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# Study on Sonic-Wave Detection of Buried Pipeline Corrosion

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**Abstract:** The detection and localization of underground pipeline corrosion is an important content of pipeline management. Now most of the detection equipment are expensive, detection speed is low, detection cost is high. This paper discusses the urgency of pipeline corrosion detection, analyzes the problems of pipeline corrosion detection, and studies basic principles, testing content, testing technology, analysis steps of the new detection method. *Copyright © 2013 IFSA.*

**Keywords:** Buried pipeline, Corrosion, Detection.

## 1. Introduction

In the operating life of pipeline safety, pipeline corrosion makes pipeline wall become thin and cause pipeline leakage, so pipeline cannot run according to the original design pressure.

The corrosion detection of underground pipeline buried under the mud, sand, cement, asphalt pavement and surface construction is difficulty.

When magnetic flux leakage detector inspects the pipeline corrosion, pipeline should be shut down for a period of time to clean up the dirt on inner wall of pipeline, the pressure of the conveying medium drives the inner detector to crawl along, bend pipe, three-way pipe and stepped pipeline are inconvenient for t the inner detector crawl along, and the detection equipment is costly of, so this technology is applied only in a few long distance pipeline.

Exerting pipe robot to detect the inner wall of the pipelines need to stop transporting conveying medium to improve the pipeline, this technology is applied mostly in gas pipeline with high cleanliness.

How to detect accurate fault location and repair to reduce leakage loss, and ensure the normal and safe operation [1-2], and prolong the service life of pipeline is one of the most concerned problems for pipeline owners. To sum up, the development of economic and suitable pipeline corrosion detection technology is imminent.

After the application of many years of research, development and testing experience is summarized, this paper studies an audio guide wave detection technique with pipeline wall corrosion.

## 2. The Basic Principle of Pipeline Corrosion Detection

Conductivity and magnetization rate reduces, the electrical resistivity increases because of pipeline corrosion, resistance is a parameter to block current transmission, and it makes the electric energy during pipeline transmission into heat energy, which cause the electromagnetic field attenuation anomaly; signal current attenuation model in the pipeline is shown in Fig. 1. Equivalent circuit of signal current on buried pipeline attenuation factor is shown in Fig. 2.

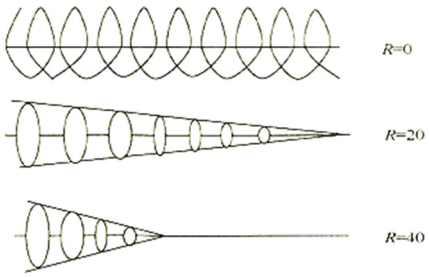


**Fig. 1.** Effect of corrosion resistance on pipeline transmission distance.

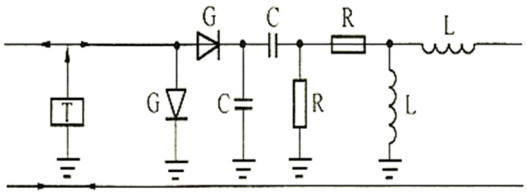


**Fig. 2.** Equivalent circuit of signal current on buried pipelines attenuation factor.

The loading detection signal current will generate reflection, refraction and transmission of voltage wave in pipeline corrosion interface, Direction of the reflection electromagnetic wave is reverse, magnetic field signal is offset, causing the magnetic anomaly. Pipeline locator can detect uneven corrosion, offset of equivalent current center in the pipeline on the ground. Pipeline external corrosion are usually generated in damaged location of anticorrosion layer, the signal current form spherical potential field here, detect the step voltage. Anticorrosion layer damage point signal spread in all direction, distribute on the ground surface vertical to the pipeline and parallel to the pipeline, lost electrical signals can be added in four directions [3].

Superimposed signal vertical to the pipeline has little effect on the detection of, but the superimposed signal parallel to the pipeline has great influence on the detection. Although there is no loss for electric signal in the location close to front end of the breaking point, due to the reverse equivalent superimposed current magnetic field will offset part of the magnetic field stimulated by the load current, therefore, the observed induction current decreases in front of the breakage points. Conversely, positive equivalent superimposed current will increase the measured induced current behind of the breaking point. The loading signal current forms electric eddy current field in the vicinity of pipeline corrosion pit position, the eddy current field disrupted magnetic field lines caused by line current. The state of pipeline corrosion and outer anticorrosive coating determine distribution of the current line, electromagnetic, electromotive force, magnetic field lines equal-potential surface and direction, the location of pipeline corrosion can determined by the reverse derivation method.

1) Detection of gradient.

Longitudinal pipeline magnetic field gradient and potential gradient are detected, and detection point is increased in the abnormal gradient.

2) Detection of divergence.

Distribution range of transverse pipeline potential divergence is detected in the damage position of anticorrosion layer, abnormal magnetic field location and eddy current position [4].

3) Detection of curl.

Coil probe rotates 360° along vertical direction, which will locate receiving magnetic signal point above pipeline, coil probe rotates 360° along horizontal direction, which will locate receiving magnetic signal point parallel to the direction of the pipeline, Pipeline magnetic force line curl is shown in Fig. 3 and Fig. 4.

