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Overview of Research on Corrosion Detection Technology for Offshore Engineering Facilities

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Abstract: Offshore oil platforms, wind power facilities, aquaculture facilities and other facilities are exposed to harsh environments such as seawater, salt spray and humidity, and are highly vulnerable to corrosion threats, resulting in great risks. Therefore, it is necessary to carry out the detection of corrosion conditions in offshore engineering facilities. Through the comprehensive detection of various corrosion, risk points can be found, risks can be prevented, and accurate protection can be carried out. This is a very effective means for the health management of marine platforms. This paper summarizes the new corrosion detection technologies of offshore engineering facilities, including Alternating current field measurement (ACFM), electric field characteristic detection method, ultrasonic method, etc. This paper also looks forward to the development of corrosion detection technology. By obtaining comprehensive and accurate corrosion test results, we can conduct safety assessments of offshore engineering facilities in order to better adjust and optimize corrosion protection measures and ultimately ensure production safety.

1. Introduction

In order to ensure the service safety of offshore engineering facilities such as oil platforms, wind power facilities and aquaculture facilities, in addition to effective anti-corrosion design, it is also necessary to carry out corrosion status detection, grasp the corrosion status of materials or structural components in real time, avoid failure due to corrosion, and ensure the safety of facilities during service period. The corrosion detection technology refers to detecting the corrosion state, corrosion rate and other corrosion-related parameters of the equipment by using detection instruments and material analysis methods, and evaluating the corrosion state and corrosion safety of the equipment according to the detection data so as to master the corrosion state of materials and summarize the corrosion rules, and accurately predicting the corrosion life of the material, avoiding material failure caused by corrosion, safety accidents and property damage.

2. New Ocean Corrosion Monitoring Technology and Application

According to the characteristics of corrosion monitoring technology, it can be divided into direct monitoring technology and indirect monitoring technology. The direct monitoring technology measures the parameters that change directly due to corrosion or erosion, while the indirect monitoring technology measures the parameters that affect corrosion or erosion or change due to corrosion or erosion. Usually, when metal structures are used in the ocean, electrochemical corrosion and erosion corrosion are the main corrosion behaviors, and the corresponding corrosion monitoring technology are also matched with the two corrosion behaviors. At present, the commonly used monitoring means is the monitoring of corrosion current and corrosion potential. Taking oil platforms as an example, corrosion potential monitoring devices are widely used in most petroleum platforms, and through judging the coating damage condition and the working condition of the cathodic protection system, they can monitor the corrosion potential [1]. The reference electrode uses Ag/AgCl electrode to collect the corrosion potential distribution data of different parts and then analyze it systematically. When the local coating is broken, the corrosion potential of the broken part decreases compared to the corrosion potential of the intact part. We can qualitatively judge the damage of the coating system through the change of corrosion potential. In addition, through corrosion potential monitoring, we can also determine the operation of the sacrificial anode cathodic protection system of the oil platform. When the sacrificial anode reaches the lower limit of consumption, or the local arrangement is unreasonable, the corresponding protection potential will be different from the standard potential. From this difference, we can judge the operation of the cathodic protection system. In addition to conventional potential and current detection, a variety of electrical, magnetic, acoustic and other technical means are also used in marine corrosion detection [2].

2.1. On-line Monitoring of Probe of Preset Monitoring System

Cathodic protection technology has been widely used as the main measure to control the corrosion of underwater steel structure of offshore platform. The cathodic protection monitoring system is an important part of cathodic protection system. It continuously and automatically measures the main operating parameters of the cathodic protection system in different parts of the platform jacket, and provides timely information on the cathodic protection status of the underwater steel structure of the platform, so as to save the detection cost and play an important role in ensuring the long-term safe operation of the platform structure, and also provides scientific basis for the economical, reliable, reasonable and safe design of the new platform cathodic protection system. At present, the corrosion monitoring of the underwater part of the jacket of the offshore oil platform is mainly realized through the preset monitoring system. By installing potential current probes in the underwater part of the jacket, the potential and current values at different depths are monitored to determine whether the jacket is successfully protected. The monitoring system transmits the instantaneous value of the current potential of the jacket to the central control master control computer through the data cable, so that the corrosion status of the jacket can be monitored in real time, so as to determine the corrosion status of the underwater part of the jacket. The system can also accumulate corrosion parameters data in deep water, which is the data basis for the investigation of corrosion environment in this ocean area [3,4].

2.2. Non-destructive Monitoring of Alternating current field measurement (ACFM) Technology

Alternating current field measurement (ACFM) is a nondestructive testing technology developed from ACPD. The theoretical analysis of ACFM was completed by University of London in 1980s. In the early 90s, it began to be applied to the detection of offshore oil platforms. ACFM uses the effect that defects in conductive materials change the distribution of electromagnetic fields to produce piezoelectrography, and determines defects by measuring changes in the distribution of electromagnetic fields and comparing them with electromagnetic fields formed by standard ideal defects. This method combines ACPD and eddy current detection methods, and realizes detection by measuring the magnetic field change near the surface of the detection area, rather than the electric field voltage, so that non-contact defects detection can be achieved. The specific method of determining the size of the defect using the ACFM non-contact method is used: First, an alternating current is input in the area to be measured, and due to the "skin effect", the alternating current will collect on the surface of the conductor. If there is a defect in the test piece, the current line will be deflected near the defect, thereby inducing a distorted magnetic field on the test piece. We can then measure the change in the component of the magnetic field with a magnetic field probe to determine the length and depth of the crack [5]. ACFM has the following characteristics: (1) Fast detection speed, high precision, qualitative and quantitative detection of crack defects at one time; (2) Implementing non-contact detection without cleaning the paint and coating of the tested surface; (3) Any electrical conductor material can be measured; (4) No complicated instrument calibration is required; (5) Minimize the error caused by human factors; (6) High stability and resolution, it can accurately detect the length and depth of cracks; (7) Sufficient accuracy regardless of the size of the defect; (8) Good adaptability. Due to the above characteristics, ACFM is expected to dominate the area of the detection of underwater structural crack defects, replacing underwater ultrasound, magnetic particle and other detection technologies.

