to measure. In order to solve these problems, based on the LabVIEW2013 as platforms and the hardware of sensor and data acquisition card, combined with the serial communication program to design the flow measurement system, getting traffic through the information collected data and the data acquisition card to convey in the program, get traffic after processing, according to flow to calculate the hydraulic balance, judging by the imbalance rate and the degree of hydraulic balance pipeline system is in a state of hydraulic balance. At last, through the actual test analysis, it is concluded that the flow measurement system for the conclusion of practical application, it not only can be used for pipe flow measurement and equilibrium state judgment, and also to have certain security on accuracy.

1. Introduction
The concept of virtual instrument was first proposed by the America company National Instruments (NI) in 1986 and has been developed and applied at high speed [1], investigating its reason, mainly is the computer ability to the powerful data processing, and then combined with the data acquisition card or bus and other related hardware and programming software and developed a kind of convenient and visual instruments.

Virtual instrument is the most essential is the meaning of "software is instrument", it has the following characteristics: strong running environment, software and hardware resource sharing, short development cycle, less cost and visualization programming languages and display interface etc [2]. LabVIEW is a through the use of graphic symbol, function and connection for programming software platform, it uses a programming language called graphical programming language, namely the G language, using the G language compared with traditional programming languages, short time-consuming, programming efficiency has improved greatly.

Computer, hardware, and LabVIEW combined into a virtual instrument can fully configured, however the cost is only a small part of the traditional instruments, even when changes to the requirement of instrument, it can be modified in an instant.

Therefore, the flow measurement system based on LabVIEW will have great development prospect and application scale in the field of flow measurement.

2. System composition
The entire virtual instrument system consists of two parts: hardware and software design.
The hardware foundation includes differential pressure sensor, data acquisition card and serial port communication program, etc. By comparing the advantages and disadvantages and using range of a variety of flow measurement method, combining the application of the virtual instrument conditions, this paper uses the differential pressure type flow measurement methods, and selection of the differential pressure type sensor in the flow sensor, throttle type models for BC69, its technical indicators as shown in table 1.

Choose the data acquisition card (DAQ) [3] for PCI8025, physical channel number is 4 channel, the input method of analog quantity is Double-end analog revenue, 12 of the 1 D/A channels and switch input and output channels all 16 road, resolution is 14, programmable gain 1 times, 16 k word FIFO memory, the sampling rate of up to 1.6 MHz, trigger type has edge trigger and pulses (level) trigger, the nonlinear error is plus or minus 1 LSB, system measuring accuracy is 0.05%, operating temperature range for - 40 ~ + 85. Serial communication programs mainly include the initialization of serial port and serial port data transmission, and the initialization of serial port is mainly used to set baud rate.

In the communication, the serial port communication baud rate is 9600, which uses the query method to send the data in the program design, the flow chart of serial communication program as shown in figure 1.

Table 1. Performance indicators of throttle flow sensor.

| range         | Working voltage | The output voltage | precision | Allow overload |
|---------------|-----------------|--------------------|-----------|----------------|
| 0~5000 kPa    | 24VDC           | 0~5 V              | ±0.5% FS  | 300% FS        |

Figure 1. The flow chart of serial communication program.

System software design using LabVIEW platform, a whole program [4] written in it composed by one or more of the children of the virtual instrument, virtual instrument in the following paper will be referred to as VI, each VI is constitute by three parts: the Front Panel, visual interface, program Block Diagram - the background program show and ICONS/connection port - connection hub [5].

System design in this paper not only includes the flow measurement, and even after the measured flow on the basis of these data get pipeline imbalance rate and hydraulic balance to reflect the piping system is whether or not to achieve hydraulic balance state.

Main program includes three parts: login module, real-time data and historical data, mainly through the serial port to receive the 8-bit digital quantity conversion and acquisition by lower machine to send
4 road A/D, through data processing to calculate the flow rate value, and the degree of hydraulic balance, unbalance rate can be shown up on the front panel at the same time. In addition, achieving the function of alarming, data storage and data acquisition parameter setting, etc.

3. The software design

3.1. Custom control and subVI design

Before editing the VI program may customize some controls that have specific request, on the custom control panel, it is a front panel that similar to the VI, according to user needs to be set, but the difference is not the program block diagram. In order to make the whole interface clearer and more intuitive, in this article, the mainly customized controls of the alarm lamp, starting collection, flow rate and hydraulic balance are made in real time.

As shown in figure 2, the self-definition setting of the control is shown in real-time display of alarm lamp, starting collection, flow rate and hydraulic balance.

In addition to customize control, it is written to the subVI of the call before the main program is written. The subVI, which is set up in the paper, has the flow meter operator VI, the hydraulic equilibrium calculation subVI, the alarm subVI, and TAB subVI, etc, which can be called in the main VI. The following is a presentation of the part VI, figure 3 is the flow meter operator VI's front panel and program block diagram, flow meter operator program block diagram of the writing is according to the principle of flow measurement of differential pressure type, and on the various parameters input and run after receiving the differential signal can get flow measurements.

Figure 4 is the pipeline resistance loss subVI and imbalance rate calculation subVI program, the concept of programming is based on unbalance rate, namely the difference value of pipeline working pressure and the pressure loss of the calculation of line and the ratio of the pipeline working pressure.
Figure 5 is hydraulic balance calculation VI's front panel and program block diagram, programming is also derived from the concept of hydraulic balance, in the case of known design flow to calculate the hydraulic balance.

