Scholar Publishing Group
Frontiers in Ocean Engineering
https://doi.org/10.38007/FOE.2020.010401
ISSN 2790-2706 Vol. 1, Issue 4: 1-8

Marine Pipeline in Marine Engineering Based on Positioning Analysis Method

Diana Raufelder*

Russian Acad Sci, Dept Luminescence, PN Lebedev Phys Inst, 53 Leninskiy Ave, Moscow 119991, Russia

**corresponding author*

Keywords: Positioning Analysis Method, Marine Engineering, Marine Pipeline, Pipeline Inspection

Abstract: Submarine oil and gas pipelines, as an important lifeline for the transportation of marine oil and gas resources, undertake the important responsibility of transporting marine oil and gas resources due to their economical convenience, safety and reliability. The laying of marine pipeline (MP) in the dark and humid harsh environment such as the seabed is easy to It is very meaningful to conduct regular inspections on submarine oil and gas pipelines from the perspective of economic development and environmental protection. Therefore, this paper studies the MP based on the positioning analysis method. This paper firstly analyzes the relevant factors of corrosion of MP and briefly explains the detection principle of acoustic emission detection technology. Then, it discusses the low-frequency locator launching system, node position detection and pipeline fatigue crack detection of MP. Finally, It is the positioning and repair of MP.

1. Introduction

Energy plays an important role in supporting the rapid development of the national economy and is a powerful boost to the advancement of society and economy [1]. Economic development is highly dependent on energy, and the development of offshore oil and gas resources is inseparable from the construction of oil and gas pipelines [2-3]. At present, the development of offshore oil and gas resources faces the following challenges: complex and extreme seabed environment, high pressure and low temperature in deep water, remote control operations, underwater separation and production operations, and long-distance underwater tie-back operations [4]. In order to ensure the safe production of offshore oil and gas in my country, we need to conduct in-depth research on the internal detection and positioning technology of MP, reduce the accident rate of MP, and ensure the safe and normal operation of oil and gas production [5].

In recent years, many scholars have conducted in-depth discussions and research on the positioning analysis method and MP, and have achieved good results. For example, Singh R K proposed a numerical model for the analysis of pipelines, umbilicals or cable configurations installed on the inelastic seabed. The model treats the entire pipeline as a single continuous segment, and the numerical solution uses the finite-difference discretization of the pipeline, and Sequencing the actual pipeline laying process allows for efficient contact detection, and the feasibility of the method is demonstrated by a representative parameter study [6]. A feasible numerical method for structural analysis of pipeline configurations during installation is presented by researchers such as Todorova D. The method treats the entire pipeline partially suspended and partially laid on the seabed as a single continuous pipe segment. The interaction of the bed and the pipeline were modeled by nonlinear large deformation beam theory [7]. At present, there are few researches on offshore engineering pipelines based on positioning analysis method, and the research on offshore engineering pipelines based on positioning analysis method has practical significance.

This paper studies and analyzes the MP based on the positioning analysis method. The structure of this paper can be divided into three parts: the first part introduces the relevant theory of the MP, including a brief description of the corrosion factors and detection technology of the MP; The part is the detection part of the MP, which designs the low-frequency locator launch system of the MP, explains the detection method of the node position, and analyzes the detection and location of the fatigue crack of the pipeline; the third part is the location and repair of the pipeline , mainly to test the accuracy of the positioning system and use CFRP to repair the pipeline.

2. Related Theories

2.1. Factors That Corrode MP

Seawater is rich in microorganisms, sediments, various mineral salts and water-soluble gases, which directly or indirectly cause corrosion of MP. Exploring different corrosion factors of MP has become a necessary measure to study MP anticorrosion [8]. The main corrosion causes of pipelines are different in different marine environments. The corrosion factors in the marine environment are as follows:

(1) seawater temperature

Temperature has a great influence on corrosion. Seawater temperature will provide a suitable environment for microorganisms and chemical reactions to cause corrosion, and accelerate the corrosion of pipelines [9].

(2) Salinity

The salt content of seawater is approaching the critical value of the concentration required for maximum corrosion rate of pipeline steel. Salts in seawater, as electrolytes, can produce strong chemical reactions with MP steel, causing the decomposition of pipeline materials, resulting in serious pipeline corrosion [10-11].