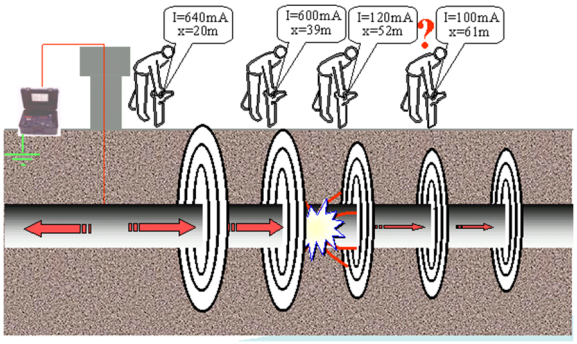


**Fig. 3.** Distribution pattern of current and magnetic force line loaded in buried pipeline.

## 3. Mirror Image Method

Image method is an indirect method for solving boundary value problems (as shown in Fig. 5), pipeline buried underground are unable to be detected directly, in the detection of buried pipeline surface electromagnetic parameters. Subsurface electromagnetic propagation parameters multiplied by K correction coefficient become pipeline electromagnetic propagation parameters, the method for detecting and solving is simple.

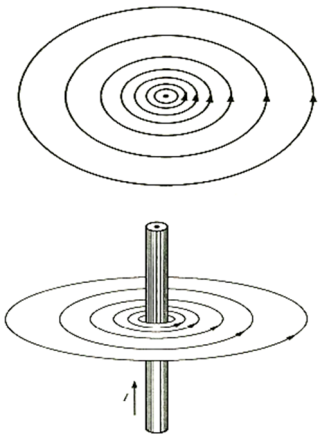

**Fig. 4.** Field rotation (left) and a long straight current carrying conductor magnetic rotation.

## 4. Analysis of Guided Electromagnetic Wave Reflection and Transmission

Pipeline corrosion location will make the electromagnetic transmission capacity of pipeline becomes non uniform, the audio guide wave detection of underground pipeline corrosion is exerting the audio signal into the underground pipeline, producing the underground pipeline electromagnetic with cylindrical distribution(as shown in Fig. 3, Fig. 4). The electromagnetic distribution parameter such as magnetic field and voltage in the surface of soil medium transmitting boundary is detected, comparing detection data of the non-uniform transmission line with uniform transmission line, so as to judge the corrosion location.

### 4.1. Analysis of Pipeline Fault Detection of Reflection and Transmission Method

In the ultrasonic guided wave detection technology, using guided wave probe emission distorted wave along the wall of the tube wall of the pipeline transmission, transmission of guided electromagnetic waves reflected back by the probe detected along the weld defects and corrosion failure position, to form the image displayed on the screen, testing personnel by analyzing the image shape can judge pipeline the fault type.

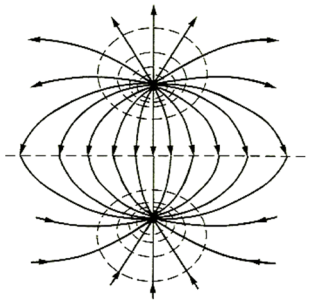

**Fig. 5.** Effect of image charge instead of the earth.

### 4.2. Analysis of Pipeline Fault Detection of Reflection and Transmission Method

When the audio guide electromagnetic wave transmits line in the pipeline, there is reflection, transmission and refraction of the current wave and voltage wave, magnetic field direction formed by reflection current is opposite to the direction of the original magnetic field, offsetting strength of the magnetic field, the magnetic field in the pipeline corrosion location becomes stronger, different current wave, voltage wave reflection, transmission and refraction model is shown in Fig. 6-8.

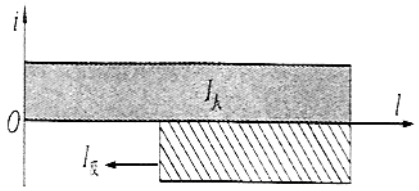


**Fig. 6.** Schematic diagram of total reflection of current wave with no loss.

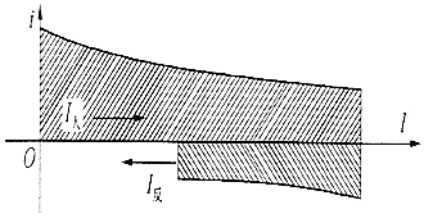


**Fig. 7.** Schematic diagram of total reflectance of attenuated current wave.

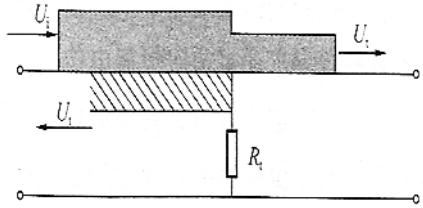

**Fig. 8.** Schematic diagram of reflection and transmission of current wave without loss.

Detecting transverse potential above the line, the transverse potential is different before and after corrosion location under the same conditions, the pipeline leakage field divergence is a function of the voltage, the higher the voltage, the greater the scope of divergence. When liquid medium in the pipeline leak, the greater pipeline pressure is, the greater the amount of leakage is; leakage is proportional to the square of pipe pressure.

## 5. Application Examples

In 2013 February, buried pipelines of the Da Qing oilfield in China were detected by this theory,

13 pipeline corrosion location were detected, according to 20 % excavation of verification, there are pipeline corrosions in all excavation(as shown in Fig. 9).

**Fig. 9.** Pipeline corrosions in some excavation.

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