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Research on Acoustic Emission Signal Acquisition and Acoustic Source Identification of Tank Floor Corrosion

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Abstract

Based on the acoustic emission source location theory of tank bottom, the sensor located among the medium inside the tank is put forward, which could identify the acoustic source of tank bottom corrosion defects together with the sensors which are arranged on tank outside wall near tank bottom, and thus the reliability of acoustic emission source location technology on the tank bottom can be increased. Location experiment of simulative tank bottom, attenuation characteristic experiment of simulative tank and acoustic source identification experiment of simulative tank bottom corrosion have been conducted. The results present that the method of acoustic source identification and location could enhance the identification of acoustic source in arbitrary triangle location, increase the area of the tank bottom zone location, decrease the missing signals caused by acoustic attenuation, at the same time, the sensors inside tank are more sensitive to acoustic source of corrosion than that outside tank, and reduce the influence caused by weather and other factors on acoustic source location. So the method can improve the reliability of acoustic emission source identification and location on tank bottom, provide theory and experiment foundation for acoustic emission testing evaluation of tank bottom.

Key words: Tank bottom; Acoustic emission; Positioning; Identification

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INTRODUCTION

Acoustic emission (AE) testing is a non-destructive testing method which can quickly evaluate the structural integrity of the pressure vessel, storage tank can be carried out in-service monitoring, and ultimately make a reasonable safety evaluation to the tank[1]. Acoustic source recognition technology of tank bottom corrosion can reflect the number of defects, and AE activity of the actual defect[2,3].

However, the acoustic source recognition technology of tank bottom corrosion still has some limitations, positioning sonic complexity, diversity and live signal type threshold of limiting factors, the impact of the tank floor sound source localization reliability. At the same time due to the design of the tank has become large, if the tank floor flawed sound source, the media spread the tank wall is detected by the sensor, this process due to the volume of the tank is too large, it will degrade the signal activity increases, the number of events lost its position can not reasonably reflect the defects affect the safety assessment of the tank bottom corrosion credibility of the results[4]. Therefore, the need for a new sound source identification methods to solve these problems, not only can improve the reliability of positioning, and can be reasonably reflects the activity of the defect; combining both triangulation location and regional positioning applications in the detection of small tanks, but also to meet the requirements of large tanks of regional location. Therefore, this paper proposes a method to identify the tank bottom sound source to solve the above problems.

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1. TANK BOTTOM CORROSION SOUND SOURCE IDENTIFICATION METHOD OF THEORETICAL ANALYSIS

In the field testing process, specific measures to locate the tank AE testing is based on the size of the tank model, in the vicinity of the tank bottom of the tank wall around the uniform array of several sensors, Figure 1 is an arbitrary triangle location snare map of tank floor, uniformly around the tank coupling six sensors, are formed between the three sensors triangle location, forming a total of six groups each positioned adjacent triangles.

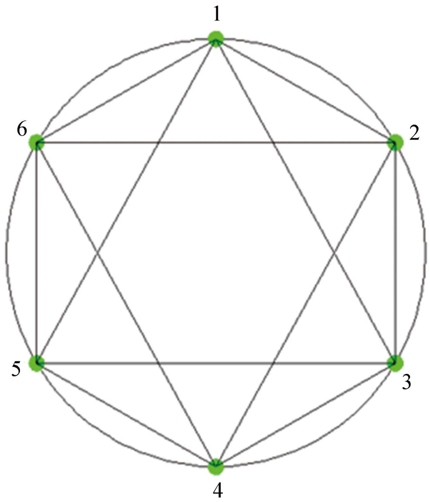

Figure 1
Triangle Location Net of the Tank

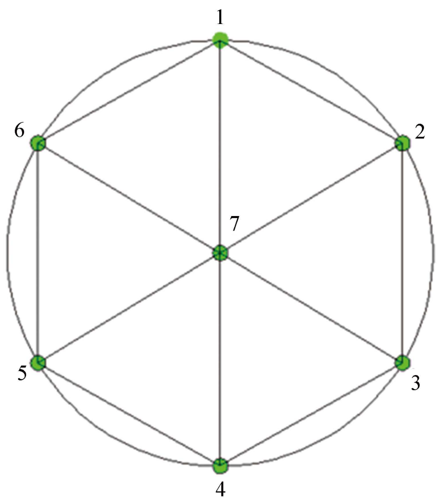

Figure 2
Tank Bottom Center Placement of a Single Sensor Triangulation Net

Although the conventional way of positioning a plurality of sets may be formed triangle location, but for large-scale storage tank volume, tank bottom defect signal amplitude is small, in particular, corrosion attenuated signal, the signal has a larger, so that the defect signal is likely to cause leakage of detection and false positives[5]. Thus the sensor is placed inside the tank becomes necessary, the sensor and the sensor outside the tank at the same plane, so that for small tanks, the main difference in the location of the sound source can be reduced misjudgment, preventing AE signals "lost". For large tanks, in the area of positioning, positioning can increase the detection coverage are 2, the sensor 7 is placed in the center of the tank bottom, the tank wall with six sensors form a triangle around the location. Set a sound source at the bottom of the tank in *S*, its location shown in Figure 3.