(3) Seawater velocity

Seawater carries a large amount of oxygen in the flow process. With the increase of seawater flow rate, the scouring force on the pipeline is stronger, and particles such as soil and gravel are entrained, which increases the wear on the pipeline. At the same time, with the acceleration of seawater velocity, the oxygen in seawater can fully contact the outer surface of the pipeline, thereby accelerating the corrosion of MP [12].

2.2. Principle of Acoustic Emission Detection Technology

The generation of acoustic emission requires external excitation to the object. The internal defects of the object can actively release elastic waves under the action of external forces. The propagation of elastic waves in the structure will cause particle vibration on the surface of the material. The built-in piezoelectric ceramics of the acoustic emission sensor is the The local surface particle vibration is converted into an electrical signal, which is collected by the acoustic emission sensor in this way. After acousto-electric conversion, signal amplification, and signal processing, it is finally recorded by the acoustic emission system device. By analyzing the data, the structure can be judged state [13].

3. MP Inspection

3.1. Low-Frequency Locator Launch System

Because the MP is located on the seabed and the pipe wall is thick, which affects the communication ability of the signal transceiver system, we usually use low-frequency signals, because low-frequency signals have the characteristics of penetrating seawater and metals and other intermediates, and low-frequency signals are widely used in seabed detection and localization applications [14]. The low-frequency positioning device is often installed on the detector in the subMP. When the equipment is running in the pipeline, it is often restricted and affected by the complex environment. In the design process, the following points should be paid attention to:

(1) Size requirements, the length and width of the device must be within the predetermined pipe size limit;

(2) The transmission power should be adjusted in a cost-effective manner according to the supply capacity of the power supply module mounted on the detector to meet the requirements of long-term operation during the submarine mission;

(3) The power supply module of the transmitter needs to meet the constraints of size and battery life, weigh various constraints, and make a reasonable choice [15]. Figure 1 is a schematic diagram of the specific structure of the transmitter.

