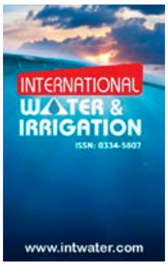

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Study on the Installation Quality and Ecological Environment Evaluation of Pressure Pipeline

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Abstract In order to further strengthen the safety supervision of pressure pipelines and improve their environmental affinity, this paper focuses on the research of pressure pipelines conveying flammable, explosive, toxic and other media, and describes their quality management methods. Combined with practical application experience, the safety management system of pressure pipeline is established based on the safety technical specification and the latest version of ISO9001-2015 quality management system standard. The monitoring system designed in this paper is mainly composed of fiber grating surface strain sensor, fiber grating demodulator, LabVIEW computer software and GSM communication module. The surface strain of the measured object is detected by the fiber grating surface strain sensor. The fiber grating demodulator is connected to demodulate the central reflection wavelength of the fiber grating. Then the wavelength information of the sensor is collected by the computer software LabVIEW system and input to the computer for analysis and processing. The real-time monitoring function of the monitoring system is verified by experiments. The real-time data information of the sensor and the change trend of the whole strain can be read from the monitoring system.

Keywords**:** Pressure pipeline, environmental compatibility, environmental protection, strain sensor.

1. Aims And Background

In today's developed industrial society, the so-called "pressure pipeline" does not only refer to the pipeline under pressure inside or outside the pipeline, but also includes the impact of a series of factors such as various media transported inside the pipeline and the external high-temperature environment on the pipeline[1-3]. Pressure pipes are widely used in various industrial manufacturing industries such as petrochemical industry, aerospace, steel energy, environmental protection, pharmacy, etc., bearing huge economic investment, and their safety issues have attracted more and more attention from all walks of life[4]. The statistics of a large number of accidents show that, excluding the congenital manufacturing defects and manual misoperation of pipes, the main reasons for leakage and explosion accidents of high-temperature pressure pipes in service for a long time are high-temperature creep and pipe wall corrosion thinning[5]. Whether it is high temperature creep or pipe wall corrosion thinning, its external effect will cause the stress and strain of the outer wall of the high temperature pipe, and ultimately lead to the failure and cracking of the pipe[6]. Therefore, monitoring the outer wall strain of the pressure pipeline can predict the safety condition of the pipeline, eliminate the potential safety hazards of the pressure pipeline in advance, ensure its safe operation, and avoid pipeline leakage and explosion accidents.

2. Experimental

2.1.Design Of Monitoring System

The external wall of the pressure pipeline that has been in service for a long time under the high-temperature and high-pressure environment will be subject to high-temperature creep, which will lead to the pipeline rupture[7-9]. This monitoring system monitors the safety condition of the pipeline through online and real-time monitoring of the surface strain of the pipeline wall to prevent the occurrence of pressure pipeline accidents. The monitoring system is composed of fiber grating strain sensor, fiber grating demodulator, computer LabVIEW software, GSM communication module, optical fiber connecting line, twisted pair and serial port line. The fiber grating sensor is used to detect the pipeline surface strain, and the fiber grating demodulator demodulates the reflected light signal of the fiber grating. The computer connects the demodulator through the Ethernet network to collect data, and collects the sensor wavelength information to the computer, which is displayed and stored after optimization. Finally, the early-warning system makes a real-time logical judgment on the wavelength information[10]. When the wavelength drift exceeds the alarm threshold, the alarm system will be triggered to send out the early-warning information.

The computer software of this monitoring system is compiled based on LabVIEW. Its main functions include: user system, data acquisition, wavelength data processing and display output, wavelength information storage and query, monitoring report, early warning system and short message receiving and sending system.

Sensing signal demodulation technology is a key technology in fiber grating sensing system, which has been paid great attention by technicians. The fiber grating demodulation system can accurately and rapidly measure the amplitude and spectrum of the signal, and reproduce the function waveform of the time-domain signal without distortion. The demodulation system used in this monitoring system is the sm130 fiber grating demodulator of the LLL Company. It is a high-speed, multi-sensor, high-power measurement system, mainly used in mechanical sensing. Sm130 uses Micron Optics patented technology to calibrate wavelength scanning laser, with high power fast scanning (up to 2 khz). It is a perfect system with a scanning light source, which can simultaneously measure the optical signal reflected back by each fiber through four detector channels. Sm130 is widely used for long-term health monitoring of large buildings, bridges and dams; Continuous monitoring of structural integrity of ships and aircraft; Damage and danger assessment of roads, dams and bridges in earthquake area; Highway, railway and coastline monitoring; Deep well oil pressure or embedded stress measurement of reinforced concrete structures have their presence in engineering applications.

LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a tool for virtual instrument software development developed by NI (National Instrument) of the United States. It has the same functions as such development tools as Microsoft Visual C++. The programming method of LabVIEW software is graphical programming. It does not have the tedious code like traditional programming language, but it has very similar programming ideas, data structures, etc. with traditional programming language.

LabVIEW, as a graphical software platform, has the following main characteristics: (1) adopting the programming idea of data flow model, it can easily realize multithread programming, and then complete the processing capability of multiprocessors; (2) A large number of drivers and conversion tools are provided, which can realize the connection of almost any excuse hardware; (3) Rich additional modules enable LabVIEW software to be applied in PDA module, real-time module, FPGA module, machine vision module, touch screen module and other fields; (4) When programmers write programs, the internal compiler will automatically generate compilation tasks in the background. Therefore, programmers can be reminded immediately when syntax errors occur in programming; (5) The rich graphical controls and graphical programming methods make the program break away from the boring text code programming mode, making the programming process more vivid and interesting, and more convenient and fast; (6) The EXE executive program and various installation packages can be generated by using the application generator; (7) It supports multiple system platforms, and the application program developed by one system platform can also be ported to run on other system platforms.

2.2.Software Design Of Monitoring System

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In the fiber grating sensing measurement system, the monitoring software can provide various monitoring information to users in real time, establish effective engineering environment for users, and solve problems encountered in time. This high temperature pressure pipeline strain monitoring system is used to monitor the surface strain of high temperature pressure pipeline and judge the pipeline safety condition by analyzing the strain condition. Therefore, the monitoring software should have the function of data collection, provide real-time display of strain information, and provide early warning when the pipeline safety condition is in trouble.

The implementation process of this monitoring software is as follows:

(1) Establish a user login system, log in with different permissions, and administrator users with permissions can manage users;

(2) The Ethernet technology is used to collect the central reflected wavelength data of the FBG sensor demodulated from the FBG demodulator;

(3) The original data is optimized, and the wavelength data of each grating in each channel after processing is displayed and stored for user observation and analysis;

(4) Set the threshold of early warning. The upper limit value required for early warning is set according to the actual demand for early warning judgment;

(5) Judge whether the real-time data exceeds the early warning threshold. When the judgment exceeds the early warning threshold, start the early warning system to remind the user of the dangerous situation.

Before using the database, the database must be established first. LabVIEW database tools, such as LabSQL, can realize the data operation of database files, but the establishment of database files must rely on a third-party data management system, which uses Microsoft Office Access (hereinafter referred to as Access) database management system. This monitoring system is used to monitor the strain condition of the outer wall of the pipeline. First, a database file named monitoring data.mdb is created.

After creating the database file, you need to connect to the database to use the database. The LabVIEW database tool is based on ODBC (Open Database Connectivity) technology, and you need to provide the DSN Data Source Names to connect to the database file. Therefore, the first step is to create the data source name.

One of the important reasons for leakage or explosion of high temperature pressure pipeline is high temperature creep of pipeline wall. High temperature creep causes strain on the pipe wall. How to analyze the change of strain and determine the safety condition of the pipe? In 2003, the scientific researchers of Xi'an Thermal Engineering Research Institute put forward a model-C mapping method to judge the service life according to the deformation characteristics of the measured object itself and the actual monitoring situation. The expression of C mapping method is:

$$\varepsilon=\sum_{i=0}^{\infty} c_i t^i \qquad (1)$$

Where, Ci is a system related to material properties, geometric characteristics of the tested object and operating environment (temperature and stress)

Number.

In this paper, two judgment models are designed based on the strain overrun warning model, namely, the upper limit of strain accumulation and the strain rate overrun. The first strain accumulation upper limit mode. Because the pipeline creep strain always exists, there will be a certain accumulation of strain in a period of time. When the accumulated value reaches an upper limit and reaches the later stage of creep, the safety condition of the pipeline changes, and the system needs to give an alarm. In the LabVIEW program design, set a strain upper limit constant F_{MAX}, and compare the detection value F with F_{MAX} through the relational operator. When $F \geq F_{MAX}$, the operator output will give a true value to control the start of the alarm program under the conditional structure.