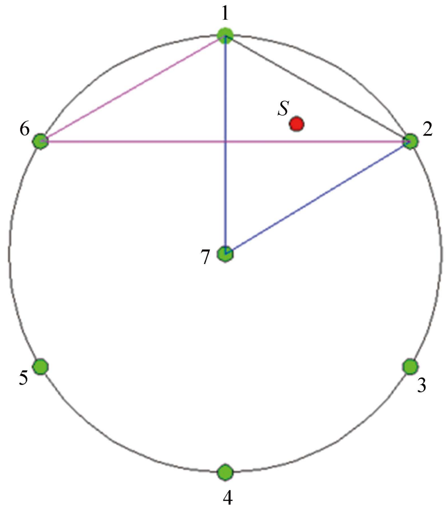

Figure 3
S at the Floor of the Tank AE Localization

As can be seen from Figure 3, the sensor 7 is placed in the center of the tank bottom and 6 may be formed around the sensor 6 triangles positioning, this is better than shown in Figure 1 positioned almost halved attenuation.

2. SIMULATING THE TANK FLOOR SOUND SOURCE IDENTIFICATION METHOD

2.1 Experimental System and Parameter Settings

In this study, using a circular steel vertical storage tank bottom Q235 common materials made of carbon steel, steel plate diameter of 900 mm, thickness of 8 mm; Selection of American PAC produced by DP3I sensors, and integrated higher more suitable for pressure vessel inspection 3rd generation all-digital system[6]. PDT is 300 μs, HDT is 600 μs, HLT is 1,000 μs[7].

2.2 Sensor Layout Programs and Experiments

In this experiment, six sensors in a uniform circular plate coupled to the periphery, at the same time, in the center of the circular plate coupling a sensor, the position sensor arrangement and lead off the diagram shown in Figure 4. Table 1 shows the sensor coordinate No. 1-6.

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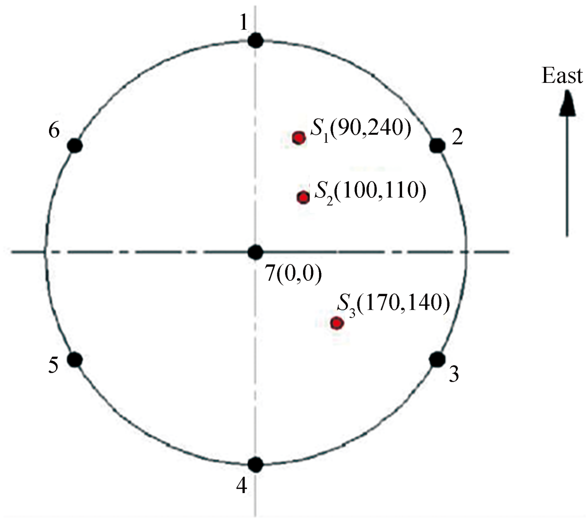

Figure 4
Sensor Arrangement Lead Break Position Schematic

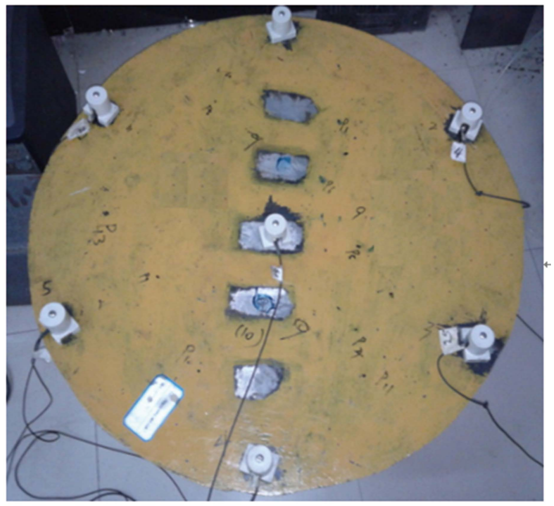

Figure 5
Simulation Experiment Tank Floor Location Map

Table 1
The Coordinate of Every Sensor

Senser number	1	2	3	4	5	6
Coordinates	(0, 400)	(346, 200)	(346, -200)	(0, -400)	(-346, -200)	(-346, 200)