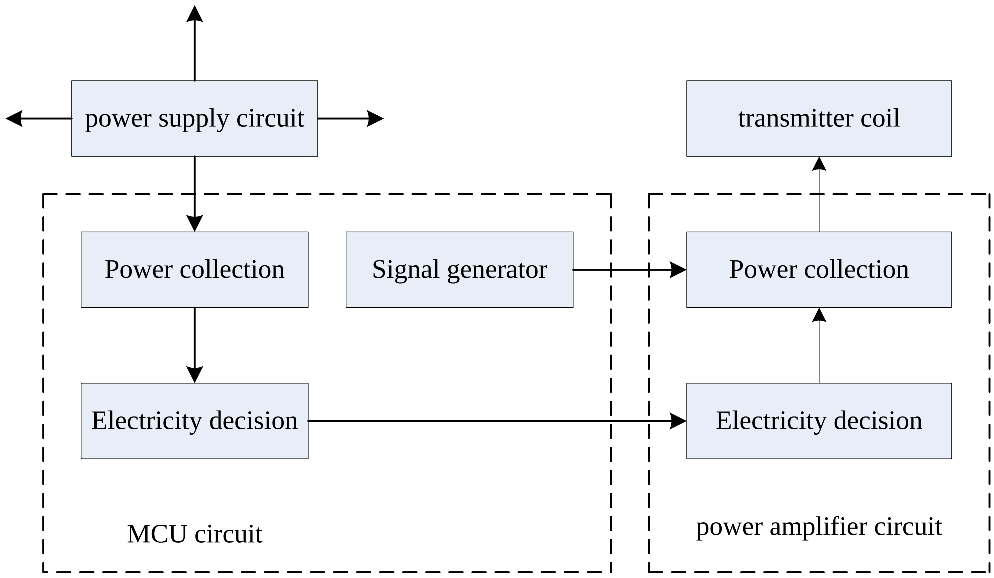

Figure 1. Transmitter block diagram

3.2. Node Location Detection

The most direct way to detect the position of the sub sea pipe node is to use the position data of the sub sea pipe node to directly correct the output of the inertial navigation system, thereby obtaining a relatively accurate position data [16]. As shown in Figure 2 below, a very important point for an accurate navigation and positioning system is to set a good benchmark. In a land navigation system, a significant marker is usually selected, its position coordinates are calibrated using GPS, and based on this, the carrier is positioned by measuring the relative position between the carrier and the reference in real time. In the sub sea pipeline inspection operation, due to the special material of the sub sea pipeline, and the different sizes and shapes of the various components of the sub sea pipeline, the magnetic flux and waveform generated will also be different. Using the non-contact magnetic scanning technology, without touching the pipeline, according to the known characteristics of the magnetic field detection waveform of the sub MP, compare the changes of the magnetic field strength to identify the stress changes, so as to determine and distinguish the welds, defects and corrosion of the sub MP. etc. phenomenon. After the sea pipe is welded, the precise position information of the sea pipe welding seam is obtained through the assistance of the surface boat, and the inertial navigation information is corrected based on this as the underwater reference, which can effectively suppress the accumulated error generated by the inertial navigation system. It is a relatively direct correction method.

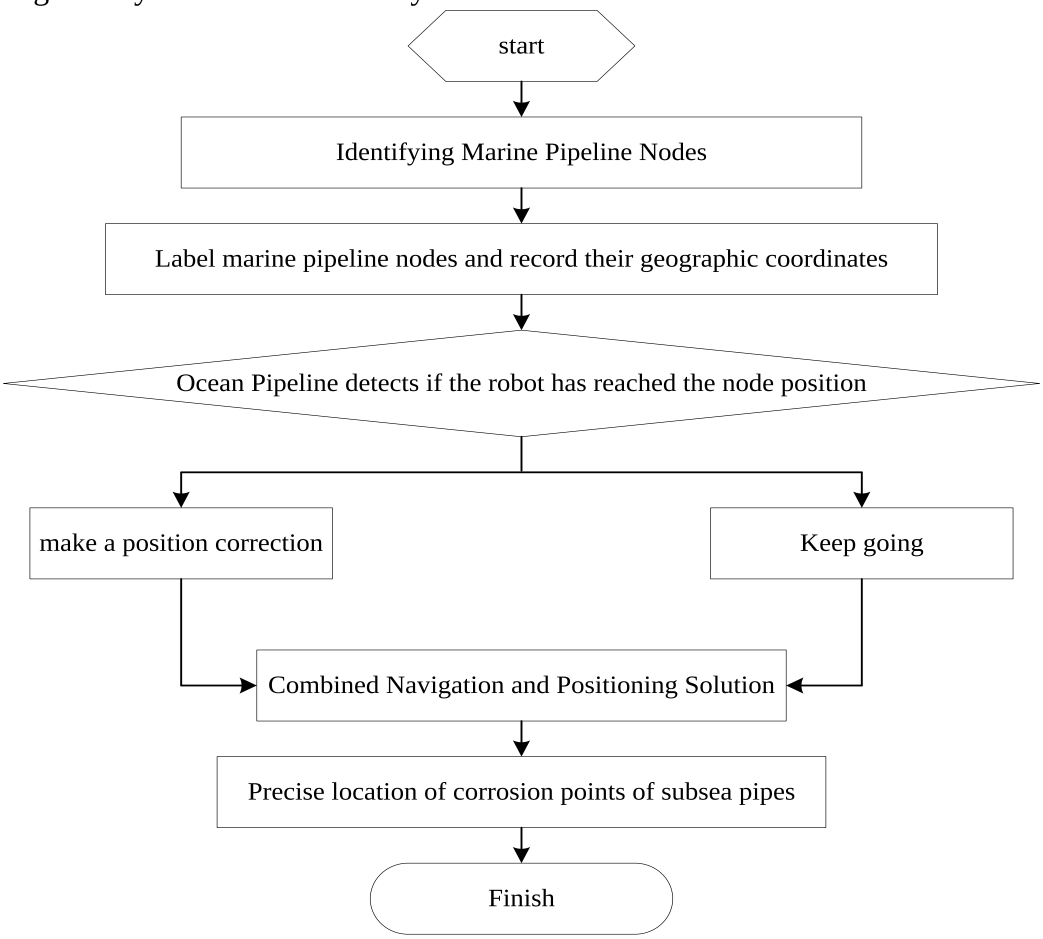

Figure 2. The working flow chart of the direct compensation method for the position of the subsea pipeline node

3.3. Pipeline Fatigue Crack Detection

Due to the complex and harsh environment of MP, fatigue cracks are easily generated under the action of cyclic loads. Fracture mechanics theory can safely assess the pipeline structure and repair it in time, and once the crack propagation enters the unstable expansion, it will cause irreversible damage to the service performance of the pipeline structure. Therefore, for MP, pipeline cracks can be monitored as soon as possible. The safe operation of MP and the reduction of economic losses are of great significance [17].

