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APPLICATION OF ACOUSTIC EMISSION DETECTION TECHNOLOGY ON MULTILAYER BINDING HIGH PRESSURE VESSEL

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Abstract

According to the structure characteristics of multiplayer binding high pressure vessels, acoustic emission linear location method is used to detect deep active defects in hoop weldments. At the same time, triangle location and zone location methods are used to inspect the whole cylinder. The result shows that multiplayer binding vessel with excellent integrity presents elastic characteristic like monolayer vessel in the second boosting period. In the second holding period, there are only few AE hits and no obvious acoustic sources. To the vessel with active defects, latent dangerous sources can be located, which can not be located by other testing methods. All of these approve that acoustic emission technology can not only be used on the testing and assessment of monolayer pressure vessel, but also on multiplayer binding high pressure vessel.

Keywords: multiplayer binding, urea synthesize tower, Acoustic emission testing, assessment

1. Introduction

Because of the simple structure, excellent ductility, little probability of brittle fracture and high security of multilayer binding high-pressure canister body, it is widely used in pressure vessels. Urea synthetic tower, one of the key equipments of chemical fertilizer settings, is a high-pressure vessel that adopts the multiplayer binding vessel. However, due to the characteristics of the multiplayer binding vessel, it is hard to inspect and evaluate overally with common nondestructive testing methods. So we have to use AE detection technology to overally check whether urea synthetic tower has active defect under hydrotest[1].

AE detection makes use of piezoelectricity sensor coupling on outside surface to detect the stress wave eradiated from material craze and defect activities. Sensors are arranged by some array, and they do not need to scan on the equipment. Usually, we can detect the activity and severity of objections and analyze the location of active defect. We can evaluate urea synthetic tower comprehensively according to the examination results and related detection standards[2].

We have carried out AE inspection and security assessment on 12 multilayer binding high-pressure vessels; 2 of them are high-pressure exchanger shells(diameter 800mm, height 15m,designed pressure 15MPa), 9 are hydrogen and nitrogen storage tanks (diameter 500m,height 8600mm, design pressure 14.7 MPa), and one is urea synthetic tower. The examination results indicate that the multilayer binding vessel of excellent integrality displays elastic characteristics that is similar to the monolayer vessel in the 2nd rising pressure process. There is few AE bounce in the 2nd constant pressure process, and there is no sound source after analyzing the AE bounce amount and orientation integrated data. As to the vessels with active defect, we may display the existing potential danger source through AE data analysis of the differently pressurizing process, simultaneously it substantiates that AE detection technology can not only be applied to monolayer pressure vessels but also to the inspection and assessment of multilayer binding vessels. This text takes ammonia synthetic tower as an example to introduce the AE detection and assessment methods of multilayer binding high-pressure vessels.

2 Detection Methods

2.1 Basic parameters and detection purpose of the synthetic tower

The ammonia synthetic tower of some Petrochemical plant was founded in 1975 with design pressure of 16.1MPa, operating pressure 14.8MPa,design temperature 191C.Material: canister body K-TEN62M, head SB49SR, wall thickness: canister body 84.0mm, head 120(down)94(up)mm, the tower geometry size φ 2800×33000mm. The canisterl body is welded by 7 multilayer binding shell rings. The media work is ammonia and carbon dioxide, etc. Because of the tower's structure, technology particularity and surpassing the design life, the security is a big problem of the plant. The main potential dangerous defect might be deep round welding joints and inside crack and eroded holes. Therefore, this detection adopts partial welded joint ultrasonic wave diffraction method, the stress test method, the AE Inspection method and adding intensity analysis to carry out structural integrity assessment. This text focus on AE detection and assessment method, and consult with other examination results, to validate the consistency of detect result.

2.2 Detection instruments and the selecting main parameters

The instrument used is 32 –channel AE detection analyzer made by PAC CoMPany in the United States, the type of sensor is R15, the resonance frequency is 150KHz. The main parameters adopted are: threshold 40dB, plus 30 dB. The location methods are line, triangle, and zone orientation. The average sensitivity of sensor is 91 dB, The wave speed is measured with attenuation measure method.

