

# A New Detecting Technology for External Anticorrosive Coating Defects of Pipelines Based on Ultrasonic Guided Wave

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**Abstract.** The external anticorrosive coating is the shelter for preventing steel pipelines from Corrosive damage. A number of pipelines face severe corrosive problems for the performance decrease of the coating, especially during long-term services, which usually led to safety accidents. To solve the detection problem about the defect of anticorrosive layer for pipeline, a new detection method for anticorrosive layer of pipelines based on Ultrasonic Guided Wave was proposed in the paper. The results from the investigation show a possibility of using the Ultrasonic Guided Wave method for detecting the damage of pipeline's External Anticorrosive Coating.

## 1. Introduction

As an important means of transportation, pipeline plays an important role in the oil transportation of our army. In order to protect the pipeline from damage during the service, people will apply antiseptic coating to the pipeline. In practice, the pipeline anti-corrosion layer will be affected by the environment, weather, resulting in peeling, breakage and other defects, which is shown in Figure 1.



Figure 1. Defects of a pipeline.



Figure 2. A pipeline robot

Defects in the anticorrosion layer cause pipelines to produce corrosion candles that affect the metallic properties and mechanical strength of the pipeline [1, 2]. The defects cause the pipeline to break easily, and then affect the service life and quality of the pipeline. The defects of the pipe's

anticorrosive coating bring potential risks to the safety, such as explosion. The explosion can cause waste of energy and economic loss. Therefore, it is very important to judge whether the corrosion protection layer is damaged or not.

## **2. The cause and condition of the peeling of the pipeline's anticorrosive coating**

In the pipeline protection technology, China is still behind the developed countries. Most of the pipelines that have been built are usually combined with anti-corrosion coating and cathodic protection as the anti-corrosion system of pipelines. In China, petroleum bitumen was firstly used as anticorrosion layer of pipeline, which was basically consistent with the protection from abroad. Most of the pipelines built in China in 70s still use asphalt as anticorrosion material. In 80s, after the reform and opening up, epoxy powder as the representative of anti-corrosion coating materials have been put into use in our country, the pipeline corrosion protection technology in our country has entered a new stage [3]. In the late 90s, China adopted advanced anti-corrosion technology imported from abroad. This coating technology applied fusion bonded epoxy powder and three layer polyethylene structure. The early pipeline was limited by the technology and anticorrosion materials at that time. The technical means of corrosion prevention were simple and the design was not perfect. The buried pipeline after service for many years, and later due to changes in the geological environment around the lack of maintenance and management, resulting in loss of material corrosion and anticorrosion, which makes the pipeline damaged to varying degrees. At present, our army's buried pipeline mainly has the following problems.

(a) Due to the influence of process materials, there are not many kinds of anticorrosive materials for coating. Even under the influence of human factors, there is lack of scientific design judgment.

(b) In the field construction, people cannot guarantee the absolute safety of the corrosion protection layer, resulting in damage to the corrosion protection layer, which accelerated the corrosion of the pipeline [4].

(c) In the maintenance process, due to the lack of effective detection equipment, once the cathodic protection system is damaged, the cathodic protection system cannot constitute a valid protection circuit, it will produce a protection dead zone and other corrosive environment, which cannot detect the breakage, resulting in the loss of anti-corrosion layers.

(d) Periodic mandatory checks are crude. At present, the new detection methods used abroad have not been widely adopted in our country.

## **3. Research status in China and abroad**

The detection techniques of defects in the pipeline can be mainly divided into two categories, which are outer layer inspection technique of pipeline anticorrosion layer and inner detection technique of pipeline anticorrosion layer. Among them, the outer detection technology of pipeline anti-corrosion layer can be divided into local excavation detection technology and ground inspection technology.

### *3.1. Outside detection technique of anticorrosion layer of pipeline*

At present, in the world, people mainly use the method of external detection to detect the defects of the pipeline corrosion protection layer [5]. The main methods are standard tube (P/S) potential detection method and Pearson detection method, multi frequency tube current method, variable frequency and frequency method, dense spacing potential test method (CIPS), DC potential gradient test method (DCVG), transient electrochemical technology etc.

### *3.2. Internal inspection technique for anticorrosion layer of pipeline*

The inner test of the pipeline is to detect the defects of the anticorrosion layer from the inside of the pipeline. At present, it is mainly realized in this way, that is, the testing instrument is placed in the inner part of the pipeline, and the inner part of the pipeline is detected. A robot that detects pipeline from the inside of a pipeline is shown in Figure 2.

The robot moves in the pipeline, and then collects and stores the pipeline information. Finally, the pipeline information is analyzed by computer to understand the status of the pipeline.

At present, magnetic flux leakage testing and ultrasonic testing are often used in the detection of civil oil and gas pipelines. Ultrasonic guided wave is very sensitive to delamination and hole of laminated composite material, so it is beneficial and feasible to detect the running state of anticorrosion layer with ultrasonic guided wave [6]. The propagation characteristics of the ultrasonic guided wave in the air, viscoelastic medium and elastic medium, using ultrasonic guided wave detection research on pipeline anticorrosion layer of holes, peeling, will enhance the anticorrosive layer detection function of pipeline intelligent detection device. The propagation characteristics of ultrasonic guided wave in the air, viscoelastic medium and elastic medium is not the same, therefore, the ultrasonic guided wave in pipeline anticorrosion layer of anticorrosion layer will enhance the detection function of pipeline intelligent detection device.

