Leakage Detection of Submarine Pipeline Based on Infrasonic Wave Method Based on SCADA System

Jianfeng Gao, Shaotong Zhou, CuiCui Li and Jianjun Wen

ABSTRACT

At present, many of the submarine pipeline use SCADA system to control the operation of the pipeline, but pipeline leaks will often occur. Submarine pipeline leakage can not only cause waste of resources but also cause pollution of the marine environment. Therefore, a reliable method is needed to detect and control the pipeline in real time, so as to avoid a series of damage caused by pipeline leakage. In this paper, the use of sub-acoustic method for the seabed oil pipeline leak detection can make up for negative pressure wave method and other detection methods of various deficiencies, improve the accuracy of leak detection. At the same time, the combination of SCADA system and infrasonic wave method can better realize the safe and efficient operation of submarine oil pipeline.

INTRODUCTION

In recent years, China's submarine pipeline technology has been rapid development, the community's demand for it gradually increased, which also contributed to the further development of submarine oil and gas storage and transportation. But in recent years, there are more accidents due to pipeline leakage, for example, at 20:00 on April 14, 2017, Songjiang City, Jilin Province, Ningjiang
District Construction Street Songyuan City People's Hospital on the back of the road, natural gas pipeline due to maintenance and leakage occurred in case of fire explosion. This explosion caused two deaths and many people were injured. This provided a warning to the operation of the submarine pipeline. Compared to land pipelines, submarine pipeline inspection and control is relatively more difficult. The use of traditional transmission methods and monitoring methods can not meet the needs of modern people. The application of automation technology in submarine oil and gas transportation is becoming more and more popular. SCADA system is by virtue of its advantages of automation level. It gradually replacing the traditional way to the entire oil and gas storage and transportation process for data collection and monitoring. It is necessary to select a suitable leak detection method to monitor the pipeline in real time and then transmit it to the SCADA system to avoid unnecessary leakage accidents. YanZhou and others studied the SCADA system distributed fiber pipeline leak test technology, the experiment found that SCADA system can be a good leak on the information collection and monitoring[1]. Xinliang Sun and others studied the application of SCADA system in oil pipeline. They found that the SCADA system can compare the data collected in the process of pipeline inspection to reduce the incidence of oil pipeline leakage and can analyze the correlation of the information[2]. Huijun Zhao and others found that the infrasonic wave wavelength was long and the propagation distance was far away[3]. RongxinYan and others studied learned that the use of secondary acoustic leak detection technology to locate the pipeline leakage point has great prospects[4]. Analysis of the above papers and compare the advantages and disadvantages of a variety of detection methods and the application of the final selection of sub-acoustic method for submarine pipeline inspection. In the use of infrasonic wave method to detect the leak signal at the same time using wavelet analysis for noise reduction processing, and then use the SCADA system to control the leakage of the pipeline, so as to greatly improve the efficiency of the oil process, and increase the safety of the Submarine oil and gas storage and transportation.

**USING THE INFRASONIC WAVE METHOD TO DETECT AND LOCATE THE SUBMARINE PIPELINE**

Pipeline leak detection technology research from the last century began. According to different specific circumstances, there will have different detection methods, such as infrasonic wave and negative pressure wave method. The infrasonic wave signal is the AC signal. As shown in Figure 1, the signal was spiked and the time point of the acquisition is not different. At the same time, the submarine pipeline does not produce infrasonic waves when it swings. It will not cause false positives and make up for the negative pressure wave in the submarine pipeline invalid defects. The infrasonic wave is independent of the amount of leakage. The infrasonic wave method can detect a small leak of the pipeline and take timely measures to avoid the expansion of leakage.
When the submarine oil pipeline leaks, the oil will leak from the pipeline where the leakage occurs, and the pipeline state of the fluid parameters will change. The pressure difference occurs at the dew point position. Under the action of internal and external pressure, the leakage outside the point of the fluid will flow to the point of leakage. It causes the pressure and density of the fluid in the region to change, and then spread to other areas so that the normal flow of the formation of sub-acoustic disorder, and then the sound will follow the pipeline to the first and the end station spread. The infrasonic wave sensor is installed at both ends of the pipeline,. The infrasonic wave sensor collects the infrasonic wave signal in real time and extracts the information to determine the location of the leak. When the pipeline leaks, it will produce infrasonic wave signal. The infrasonic wave sensors installed at both ends will monitor and collect all the acoustic signals and then through the data acquisition A / D conversion filter to the SCADA system. The upper computer software of SCADA system extracts its characteristic quantity. We use the signal that the infrasonic wave sensor detects when the pipe is working properly as a reference signal. When the pipeline leaks, the leakage of the infrasonic wave signal will pass through the sensor to the upper computer software of SCADA system. Then the upper computer software to compare and identify its signal, in order to determine whether the pipeline leak[5] [6]. The detection process of infrasonic wave leakage is shown in Figure 2.