2.3 The arrangement of sensors

As to this kind of multilayer high-pressure vessels, we can use sensor array arranged by AE technology on the outside of canister body to detect the objection activity of the body and inside material. The stress wave of objection activity can spread out through affixing pre-tighted phywoods, or through the deep round welded joints of the canister body’s ends, and it will be received by the sensor coupling on the outside surface and the signal of AE is effectively dealed with and analyzed.

In order to improve the detect sensitivity and reliability of objection location, we put the AE sensor on the outside of the deep girth weld in the tower, and three sensors on the circle of the round slot averagely, the distance between 2 sensors is 3000mm; The sensors of two consecutive round slots are staggered as a triangle array, so that we can use linear location software to detect deep round welded joints and at the same time to detect multilayer binding canister body through triangle location and zone location. The distribution of sensor array can be seen in Fig 1. The biggest distance between sensors is 4460mm.

2.4 Pressurizing process

In order to ensure the effectiveness of AE detection, we use two cycle pressurizing process. The pressurizing curve can be seen in Fig 2. The hydraulic pressure test is determined at Pr=17.8MPa.

3 Detection results

3.1 AE detection results

We can obtain the following results of individual phases through the AE detection and data analysis of hydrotestto multilayer binding urea synthetic tower[2].

(1)The first pressurizing cycle

This phase received a lot of AE signals, most of which come from 2 pressurizing phases (F1 5.0-14.8MPa) and F2 (14.8-17.0MPa). These signals are caused by the friction between rubbed phywoods and by the crack of exterior mill scale. We can obtain 2 exhibitory sound sources through eliminating the obvious noisy signals with data wave filtering technology, see Chart 1.But whether these sound sources are surely from objections still needs to analyze the pressure dwell signal of the first phase and the detection results of the second pressurizing cycle.

There is no centralized location in either the first pressure dwell step FHz(P=14.8MPa) or the second pressure dwell step(P=17.5MPa), and few AE hits. The dispersed anchor point are mainly distributed on the above head and the above half canister body(coMPared with other parts, the exterior surface corrosion of this place is more serious), and it shows that the signals from the pressurizing phase is truly caused by the incoMPatibleness of phywoods and the crack of exterior mill scale. The active objection may still move in the pressure dwell phase, so the detection results of the pressure dwell phase are of great importance.

(2)The second pressurizing cycle

The purpose of detecting AE in this phase is to further determine whether there is dangerous sound source in the vessel. Since the transfiguration of the phywoods in the first pressurizing cycle is completed, displaying characteristics that is similar to monolayer vessel and the influence of mill scale can be eliminated, so that this phase is not interfered seriously. If there is serious dangerous objection, AE signal will turn out again in the first point that produces sound, and if even more serious, there will be sound source of high grade.

In the pressurizing phase S1(14.8-17.8MPa),sound source S3 will turn out again but not very centralized. It is in the non-round welded joints , and because this sound source display obvious signal in falling pressure phase, which means sound source S3 might come from the insufficient transfiguration or the continued crack in liner and mill scale. It is a question that needs to be verified.

There is only a few dispersed anchor points and no sound sources of any grade in the pressure dwell phase SH2(17.8MPa).

(3) The place of tubes jointed with the down head

In this place, there are 28'sensor and 26' 27' sensors of a triangle array to detect jointed welded joints. There are dispersed anchor points in the two pressurizing phases of the first pressurizing cycle. There is no formed position in the pressure dwell phase FH1. And there are only two dispersed anchor points in the pressure dwell phase FH2.There is no sound sources of any grade in the pressurizing phase S1 and pressure dwell SH2 of the second pressurizing cycle.

(4) The integrative grade of the sound source

We can put the sound sources of the above individual phases in Table 1 to determine activity grade of sound sources, and we can use the sound source strength grades determined by strength and energy, in this way, we can obtain the integrative grade of the sound source in the end[2], see Table 1.

3.2 Comprehensive results analysis

We did not find defect superscale through detecting three deep round welded joints with supersonic diffraction method; The relations of stress, strain and tension of tower body and welded joints are linear, which means the tower body is within the elastic confine during the hydraulic pressure test. Through calculation, we know that the stress in hoop direction and axial stress of the canister body and head are within the security confinement. The sound source of grade A does not need to be detected again according to AE detection standards. The B grade sound source of S3 point is caused by the surface crack of mended welded joints in liner, and it can be used safely after repairment. The B grade sound source of S4 point only appears in the first pressurizing cycle, and it is caused by skin cracking through inspection.