The second way of exceeding the limit of strain rate is because there is an accelerated creep process in the later period of pipeline creep, which reflects that the strain rate in this period is gradually increasing, and the safety condition of the pipeline has problems. In the program design, the strain rate of the pipeline is calculated by analyzing the data information after the previous data processing. LabVIEW has a wealth of mathematical calculation tools. By calculating the following formula:

$$k = \frac{\left[x(t) - x(t-1)\right]}{\Delta t} \qquad (2)$$

Where x (t) is the detection value at time t, and x (t-1) is the detection value at the previous time, Δt is taken according to the sampling frequency, and the k obtained is the slope of the creep curve, reflecting the strain rate of the pipeline. When the K value is compared with the upper limit of strain (K_{max}), and the upper limit (K_{max}) is exceeded, it is the process of accelerating creep in the pipeline creep curve. When the pipeline safety problems occur, the system triggers an alarm.

When the alarm program detects the alarm information, it will trigger the start of the alarm program. The monitoring window will pop up a warning prompt window, and the system will give an alarm sound. At the same time, it will trigger the start of the SMS sending program, and automatically send an alert message to the relevant staff.

The monitoring report is a summary of the system's pipeline safety monitoring within a day. The monitoring report designed for this system includes the average, minimum and maximum of the monitoring data of the day, the record of alarm times, the analysis of alarm causes, the safety status, etc. Under the LabVIEW system programming environment, NI LabVIEW Report GenerationToolkit for Microsoft office toolkit is used to realize the automatic generation of monitoring reports. Through this office toolkit, you can insert text, data, charts and other information into excel reports. The monitoring report is generated automatically. When the daily monitoring task is completed, the daily monitoring report is automatically generated at the scheduled time, and the report is printed or sent to the mailbox of the required personnel.

3. Results And Discussion

In order to reflect the strain of the outer wall of the pipeline, the fiber grating strain sensor is mounted on the surface of the cantilever beam, and then the cantilever beam is pressurized by a weight to generate strain. The experiment was completed at room temperature. The experimental equipment used in the experiment includes:

(1) two fiber grating strain sensors, with standard central reflection wavelengths of 1544 nm and 1555 nm respectively;

(2) One SM130 fiber grating demodulator and one network cable;

(3) A computer, a TC35i communication module, and a serial port line; (4) Several weights weighing 250g.

First, connect two FBG strain sensors in series, paste the sensor with the reflective wavelength of 1555nm on the surface of the cantilever, and then connect one end of the sensor to the input port of FBG demodulation, and close the other end (the SM130 FBG demodulator has its own light source, so it is unnecessary to equip the FBG sensor with a broadband light source). Then connect the SM130 to the computer with a network cable, and connect the TC35i to the computer with a serial port cable. The preparations are ready.

This experiment is used to reflect the continuous creep and accelerated strain process of high temperature pressure pipes. Based on this requirement, two methods to produce strain effects are designed.

(1) Apply weights to the cantilever beam one by one at regular intervals to make the cantilever beam produce a continuous strain process. The whole process is gentle and continuous, which is used to reflect the slow strain process of the pipeline;

(2) When the cantilever beam is unloaded, multiple weights are applied to it at one time to make the cantilever beam produce a large instantaneous strain, which is used to reflect the accelerated strain process of the pipeline.

When the weight is continuously applied to the cantilever beam, the waveform trend display window of the monitoring system can display the change and trend of the wavelength. Repeat the experiment for 4 times, and record the wavelength value of the sensor in each experiment. As shown in Table 1 - Table 3.

Table 1. First strain data

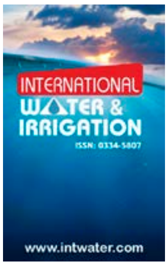
Serial number	Number of weights	Sensor 1 (no strain)	Sensor 2 (strained)
1	0	1544.0679(nm)	1554.2895(nm)
2	1(250g)	1544.0679	1554.4129
3	2	1544.0674	1554.4354
4	3	1544.0660	1554.4559
5	4	1544.0662	1554.474
6	5	1554.0653	1554.4833
7	6	1554.0680	1554.4852

Table 2. Second strain data

Serial number	Number of weights	Sensor 1 (no strain)	Sensor 2 (strained)
1	0	1544.0654(nm)	1554.2885(nm)
2	1(250g)	1544.0668	1554.4046
3	2	1544.0679	1554.4148
4	3	1544.0674	1554.4252
5	4	1544.0649	1554.4384
6	5	1554.0659	1554.4515
7	6	1554.0684	1554.4627

Table 3. Third strain data

Serial number	Number of weights	Sensor 1 (no strain)	Sensor 2 (strained)
1	0	1544.1679(nm)	1554.2878(nm)
2	1(250g)	1544.0679	1554.4054
3	2	1544.0674	1554.4140



4	3	1544.068	1554.4271
5	4	1544.0662	1554.4394
6	5	1554.0653	1554.4544
7	6	1554.0640	1554.4646

From the above table, we can see that the monitoring system can detect the strain information of the measured object in real time, and reflect the actual strain in the trend chart. When multiple quads are applied to the cantilever beam at one time to generate a faster strain rate, the data change of wavelength is recorded, as shown in Table 4.

