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Application of Nondestructive Testing Technology in Pipeline Operation

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Abstract: With the increasing application of pressure pipeline, pressure pipeline accidents are gradually increasing, causing attention. With the development of science and technology, nondestructive testing technology has been developed and applied to pipeline testing. This paper introduces several nondestructive testing technologies commonly used in pressure pipeline, introduces their advantages and disadvantages, and probes into their application.

Keywords: Nondestructive testing; Pressure pipeline

Introduction

Pipeline transportation, as one of the five major modes of transportation in the world, plays an increasingly important role in economic development. Pipeline operation capacity and technical level have become an important index to evaluate a country's economic development. So far, the total length of the world's oil and gas pipelines has exceeded 450000 km. In recent years, with the continuous development of China's economy, China's oil and gas pipelines have developed rapidly. By the end of 2008, the total length of China's oil and gas pipelines has been about 64000 km. At present, Sinopec and petrochina are actively building their own oil and gas pipeline networks, and the construction of oil and gas pipelines will reach its peak in the next few years. Due to the increase of domestic oil and gas pipeline reserves and the introduction of a large number of foreign resources, the market link and connection of the pipeline will be developed rapidly.

Up to now, about 50% of the world's pipelines are aging, and people are very concerned about the safe operation of these pipelines. Many of China's oil and gas pipelines have been in operation for 20 to 30 years and are nearing their service life. In order to avoid all kinds of defects during the pipeline operation and ensure the safe operation of the pipeline, it is very necessary to carry out regular safety inspection on the in-service pipeline.

1. Nondestructive testing technology overview

Nondestructive testing technology suitable for pipeline testing is to study high-precision, intelligent, green and friendly testing equipment in the future development direction. Nondestructive testing refers to the detection of the position, size and distribution of defects on the surface and inside of the test parts without damaging the tested parts. Pipeline accidents can be identified as early as possible so as to prevent them.

With the vigorous development of modern science and industry, it has provided a perfect theory for the development of nondestructive testing. Nondestructive testing technology is widely used in machinery, nuclear power, petroleum, chemical industry, aviation, electric power, metallurgy and other industries with its unique advantages. With the development and progress of the theory of nondestructive testing, pipeline testing technology is mainly divided into ultrasonic detection, magnetic flux leakage detection, X-ray detection, eddy current detection, metal magnetic memory detection, penetration detection and optical principle detection.

2. Application of nondestructive testing technology

2.1 Ultrasonic Detection

Ultrasonic detection technology uses the refraction and reflection phenomenon of ultrasonic wave transmitted to the interface, the instrument equipment amplifies and receives the reflected signal received by the signal receiver, and then analyzes and obtains the defect information inside the pipeline. Ultrasonic detection is mainly used to detect the weld internal defects of pressure pipelines. This detection method is suitable for volume and area defects, sensitive to deep defects and easy to miss defects near the surface. The advantages are strong penetration ability, simple equipment and fast detection speed. The disadvantage is that the coupling agent such as oil or water is needed and it is not suitable for the detection of thin-walled tubes.

2.2 Magnetic flux leakage detection

Magnetic flux leakage detection refers to the formation of magnetic flux leakage field on the surface of the sample due to defects on the surface or near the surface of the ferromagnetic material after it is magnetized. Defects can be found by detecting changes in magnetic flux leakage field[1].This method can detect the defects on the surface with thickness of 0.1~0.2 mm and near surface, and the longitudinal defects parallel to the magnetic force line are easy to be missed. The advantages of this method are high efficiency and no pollution, and it is ideal for pipe wall in the range of 6~15mm. However, its disadvantages are that it is not suitable for thick wall pipe (above 25m), the effect of lift-off is large, and it has strict requirements on the inner surface of pipe.

2.3 X-ray Detection

X-ray detection technology is a technology that uses ray to transparently illuminate the material or specimen, check its internal defects or analyze its crystal structure according to the diffraction characteristics. Commonly used X-ray detection technology can be divided into observation detection method, radiographic detection method and television detection method. The detection of crack defects is affected by the angle of penetration, the advantage is that the image is more intuitive and less affected by the surrounding environment, the disadvantage is not suitable for online detection.

2.4 Eddy Current Detection

As a nondestructive testing method of non-contact measurement, eddy current detection method is based on the principle of electromagnetic induction. When the coil with alternating current is gradually close to the tested conductor specimen, the magnetic field generated by the coil will cause eddy current in the specimen. At the same time, the size and phase of eddy current are affected by the performance of the specimen, and a magnetic field will react on the coil magnetic field, and the impedance of the coil will change under the action of this magnetic field. Therefore, defects and characteristics of specimens can be determined by detecting changes in coil impedance[2]. This method is suitable for surface and near surface defect detection, and has high detection accuracy, but its disadvantages are slow scanning speed, low efficiency, large probe geometry and complex structure.

2.5 Magnetic memory detection

Magnetic memory testing technology is a new nondestructive testing method. The detection principle is that the ferromagnetic metal components are subjected to the joint action of load and earth magnetic field during processing and operation, magnetostrictive domain organization orientation and irreversible reorientation occur in stress concentration and deformation regions. Fixed nodes of magnetic domains appear at the stress concentration sites, producing magnetic poles that create their own leakage fields on the metal surface. This technology can not only detect the macroscopic defects that have been formed, but also detect stress concentration and early damage. It does not need special magnetization device, detection surface does not need to be cleaned, lift off effect is small, detection instrument size is small, but there is not enough experience in signal processing and defect feature extraction.

2.6 Penetration detection

Penetrant detection technology is to apply penetrant solution containing fluorescent dye or coloring dye to the surface of the pressure pipeline, under the capillary action, after a certain time, penetrating fluid infiltration into the surface defects. After removing excess penetrant, the imaging agent was applied to absorb the permeating liquid to the surface to be tested, forming a defect display, so as to detect the surface opening defect of pipeline equipment. Pressure pipeline penetration detection does not need large equipment, generally does not use water and electricity. The detection sensitivity is lower than that of magnetic particle detection technology, but compared with radiographic detection or ultrasonic detection, the sensitivity of penetration detection technology is still very high.

2.7 Optical principle detection

This kind of detection technology needs to be processed by means of closed-circuit television in-pipe detection and electronic speckle detection. This kind of detection technology can be used to quickly classify and locate the internal corrosion of pipelines, with high precision and intuitive display. It has a good development prospect in the practical non-destructive testing of pipelines. The working principle of laser holographic nondestructive testing is holographic interference phenomenon, through fluid loading pressure, thermal loading, mechanical loading and other ways. The detection of small deformation can be quickly completed. According to the comparison of waveform before and after the load of the detected medium, combined with interference fringes, pipeline defects can be determined. Laser holographic nondestructive testing is a non-contact measurement method, which has the advantages of fast detection speed and high sensitivity. In the detection of component shape and surface shape, the corresponding interference fringes must be converted into specific information in time, usually digital images, which will be imported into the computer for calculation. After processing, digital and automatic comparison can be completed. In the application of the above detection method, it is necessary to ensure light avoidance and seismic effect, and strict loading conditions in the early stage should be considered.

3. Conclusion

In summary, nondestructive testing technology has been completely applied in pressure pipeline testing and has made great progress. It is necessary to select appropriate testing methods according to the field conditions, specimen structure and characteristics of testing methods to ensure the operation of pipelines.

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