The results of welded joints ultrasonic diffraction detection, stress testing and AE inspection show that the structural integrity is excellent. However, taking the towers overtime load into consideration, we should enhance security management and monitoring.

4 Conclusions

(1) The detection results indicate that AE detection technology can not only be applied to monolayer pressure vessels but also to the inspection and assessment of multilayer binding vessels.

(2) It is a reasonable sensor arrangement to make use of line location to mainly detect deep round welded joints and triangle location that comes through two nearby welded joints.

(3) Whether the sound sources of the first pressurizing cycle are from the true objection needs to be determined by analyzing the detection results of the pressure dwell phase and the second pressurizing cycle.

(4) The multilayer binding vessels of excellent integrality displays elastic characteristics that is similar to monolayer vessel in the second rising pressure process, and there is no sound source that appear in the pressurizing process in the second pressure dwell process.

(5) The B grade sound source of S3 place is caused by the surface crack of mended welded joints inside, and it can be used safely after repair.

(6) The welded joints ultrasonic diffraction detection, stress test and AE inspection results show that the structural integrity is very excellent, However, taking the towers overtime load into consideration, we should enhance security management and inspection.

References

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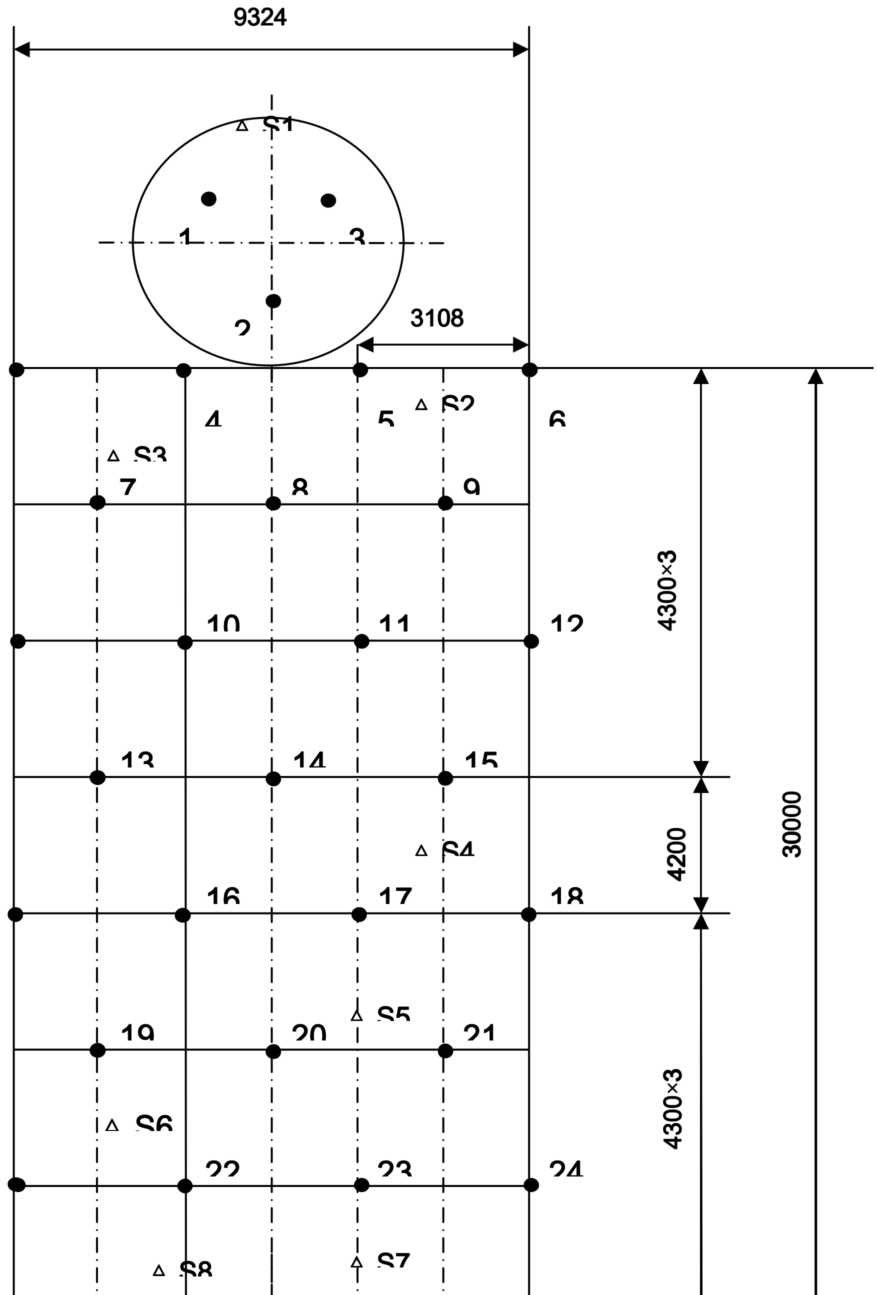
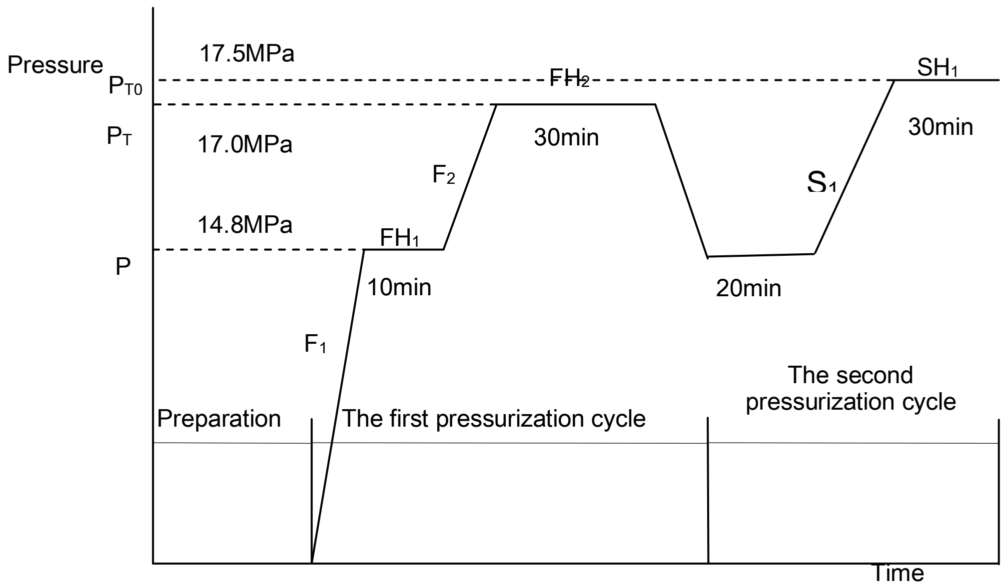