Table 4. Accelerated strain experiment

Serial number	Number of weights	Sensor 2 (strained)
1	0	1554.3915(nm)
	2(500g)	1554.4188
2	0	1554.3894
	4(1000g)	1554.4402
3	0	1554.3902
	4(1000g)	1554.4377

At the same time, when 4 code shedding are applied to the cantilever beam at one time, the cantilever beam will experience a process of instant strain increase, and the system interface will give an early warning.

An alert prompt window will pop up in the monitoring interface to display the alert information and the serial number of the sensor where the alert occurred. At the same time, the warning light below will also turn red, giving a significant warning. Finally, the system will play an alarm sound to remind all control personnel.

The above data information and pictures show that the monitoring system can detect the process of instantaneous large increase in the strain of the measured object, and can send a system warning when the strain is too fast. At the same time, the display functions of each part of the monitoring system software can operate normally, and the key functions can be realized.

4.CONCLUSIONS

With the development of fiber grating sensing technology becoming more and more mature, and its unique advantages compared with traditional mechanical and electronic sensors, such as small size, corrosion resistance, electromagnetic interference resistance, and self explosion prevention, its application fields are becoming more and more extensive, such as large-scale composite materials, health monitoring of concrete structures, power industry, medicine, and petroleum industry. At the same time, with the rapid development of PC technology and the gradual improvement of memory, graphics processing (GPU), central processing unit (CPU) and other performance, the function and performance of virtual instrument system are becoming more and more powerful, and the "virtual" measurement and automation system has also been developed rapidly.

In this paper, according to the actual requirements of high temperature pressure pipeline safety monitoring, combined with fiber grating sensing technology and virtual instrument technology, a set of fiber grating strain monitoring system for high temperature pressure pipeline based on LabVIEW is designed. This monitoring system uses fiber grating sensor to design a distributed sensing system and a system monitoring software based on LabVIEW. The software has the functions of user login and management, data acquisition, data processing, data display and storage, early warning system, etc.

REFERENCES

[1] L. LV: The Legal Analysis of China's Environmental Tax System Reform. Wuhan University Press, Wuhan, 2010.

[2] C. J. M. ONDERSTEIJN, S. B. HARCH, G. W. J. GIEREN, A. C. G. BELDMEN, R. B. M. HUIRNE: Management Strategies on Dutch Dairy Farms to Meet Environmental Regulations; a Multi-case Study. NJAS-Wage Life Sci J, 50 (1), 47 (2002).

[3] P. WANG: The French Draft Finance Bill for 2014, Budgetary Situation and Signs of a Coherent Environmental Tax System. Social Science Electronic Press, London, 2014.

[4] T. R. SADLER: Regulating Chemical Emissions with Risk-based Environmental Taxation. Int Adv Econ Res J, 6 (2), 28(2000).

[5] W. F. SONG, X. F. HAN, C. CAO: Land Transfer Price Assessment in the Development of Mineral Resources and Environmental Optimization Governance. China Popular Ways En J, 24 (93), 34 (2014).

[6] C. CHEN. H. U. FANG. J. SUN: Resources, Ecological Environment and Sustainable Development. Qingdao University Press, Qingdao, 2009.

[7] C. HAI: Dynamic Feedback Mechanism between Ecological-Environment and Economy for Sustainable Development. American Academic Press, New York, 2004.

[8] L. R. HU: Evaluation of Talent Training Ecological Environment Sustainable Development Based on Relational Database. Information Engineering and Applications. London, 2012.

[9] S. DERISSEN, M. F. QUAAS**, S.** BAUMGДRTNER: The Relationship between Resilience and Sustainable Development of Ecological-economic Systems. Eco Econ J,70 (6), 957 (2009).

[10] Y. P. TAO: Exploitation and Sustainable Development of Ecological Environment Resources for Sports Tourism and Leisure Sports. Adv Mater Res J, 60 (3), 13 (2012).