Figure 4 is placed in the center of the tank floor analog sensor, and the sensor is formed on the outer periphery of the positioning, and triggering a circular plate at three locations pencil broken analog source, analog tank bottom center unplaced sensor tradition the results positioning method for comparison. Three lead break position coordinates are S_1 (90, 240), S_2 (100, 110), S_3 (170, -140). Circular plate positioning experiment Figure 5 is a sensor placed in the center.

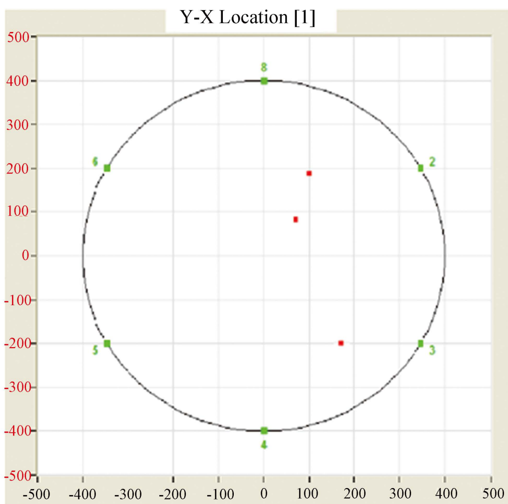

Figure 6
Traditional Positioning Method for Acoustic Localization Sensor Location Map

2.3 Experimental Results and Analysis

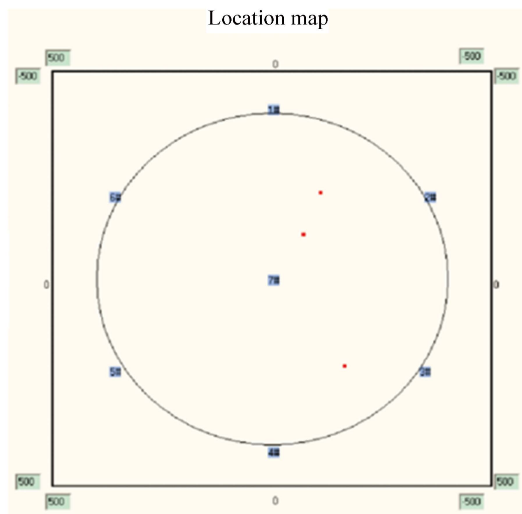

Figure 7
Place Bottom Center of the Source Localization Map

US PAC developed AEwin bottom of the tank when the tank positioning software sound source localization floor, not the bottom center of the experimental arrangement of the 7th position sensor as positioning sensors. Therefore developed a sensor in the tank for a place to identify the location of the sound source software systems, NTBPT™-New Tank Bottom Position Testing. Application AEwin system and NTBPT™ said sound source systems respectively for positioning the same experiment, in which Figure 6 is AEwin tank bottom positioning software sound source localization, and Figure 7 for the independent preparation of NTBPT™ sound source localization Figure.

Positioning the two software systems analysis results show that lead to breaking the sound source S1, S2, S3 when positioning, positioning results AEwin software is 1,2,6 sensor S1 by the number of positioning, and a positioning result from the sensor indicates NTBPTTM lead break signal is received chronological point of view, S1 by numbers 1,7,2 triangle location sensors, and the magnitude of the 7th to the 6th sensor sensor amplitude higher than 92dB 91dB, the same as the other 2 acoustic source.

Visible placed in the center of the tank floor can increase the amplitude of the triangle position sensor positioned in the formation of the signal received by the sensor, increasing arbitrary triangle positioning AE detection of the sound source recognition level, thus improving the reliability of positioning results.

3. EXPERIMENTAL STUDY OF THE ATTENUATION CHARACTERISTICS OF THE AE SIMULATION TANKS

3.1 Experimental System

AE detection system is still used SAMOS system. One sensor is DP3I, operating frequency range of 20 kHz-220 kHz, the peak frequency of 31.74 kHz, 40 dB gain, a temperature range of -65℃-175℃; another is R.45IUC underwater sensor, the operating frequency range of 20 kHz-220 kHz, the peak frequency of 22.461 kHz, this sensor is 100% waterproofing.