9324
S1
1
3
2
3108
4
5
S2
6
S3
7
8
9
4300×3
10
11
12
13
14
15
S4
4200
30000
16
17
18
S5
19
20
21
S6
4300×3
22
23
24
S8
S7

Fig 1 The sensor array and distribution of acoustic sources



PT —Hydrotest pressure; PT0 —Upper limit pressure in the second pressurization cycle;

P— service pressure; F1—The first increasing pressure stage in the first pressurization cycle;

FH1—The first holding pressure stage in the first pressurization cycle;

F2—The second increasing pressure stage in the first pressurization cycle;

FH2—The first holding pressure stage in the first pressurization cycle;

S1—The first increasing pressure stage in the second pressurization cycle;

SH1—The first holding pressure stage in the second pressurization cycle.

Fig2 Pressurization procedures

Table 1 Acoustic activity level, intensity level and compositive level

No	F_1	FH_1	F_2	FH_2	S_1	SH_1	activity	intensity	compositive level
S1	○	×	×	×	×	×	not active	feeble	※
S2	×	×	○	×	×	×	not active	feeble	A
S3	○	×	○	×	○	×	feeble	feeble	B
S4	○	×	○	×	×	×	feeble	strong	B
S5	○	×	○	×	×	×	not active	strong	A
S6	○	×	×	×	×	×	not active	feeble	※
S7	○	×	○	×	×	×	feeble	feeble	A
S8	○	×	○	×	○	×	feeble	feeble	※

○ —representing that there are acoustic emission resources in the stage of increasing pressure or holding pressure

×—representing that there are no acoustic emission resources in the stage of increasing pressure or holding pressure

※—representing the acoustic emission resources are noneffective