The one-dimensional time difference positioning method is adopted for the pipeline system structure, and the fatigue crack of the pipeline is simulated by the lead breaking test. Since the time to sensor 1 and sensor 2 are different, the time difference is ΔT, the propagation speed of the acoustic emission wave is V, and the two sensors Distance L, according to the following formula to determine the lead break position P:

$$\Delta T = T_2 - T_1 \tag{1}$$

$$P = \frac{1}{2}(L - V\Delta T) \tag{2}$$

In this way, the location of fatigue cracks in the pipeline structure can be determined.

Since there are many factors that affect the wave speed, including the paint coating on the outside of the pipeline system structure, whether there is liquid, etc., it is not possible to use the wave speed in the specification for positioning test research. At the same time, in order to exclude the difference in the acoustic emission wave speed that may be caused by different pressures Before the test, it is necessary to measure the wave speed under the pressure of 1Mpa, 2Mpa, 3Mpa and 4Mpa respectively. Through the analysis of Table 1, it can be seen that the sound wave propagation velocity of the pipeline system structure will be different under different pressures, and it will increase slightly with the increase of the internal pressure, but the overall change is not large.

Table 1. Table of wave velocity values under different pressures

Numbering	Pressure value	Wave speed value
1	1Mpa	1921.24
2	2Mpa	1937.45
3	3Mpa	1967.34
4	4Mpa	1980.93

4. Pipeline Positioning and Repair

4.1. Accuracy Test of Positioning Device

The low-frequency magnetic transmitter needs to be installed on the detector, which can ensure that the detector and the pipeline always maintain an axially parallel relationship. In addition, the low-frequency receiver needs to run parallel to the pipeline. When the low-frequency magnetic transmitter is carried out in the pipeline, the receiving terminal The data from the transmitter can be received in real time, and the experimental results show that the low-frequency positioning system has good performance in the actual pipeline measurement [18].

Table 2. Subsea pipeline inspection data sheet

Speed	Number of experiments	Number of valid inspections	Accuracy
1m/s	200	198	99%
3m/s	200	192	96%
5m/s	200	188	94%
6m/s	200	184	92%

Carry out the influence experiment of the running speed of the detector, drag the transmitting device to advance in the pipeline at different speeds, observe and record the detection accuracy of the receiving device, the results are shown in Table 2, the detection speed is 1m/s respectively , 3m/s, 5m/s, 6m/s four speed conditions, according to the characteristics of the signal received by the receiving device to determine the detection situation. It can be seen from the experimental data in Table 2 that there is a certain inverse proportional relationship between the detection accuracy and the running speed, and the detection accuracy is getting lower and lower as the running speed of the detector increases. However, when the in-pipe detector runs at a speed of 6m/s, the accuracy of the positioning device is still 92%, with a certain accuracy, indicating that the entire system can still operate normally and stably.

4.2. CFRP Pipe Repair

CFRP has the advantages of light weight, high strength, easy construction and operation, and good corrosion resistance. The method of repairing sub MP by winding CFRP has the advantages of simple repair process, short time consumption, good repair effect and low cost, and does not require welding during repair, which effectively reduces the operation risk. It is currently widely used in the repair of corroded pipelines. .

In order to study the effect of different pipe wall thicknesses on CFRP repaired pipes, numerical simulation studies with different thicknesses (1.3 mm, 1.5 mm, 1.7 mm and 2.2 mm) and the same outer diameter (22.4 mm) were used in this section. The load displacement of different pipe wall thicknesses is shown in Figure 3. It can be seen from the figure that with the continuous increase of the pipe deflection, the ultimate bending load increases linearly, and then the load curve shows a gentle trend and continues to increase. After reaching the peak, due to the change of the pipe shape As a result, its flexural rigidity decreases, and the flexural load decreases continuously as the deflection increases. It can be seen from Figure 3 that the wall thickness of the pipeline can affect the flexural rigidity of the CFRP repaired pipeline. The greater the wall thickness, the greater the flexural rigidity of the pipeline.