![Figure 1. Schematic diagram of the infrasonic wave signal.](image1)

![Figure 2. The infrasonic wave leak detection diagram.](image2)
At the same time, this test will be affected by different degrees of interference. In order to improve the accuracy of detection and reduce the false alarm rate, we need to use wavelet analysis to get the real signal to the collected signals. According to the time difference between the beginning and end of the pipeline and the velocity of the propagation velocity of the subsonic signal in the pipeline, the location of the leak point can be determined. Assuming that the starting point of the infrasonic wave sensor is A, the position of the end infrasonic wave sensor is B, the position of the leak point is C and the distance between the AB points is L. The distance from the leak point position C to the pipe starting point A is X. The time of infrasonic signal propagation from C point to A point is $t_1$, and the time from C point to B point is $t_2$. $V$ is the velocity of propagation of a subsonic signal the pipeline\(^\text{[7]}\). The following relation can be obtained through the above information:

\[
    t_2 = \frac{X}{V} \quad (1)
\]

\[
    t_2 = \frac{L - X}{V} \quad (2)
\]

\[
    \Delta t = t_1 - t_2 \quad (3)
\]

The formula for determining the position of the dew point can be deduced from the above formula:

\[
    X = \frac{L + V\Delta t}{2} \quad (4)
\]

So as long as we know the starting point of the sensor and the end of the sensor time and the infrasonic wave in the pipeline in the propagation speed, we can determine leakage position according to the formula 4.

THE SCADA SYSTEM IS USED TO CONTROL THE LEAKAGE OF THE SUBMARINE PIPELINE

SCADA System Components and Control Methods

SCADA system that is data acquisition and monitoring system. Under normal circumstances, a more perfect SCADA system include the central control system, monitoring system, data communications, storage systems and field process parameters of automated instrumentation system\(^\text{[8]}\). The dispatching center control system mainly plays a direct supervisory role in pipeline operation and production operations. Then, the production information and detection of each station can be
displayed and stored by the network communication system and keep an eye on the situation at every station to ensure the closure of the pipeline. Field process parameters of automated instrumentation system will be on-site measurement of the relevant data collection and monitoring. Then through the relevant sensor conversion, using the selected communication network transmission to the storage system for storage, but also displayed in the computer screen so that the staff timely analyze the collected information and take corresponding solutions to the existing problems. At the same time, preventing pipeline leakage and other issues arise. If the dispatch center control system receives a signal transmitted from the infrasonic wave sensor that differs from the standard signal stored in the normal operating condition before, it can take appropriate action at the dispatch center, such as closing the pump or the valve. The main component of the control and monitoring system of the dispatching center is PLC (Programmable Controller). The PLC will input the information into the PLC, then execute the logic function of the configuration and finally output the control function[9].

**Data Detection and Transmission**

When the acoustic sensor detects the pipeline signal, after wavelet analysis of the signal de-noising, and then on-site detection instrument in the intelligent sensor will detect the signal into the corresponding standard current signal for remote transmission. The station control PLC real-time acquisition of the corresponding data information through the relevant network transmission to the dispatch center control room. The dispatching center monitors and the monitoring system to analyze and judge the signal. If it is judged that the submarine oil pipeline has leaked, the alarm signal is sent and the leakage point is positioned. Then the specific position of the leak point will be displayed on the computer screen of the control center control system. According to the leak point and the amount of leakage in a timely manner, the relevant site staff take appropriate measures to avoid further expansion of leakage and reduce losses. The control center's communication equipment also needs to consider its redundancy. So there are two routers, one of which is set to standby mode.

**CONCLUSIONS**

This paper combines the SCADA system with the infrasonic wave method for submarine pipeline leak detection to understand the advantages of the infrasonic wave method to the detection and positioning of the submarine pipeline, and the whole application process. The SCADA system is also analyzed in the submarine pipeline application of leak detection. The operator can use the communication network system through the dispatch center system to read the related information of the PLC directly. At the same time, the use of sub-acoustic sensor can be docked with the SCADA system can make full use of existing SCADA system information
resources. The combination of pipeline detection and positioning and SCADA system to achieve real-time remote detection and control the pipeline can be in the submarine oil and gas pipeline leak detection and monitoring to provide a reference to the submarine pipeline to achieve a more safe operation. At the same time, reducing the staff workload, improve work efficiency.

ACKNOWLEDGEMENTS

This work was supported by the 2017 special science and technology project of Zhejiang Provincial Science and Technology Bureau. The project’s name is that based on wavelet analysis of the submarine oil and gas pipeline leakage detection and monitoring system. (No. 2017C41004)

This work was also supported by the Science Research start-up foundation of Zhejiang Ocean University. (2015)

REFERENCES