3.2 Experiments

In 2H (0.5 mm) lead off the analog signal as the trigger source of AE signals, respectively, in an aqueous medium tank and the tank wall metal measured its attenuation. In the vicinity of the 1st sensor lead off, respectively, the height of the calibration 12, adjacent to the height difference of 100 mm, the height of each calibration three times to reduce the error of the nominal values, the magnitude of change of the recording, the experimental apparatus is connected as shown in Figure 8.

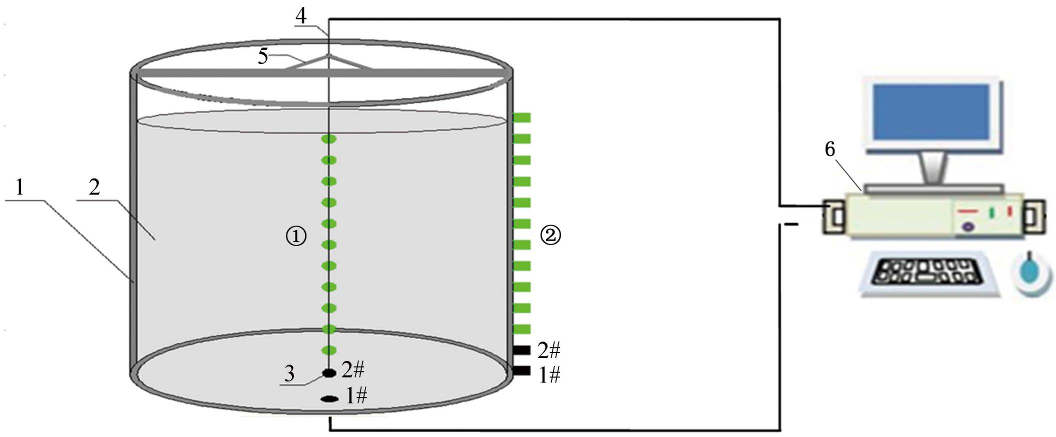

Figure 8
Sound Attenuation Experimental Device
Note. ① is underwater acousticattenuation experiment, ② is metal tank wall attenuation experiments; 1. Small vertical tanks; 2. Clear water; 3. Underwater sensor; 4. Signal line; 5. Metal clip; 6. AE detection analyzer.

3.3 Experimental Results and Analysis

3.3.1 Theoretical Calculation of the Attenuation Coefficient

AE wave energy attenuation occurs when the propagation in the medium, which mainly includes three aspects of attenuation, respectively, by diffusion caused by the diffusion of the beam attenuation, scattering attenuation caused by the nonuniformity of the medium and the absorption caused by the medium viscosity attenuation. Where the attenuation and scattering attenuation of the attenuation can be expressed as:

$$A_0\text{-}A = \alpha r+4.34\ln r-4.34\ln r_0 \qquad (1)$$

Where A_0 is the initial amplitude of the signal where $r = r_0$, dB; where A is the amplitude of the signal after propagation distance r, dB; Where α is attenuation coefficient; α is attenuation coefficient.

3.3.2 Attenuation of Lead Break AE Results and the Law in Both Media Analysis

AE wave propagation and attenuation in the tank wall in the water-borne experiment, Table 2 off lead AE wave attenuation characteristics in the tank wall and the attenuation characteristics of metals in the water table under the experimental program enacted.

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Table 2
Lead off AE Signal Attenuation and Water in the Tank Wall Attenuation Data Table

Distance D (mm)	100	200	300	400	500	600	700	800	900	100	1,100	1,200
Tank wall sound source amplitude/dB	98	98.3	99	98.3	98.3	97	98	98	97.3	97.3	98.3	98
Tank wall signal amplitude/dB	96	95	93.7	92	90.7	89	87.7	86.7	85	90.7	92.7	78
α_M dB/mm)	0.036	0.034	0.037	0.036	0.035	0.033	0.034	0.033	0.031	0.034	0.035	0.034
Sound source amplitude in water	98.3	98	98.3	97.3	97	98	98.3	98	97	97.3	98	98
Signal amplitude in water	95	93.3	91.7	88.7	85.7	82.3	79.3	76	73	70	67.3	64
α_w (dB/mm)	0.048	0.050	0.051	0.049	0.052	0.05	0.054	0.053	0.056	0.052	0.051	0.053

The data shown in Table 3 and Table 4 are used to drawn the attenuation curves and the attenuation coefficient which is lead-break AE waves propagating in metal and water, the abscissa point sound source for measuring pitch distance, the vertical coordinates are received at each measurement point according to the acoustic wave and the amplitude attenuation coefficient calculated by the Equation 4, as shown in Figure 9 and Figure 10.