2.3. Field Signature Method (FSM)

FSM (Field Signature Method) is a new type of non-destructive detection technology developed by Corr Ocean Company of Norway. This method is mainly used to detect all kinds of corrosion, and can also detect most cracks and monitor corrosion and crack propagation.

The principle is to arrange the probes or electrodes in an array in the area to be measured, then measure the minute changes in the electric field through the metal structure, and compare the measured voltage value with the initially set measurement value to detect metal loss, cracks, pits or grooves due to corrosion or the like. Based on FSM technology, a portable FSM non-destructive detection instrument (FSM-IT) is developed [6]. The detection technology has the following main advantages (1) The detection precision is high and the detection result is not influenced by operator; (2) It can be used to detect complex geometry, and the use of FSM technology can greatly reduce the detection time; (3) Due to the remote detection capability, the cost of building scaffolding is reduced or eliminated; (4) For general corrosion, its sensitivity is higher than 0.5% of the remaining wall thickness. That is, the actual sensitivity will increase with the increase of corrosion, and at the same time, its repeatability is better; (5) there is no need to remove the coating, which greatly saves the detection cost and time.

2.4. Monitoring of Underwater Robot Probe and Imaging Technology

The detection of underwater robot probe and imaging technology is mainly applicable for the detection of corrosion conditions in relatively deep water (greater than 50m). Using the deep water compression resistance of the underwater robot and the clear imaging technology, the photos and videos are taken to intuitively observe the corrosion status of the underwater steel structure. The potential probe is used to measure the cathodic protection potential of the underwater steel structure, understand the corrosion status in time, and take corresponding measures [7].

2.5. Ultrasonic Method

The pipeline steel used in the offshore pipeline has the characteristic of acoustic emission, so the ultrasonic method is often applied to the corrosion detection of the submarine pipeline. The acoustic emission monitoring device used in ultrasonic method consists of three parts: Acoustic emission unit, Sensitive receiving unit and Signal processing unit. According to the processing mode of acoustic emission signal, it can be divided into two types: Using multiple simplified waveform characteristic parameters to represent the characteristics of ultrasonic emission signal, and analyzing and processing the waveform characteristic parameters; Storing and recording the waveform of ultrasonic emission signal, and analyzing the performing frequency spectrum of the waveform [8,9]. Since 1950s, the simplified waveform characteristic parameter analysis method has gradually become the mainstream of ultrasonic emission signal analysis method, and is still widely used in ultrasonic emission detection. By interpreting and analyzing the characteristic parameters of acoustic emission, the size, location and development trend of defects in the structure can be deduced.

3. Summary and Prospect

Due to the unique advantages of corrosion monitoring technology in the aspect of material corrosion safety guarantee, the corrosion monitoring technology will attract more and more attention in the design of offshore engineering equipment, and its role will also be more and more prominent. The comprehensive and accurate corrosion detection results can be used in safety assessment for offshore engineering facilities, so as to help people better adjust and optimize the anti-corrosion measures, finally guarantee safety production [10,11]. Looking forward to the future research of corrosion monitoring technology of marine engineering equipment, there are mainly the following directions:

(1) Develop local corrosion damage monitoring techniques. Local corrosion is very harmful, and its occurrence is random. Reliable corrosion monitoring is difficult. That the development of technology that can achieve reliable monitoring of local corrosion is urgently needed in engineering applications.

(2) Multi-method synergistic corrosion monitoring technology. Ocean environment corrosion is characterized by synergistic action of multiple factors, and there are synergistic corrosion effects of mechanics-electrochemistry, bio-electrochemistry and oxidation-electrochemistry. A single corrosion monitoring technology is difficult to comprehensively reflect the corrosion risk of equipment. Therefore, multi-method collaborative corrosion monitoring technology is needed to develop so that each technology complements each other to achieve the purpose of reliable monitoring.

(3) Intelligent life prediction method based on corrosion monitoring. It is necessary to carry out research on intelligent learning and analysis methods of corrosion monitoring data, extract information on the future corrosion behavior of equipment from limited data samples, and predict and evaluate equipment corrosion risks in advance.

(4) Development of in-situ corrosion monitoring technology in extreme ocean environment. The corrosion condition of deep ocean environment is harsh and the requirement of material corrosion safety is high. However, conventional corrosion monitoring technology has shortcomings in signal transmission and information extraction. Therefore, the development of corrosion monitoring technology suitable for extreme deep ocean environments can better serve the development of deep ocean resources, which is an urgent need for future research in the field of corrosion monitoring.

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