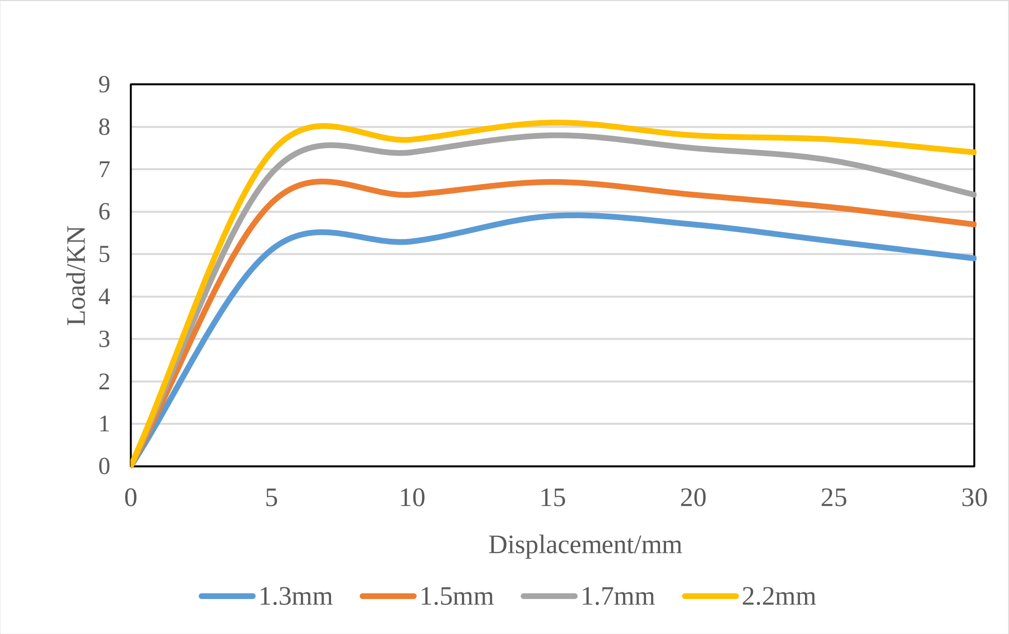

Figure 3. Limit load displacement diagram for different pipe wall thicknesses

The repair procedures and steps of CFRP composite materials are: determine the repair length and repair thickness; clean the surface of the pipeline; divide the repair area; filler repair and surface grinding; composite repair pipeline; sealing treatment and vacuum curing.

5. Conclusion

Regular inspection of MP is conducive to reducing economic losses and protecting the environment, so this paper studies and analyzes MP based on the positioning analysis method. In this paper, the following conclusions are drawn through research and analysis. The propagation speed of sound waves in the pipeline structure will be different under different pressures, and it will increase slightly with the increase of internal pressure, but the overall change is not large; as the operating speed of the detector increases, the low-frequency positioning The accuracy of the system positioning device is at a high level, indicating that the entire positioning system can operate normally and stably; CFRP is widely used in the repair of corroded pipelines. The wall thickness of the pipeline affects the bending stiffness of the CFRP repaired pipeline. The greater the wall thickness, the higher the bending stiffness of the pipeline. Although this paper studies the MP based on the positioning analysis method, there are many shortcomings that need to be improved. The research on the MP based on the positioning analysis method is a direction worthy of further study.

Funding

This article is not supported by any foundation.

Data Availability

Data sharing is not applicable to this article as no new data were created or analysed in this study.

Conflict of Interest

The author states that this article has no conflict of interest.

References

[1] Sethi W T , Ashraf M A , Alshebeili S A , et al. Thumb positioning analysis of new elliptical-shaped microwave sensors for non-invasive glucose monitoring. Electronics Letters, 2018, 54(9):553-554. https://doi.org/10.1049/el.2018.0128

[2] Bager A S . A multimodal discourse analysis of positioning and identity work in a leadership development practice. Communication & Language at Work, 2019, 6(1):40-62. https://doi.org/10.7146/claw.v6i1.113911

[3] Joel R . An Analysis on Global Positioning system and Line Crossing devices. Journal of Interdisciplinary Cycle Research, 2020, 12(1):1431-1434.