SubVI programming is completed, in order to make the main VI successful call, in the upper right corner to select the mode of connection port and establish connection with input, output controls one by one, from the white line to non-ferrous wire frame, can be connected to the main VI to call.

Figure 3. The front panel and block diagram of the sub-VI-flow calculation.

Figure 4. The block diagram of the sub-VI-unbalance rate calculation.
3.2. The login module
Login interface can stop the non-operation personnel operating system, only the prescribed operating personnel can perform relevant operation, not only can ensure the safety of the system, at the same time greatly reduce adverse consequences due to operator's wrong operation, so setting up the login module is necessary.

When operators enter the user name equal to the set value, we have set the program execution down into the structure of the second condition, the input password value equals the value again, clicking on the login confirmation, system login successful. Otherwise, the wrong password login, the system could not log in.

Tab controls make login interface and real-time data and history query interface form a complete system well-organized, in other words, does not perform the login interface program, will not be able to perform at the back of the program, which greatly increases the security and confidentiality of the system [6].

3.3. Data collection and processing module
Data collection and processing module is the display interface of real-time data and the query storage interface of historical data.

The real-time data window is mainly used to implement 4 road traffic data real-time display, real-time flow curve display, unbalanced rate and degree of hydraulic balance figure display, and can set the configuration of the serial port in this interface, such as baud rate, data bits, stop bits and parity bit; in addition, it can set the rate of flow collection, the upper and lower limit of alarm flow and the storage path of selecting data.

It can start and stop data collection at the same time. In addition, when the flow value exceeds the design limit, the alarm indicator will blink and make an alarm sound.
Figure 6 shows the front panel of the real-time data interface.

Figure 7 shows the corresponding program block diagram, including VISA configuration serial node, which can be conveniently configured for the parameters of the serial port.

The serial buffer reads the node, which can read the data sent to the serial data buffer by the node; property node, which reads the number of bytes in the serial port; connect the above nodes correctly and combine the while structure and condition structure to carry out continuous reading of the data sent by a machine; by using the data frame decoding data of the obtained serial port data, the corresponding data of each channel is obtained.

![Image of the front panel of real-time data interface](image)

**Figure 6.** The front panel of real-time data interface.

Each channel data after processing, data can be entered to the computer interface for display, with the waveform chart to display the real-time flow curve, imbalance rate displayed in numerical form, with the strength of the chart color depth to represent the extent of the actual flow deviates from the design flow, namely hydraulic balance, at the same time of each channel is shown on the interface flow numerical and hydraulic balance; data storage is done primarily by writing to a text file.

The design by pressing the start button to read the data stored in the file, and on the historical data interface shows the historical data, including historical flow graph, historical hydraulic balance figure and historical time corresponding flow value.

For the convenience of data analysis, program flowchart is a specialized in the data is used to read history, its program design as shown in figure 8, the corresponding block diagram of the front panel and the process of the historical data interface are similar to the front panel showing the real-time data interface in figure 6.
Figure 7. The program diagram of real-time data interface.
4. System test analysis

The test validation of the flow measurement system based on LabVIEW mainly consists of two aspects: one is whether can get a precise flow value, the other aspect is whether the hydraulic balance and pipeline imbalance can be obtained after the measured flow data.

In the process of testing, we mainly is shown in figure 9 pipe for the differential pressure signal acquisition, A, B, C, D respectively represent 4 users, in figures 1-4 installation of differential pressure sensor, sampling the differential information of channel 1 - %4, through the data acquisition card plug wire connection, sending information to the PC, running can get data processing of the collected information, so get the numerical flow, in order to compare with the measured results of the flow measurement system, we reference literature [7] we measured flow numerical using ultrasonic flow meter, and the error between the two and the actual design flow is calculated respectively.

Through practical test and analysis can be concluded that the measured values of flow measurement system and the measured value of the ultrasonic flowmeter is very closed, and because of the flow measurement system in the process of flow values obtained only with the differential signal has direct relation, avoiding a lot of interference from outside world, such as the environment and human factors, so its measuring accuracy is higher, it can completely satisfy the measurement requirements, hydraulic balance and imbalance rate are also intuitive display correctly, and reflect the pipeline operation state of equilibrium. It can also record, query and analyze historical data.
5. Conclusion

Through research, this paper designed the flow measurement system based on LabVIEW, the hardware foundation based on differential pressure sensor, data acquisition card, setting up a serial port communication, the design of the software of the flow measurement system, adopts the modular concept.

On the basis of custom controls and establish a subVI completed the design of the main program, the system can continuous collect signal sent by sensors, and after further to deal with these signals, achieving data computing, storage and read, and a series of processing and the flow measurement; by measuring the flow value, the hydraulic balance ratio and the pipe imbalance rate are calculated to determine whether the pipeline is in a state of equilibrium.

Test validation for the flow measurement system, not only can be flow numerical display accurate, but also can meet the measuring accuracy, so the flow measurement system can be applied practically, especially in some occasions is not easy to measure such as the buried pipe flow, and it can be judged by imbalance rate and the degree of hydraulic balance state of the hydraulic balance of the pipeline system.

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