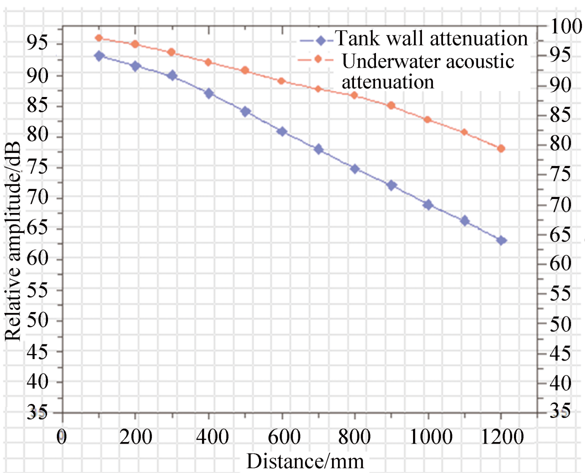

Figure 9
The Attenuation Curves of Different Media

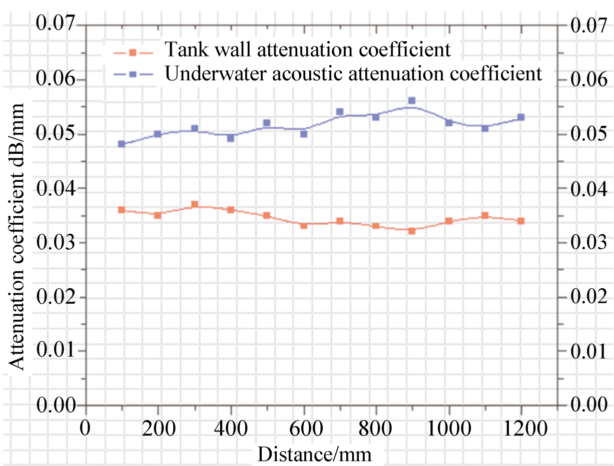

Figure 10
Attenuation Coefficient Curve of Different Media

Figure 9 shows that sound waves can be seen from the tank wall propagation attenuation curve, the whole curve is linear and relatively smooth downward trend in the height range of 1,200 mm, the signal amplitude attenuation value by an average of 98 dB to 78 dB, 20 dB attenuation loss of nearly, per 100 mm attenuation 1.67 dB; As can be seen from the acoustic attenuation curve in an aqueous medium, the entire curve also linearly decreased, in the height range of 1,200 mm, the signal amplitude attenuated by the average value of 98 dB to 64 dB, the attenuation loss of almost 34 dB, average per 100 mm attenuation 2.83 dB. Comparison of both decay curves, at the same distance, the acoustic wave propagation attenuation and attenuation in the body of metal in an aqueous medium or less, can be obtained from the experimental data only per 100 mm of the former than the latter 1.16 dB. Therefore, underwater sensor s placed in the tank the tank floor corrosion defects on AE testing is feasible and can reduce signal attenuation due to undetected phenomenon caused by corrosion of the tank floor to improve positioning reliability. And because the sensor is surrounded by the water medium in the tank, with respect to a sensor disposed outside of the tank resistance to external interference stronger influence on the positioning, the received interference signal less, the higher the reliability of positioning.

Figure 10 shows that, from the underwater acoustic attenuation coefficient curve can be seen, AE wave attenuation in the aqueous medium more stable, the attenuation coefficient and the tank wall attenuation coefficient is not much difference from the experimental data available per 100 mm of water attenuation coefficient only larger than the metal tank wall attenuation coefficient 0.017 dB/mm, further evidence placing sensors in the tank medium in AE testing method has testability and feasibility.

CONCLUSION

In the center of the tank floor position sensor placement can enhance the formation of a triangular array sensor receives the signal amplitude, increased arbitrary triangle positioned in AE detection and identification of the source of the sound.

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Application of underwater sensors tank floor corrosion defects were AE testing with testability and feasibility of regional location can increase the area of the tank bottom, reducing the signal attenuation due to undetected phenomenon caused by the other sensors in the tank because of the water and surrounded by the medium, with respect to a sensor disposed outside of the tank against external interference stronger influence on the positioning, the received interference signal less, the higher the reliability of positioning.

Characteristics of underwater AE signals received by the sensor placed inside the tank can be a more accurate description of the tank floor corrosion process, and closer to the corrosive properties of the sound source, signal loss is less.

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