#### 4. A New Detecting Technology for External Anticorrosive Coating Defects of Pipelines Based on Ultrasonic Guided Wave

Ultrasonic testing technology is a widely used nondestructive testing technology. There are many kinds of ultrasonic nondestructive testing methods, of which the most commonly used pulse reflection method. Ultrasonic waves can be excited by an instrument. The ultrasonic wave is detected in the object, and the echo signal is observed to detect the damage of the pipeline [7].

In this paper, a new method based on ultrasonic guided wave is used to detect the anticorrosive coating of pipeline. When the external corrosion protection layer of the pipeline is detected, the launching probe and the receiving probe are placed on the inner wall of the pipe and positioned relative to the Z axis so that the ultrasonic guided wave is transmitted in the YZ plane. The pipe is checked with a piezoelectric ultrasonic probe with a center frequency and inclination angle. The maximum critical value defect identification method is used to identify the peeling of the anticorrosive coating. The method can quantify the length of the stripping of the pipe anticorrosion layer and locate the peeling layer of the anticorrosive coating.

##### 4.1. Parameter selection of piezoelectric ultrasonic oblique probe

*4.1.1. Effect of center frequency of probe on delamination detection of corrosion protection layer.* Generally speaking, the trend of the peak to peak decrease of the echo signal increases with the increase of the ultrasonic guided wave excitation frequency. When ultrasonic guided waves propagate in a plate of uniform material and thickness, the attenuation of energy is related to the excitation frequency of ultrasonic guided waves. The change of ultrasonic guided wave excitation frequency will affect the attenuation coefficient when propagating in the medium. The higher the excitation frequency of ultrasonic guided wave, the more serious scattering attenuation and absorption attenuation. Absorption attenuation coefficient

$$\alpha_a = c_1 f \quad (1)$$

$c_1$  is constant,  $f$  is the excitation frequency of ultrasonic guided waves.  $\alpha_s$  Is the Scatter attenuation coefficient.

$$\alpha_s = \begin{cases} c_2 F d^3 f^4 & d < \lambda \\ c_3 F d f^2 & d \approx \lambda \\ c_4 F / d & d > \lambda \end{cases} \quad (2)$$

$F$  is the anisotropic coefficient of propagation medium,  $d$  is the grain diameter of the propagating medium,  $\lambda$  is the Ultrasonic guided wave length,  $c_2$ ,  $c_3$ ,  $c_4$  are constant. In the internal test of delamination defects, a piezoelectric ultrasonic oblique probe should be chosen.

*4.1.2. The influence of the angle of incidence ( $K$ ) of the probe on the detection of the anticorrosive coating's delamination.* When the guided wave propagates in the medium, the corresponding horizontal displacement of the primary reflected wave of ultrasonic guided waves is related to the  $K$  value of the probe. The larger the  $K$  value is, the greater the horizontal displacement of the guided wave reflected at one time. When the receiving probe of the ultrasonic guided wave receives the echo signal at the surface of the detected specimen, the receiving range is not a point, but a region with a certain area [7]. The length of this region is related not only to the size of the piezoelectric wafer to which the probe is received, but also to the placement angle of the piezoelectric wafer (the  $K$  value of the probe).

#### *4.2. Defect identification of anticorrosive coating*

*4.2.1. Quantification of the exfoliation of an anticorrosive coating.* By distinguishing the peak to peak distance of the echo signal with the distance, the length of the stripping can be quantified [8]. This can be used to assess the size of the delamination and provide the basis for the quantification of the delamination of the anticorrosion coating from the inside of the pipeline. The maximum critical value method is adopted to identify the length of the stripping of the anticorrosive coating.

*4.2.2. Error analysis.* Through the detection of anti-corrosion layer of the pipeline, it is found that the size of the anti-corrosion layer is larger than the true value. The measurement accuracy increases with the increase of the stripping length of the anticorrosive coating. The larger the stripping length of the coating, the more accurate the identification result and the higher the measurement accuracy. This is because the detection of pipeline corrosion protection is based on discrete fixed-point testing, and the distance between the two adjacent detection points affects the accuracy of the determination of the starting and stopping points of the stripping of the coating. Thus, the quantization accuracy of the coating delamination is affected, and the quantization error is present.

#### *4.3. Location of the peeling of the anticorrosive coating*

The method of maximum critical value corrosion protection layer peeling can locate the starting and stopping positions of the coating. In order to find the damage location of the anticorrosion layer and repair it. This also provides the engineering basis for the detection of the corrosion resistance layer in the pipeline.

### **5. Conclusion**

The New Detecting Technology Based on Ultrasonic Guided Wave is an effective method to detect the External Anticorrosive Coating Defects of Pipelines. The maximum critical value method of delamination identification can locate the starting and stopping positions of the anticorrosive coating. Then it can find the damage location of the anticorrosion layer and repair it.

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