[4] Hong T , Jo A , Lee J . Analysis of Ship Positioning Error based on the Distance Measurement by RADAR. Journal of Korean institute of intelligent systems, 2020, 30(3):208-213. https://doi.org/10.5391/JKIIS.2020.30.3.208

[5] Silvia Z , Martina C , Fabio S , et al. Ultra Wide Band Indoor Positioning System: analysis and testing of an IPS technology. IFAC-PapersOnLine, 2018, 51(11):1488-1492. https://doi.org/10.1016/j.ifacol.2018.08.292

[6] Singh R K . Analysis for beam positioning in a disc-loaded gyro-TWT amplifier. Journal of Computational Electronics, 2018, 17(1):392-398. https://doi.org/10.1007/s10825-017-1114-4

[7] Todorova D , Gergova N , Christova M , et al. Theoretical Analysis And Positioning Benchmarking As A Product Quality Measuring Instruments. Mest Journal, 2019, 7(1):111-117. https://doi.org/10.12709/mest.07.07.01.15

[8] Kuzmi T , Bulatovi V . Performance analysis of PPP positioning method by using IGS real-time service. Geodetski Vestnik, 2018, 62(4):604-618. https://doi.org/10.15292/geodetski-vestnik.2018.04.604-618
[9] Arpita De , Arvind Mittal Arpita De , Arvind Mittal. An Optimal Positioning and Voltage Stability Analysis of Renewable Distributed Generation and Grid Integrated Energy Systems – A Review. International Journal of Electrical and Electronics Engineering Research, 2019, 9(2):13-20. https://doi.org/10.24247/ijeeerdec20192
[10] Lee J H , Kong K J , Jung B K . Performance analysis of dynamic positioning system with loss of propulsion power of T/S NARA. Bulletin of the Korean society of Fisheries Technology, 2018, 54(2):181-187. https://doi.org/10.3796/KSFOT.2018.54.2.181
[11] Yeo K S , Ting A , Ng S C , et al. Wi-Fi Indoor Positioning Fingerprint Health Analysis for a Large Scale Deployment. International Journal on Advanced Science Engineering and Information Technology, 2018, 8(4-2):1411. https://doi.org/10.18517/ijaseit.8.4-2.6837
[12] Alkan, Reha, Metin, et al. Analysis of RTK Positioning Methods Comparative Study of Single-Baseline and Network RTK. Sea Technology: Worldwide Information Leader for Marine Business, Science & Engineering, 2018, 59(10):16-18.
[13] Tozar A , Kurt A , Tasbozan O . New wave solutions of an integrable dispersive wave equation with a fractional time derivative arising in ocean engineering models. Kuwait Journal of Science, 2020, 47(2):22-33.
[14] Esa C , Mg B . Solitary wave solutions for the variable-coefficient coupled nonlinear Schrdinger equations and Davey–Stewartson system using modified sine-Gordon equation method. Journal of Ocean Engineering and Science, 2020, 5(2):180-185. https://doi.org/10.1016/j.joes.2019.10.003
[15] Bulitta C , Schlautmann B . Relevance and implications of positioning analysis for infection-preventive effectiveness of ventilation systems with low-turbulence dis-placement flow. Current Directions in Biomedical Engineering, 2020, 6(3):304-306. https://doi.org/10.1515/cdbme-2020-3078
[16] Dutta S , Hawlader B . Pipeline-soil-water interaction modelling for submarine landslide impact on suspended offshore pipelines. Geotechnique, 2019, 69(1):29-41. https://doi.org/10.1680/jgeot.17.P.084
[17] Langdeau S . Software solution provides seabed soil analysis, optimizes pipeline route. Offshore, 2018, 78(10):64-64.
[18] Ahmed S S , Ahmed S S . Finite Element Modeling of Axial-Vertical Interaction Behavior of Buried Pipelines in Dense Sand. International Journal of Offshore & Polar Engineering, 2019, 29(1):70-77. https://doi.org/10.17736/ijope.2019.bn15