위상배열초음파를 이용한 손상된 열가소성 플라스틱배관 전기용착부 비파괴검사

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Non-Destructive Testing of Damaged Thermoplastic Pipes Electrofusion Joints Using Phased Array Ultrasonic

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요약

열가소성 플라스틱배관의 전기용착부에 대한 비파괴검사방법은 용착부의 안전성을 확보하고 장기적인 신뢰성을 확보하기 위한 방법이다. 정상적인 방법에 의하여 용착된 접합부에서도 배관의 진원도와 전기용착 소켓과의 진원도 차이 또는 기공 등에 의해 용착부에 결함이 발생할 수 있다.

본 연구에서는 위상배열초음파를 이용하여 손상된 폴리에틸렌 전기용착부의 검사를 수행하였다. 검사 대상인 250mm 직경의 폴리에틸렌 배관 전기용착부는 1994년 12월에 용착되었으며 실제 작동 압력은 2.45kPa이다. 2004년 2월 소켓 이음부 근처에서 가스가 누설되어 수거되었다. 손상된 전기용착부에 대하여 첫 번째로 육안검사를 실시하고 다음에 위상배열초음파를 이용한 비파괴검사를 실시하였다. 그리고 절단 검사를 실시하여 각각의 검사 결과와 비교하였으며 위상배열 초음파를 이용한 검사결과와 절단 검사 결과가 동일함을 확인하였다.

Abstract - Non destructive testing(NDT) methods of electrofusion(EF) joints of thermoplastics pipes are required for fusion joint safety and for the long term reliability of a pipe system. Electrofusion joints, which are joined at the proper fusion process and procedures, may encounter defects due to the difference of ovality between pipes and coupling, improper fusion process or porosity result from electrofusion joining. These defects can cause the failure of pipeline and by extension, they can be caused the limit to expand the use of plastics pipes.

This paper studies inspection results using ultrasonic imaging method for damaged polyethylene electrofusion joints. Gas was leaking from 250mm diameter polyethylene electrofusion joints at February 2004 which was electrofused at December 1994 and operation pressure was 2.45kPa. First, surface inspection was conducted and then in order to find the types of defects examination using ultrasonic imaging method was performed. Lack of fusion and inappropriate inserting for polyethylene pipes into electrofusion coupling were found and causes of the gas leak were judged that misalignment and insert defect. Cutting inspection was performed and each inspection results were compared to. Results of ultrasonic imaging method and cutting inspection were the same.

Key words : Thermoplastics pipes, Electrofusion, NDT, Phased array ultrasonic

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I. Introduction

Electrofusion(EF) joints have been widely used as they are ease to fuse and suitable for high quality joints for thermoplastic pipes. But such as voids, cracks, discontinuities, foreign particles, defects can be identified in the heat fusion joints by EF process for large diameter pipes than smaller ones. Because ovality is more likely occurred at large diameter pipes.

Non destructive testing(NDT) methods of EF joints of thermoplastic pipes are required for fusion joint safety and for the long term reliability of a pipe system. EF joints, which are joined at the proper fusion process and procedures, may encounter defects due to the difference of ovality between pipes and coupling, improper fusion process or porosity result from EF joining. These defects can cause the failure of pipeline, they can be caused the limit to expand the use of thermoplastic pipes. Ultrasonic imaging method can be done in the field in a minimum amount of time. It does not cause significant construction delay, while still providing an aid to quality control before burial of the pipe.

II. Examination

This paper studies defects detection for EF joints of thermoplastic pipes being utilized by the ultrasonic imaging method. One case was studied. Gas was leaking from EF joint which is 250mm diameter polyethylene pipes at February 2004 and EF coupling. The damaged EF joint was installed at 22, December 1994 and operation pressure was 2.45kPa.

2.1. Exterior examination of first case

Figure 1 is the side view picture of damaged EF joint. From figure 1 we couldn't find any defects visually for example melting flowings at electrofused interface and material defects of polyethylene pipes and coupling.

From figure 2 we know differences of gap between EF coupling and polyethylene pipes.

Observation results of the exterior for EF joint are as follows. First, one side of polyethylene pipes was inserted through the opposite side to heating wires, the other side of polyethylene pipes was inserted less

Fig. 1. Picture of electrofusion joint(side view).

in the same side. Figure 4 was expected figure based

Fig. 2. Picture of electrofusion joint(front view).

Fig. 3. Picture of detailed geometrical shape of electrofusion joint.

Table. 1. Data of gap between electrofusion coupler and thermoplastic pipes (Unit : mm)

	Top	Left	Right	Bottom
Gap between electrofusion coupler and thermoplastic pipes	14.62	5.66	5.95	0

Fig. 4. Expected figure based on results of exterior examination of electrofusion joint.

on result of exterior examination of EF joint. Second, polyethylene pipes and EF coupling must be connected to the parallel, but polyethylene pipes were not inserted parallel to the EF coupling. Due to these reasons, EF joint was estimated as shown figure 4.

2.2. Ultrasonic imaging method

Ultrasonic imaging method was performed in order to find types of defects. 5.0MHz phase array sensor was used.

The following figure 5 is the result of ultrasonic imaging method of EF joint and figure 7 is the detailed result of ultrasonic imaging method at a region(200mm to the right of the circumference) of EF joint. As shown in figure 7 defects were detected on the left and right side of EF joint. Especially at left part abnormal wire arrangement could be seen from the result of ultrasonic imaging method. So we could notice that fused region between polyethylene pipes and EF coupling was completely separated. This defect was assumed to be the biggest defect of EF joint. The right region of EF joint was better than left region when compared to the performance of EF, but porosity between heating wire and heating wire was detected so porosity could be estimated to grow more and more depending on the course of time. Figure 8

Fig. 5. Result of ultrasonic imaging method of electrofusion joint.

Fig. 6. Inspection position of ultrasonic imaging method of electrofusion joint.

Fig. 7. Detailed results of ultrasonic imaging method of electrofusion joint(200mm).

is the estimated figure based on results of ultrasonic imaging method of EF joint. Lack of fusion was founded and heating wires were not arranged evenly.

Fig. 8. Estimated figure based on results of ultrasonic imaging method of electrofusion joint (figure 7).

Fig. 9. Detailed results of ultrasonic imaging method of electrofusion joint(470mm).

Fig. 10. Estimated figure based on results of ultrasonic imaging method of electrofusion joint(figure 9).

Figure 9 is the result at a region(470mm to the right on the circumference) of EF joint. At left, we can see defect indications which are lack of fusion and at right, we can see porosity indication.

Figure 11 is the result at a region(800mm to the right on the circumference) of EF joint. At left, we can see the indication of lack of fusion and at right, indication of porosity also.

Figure 13 are results of ultrasonic imaging method of EF joint at a region(930mm to the right on the circumference) and we can see the porosity indication at right.

Fig. 11. Detailed results of ultrasonic imaging method of electrofusion joint(800mm).

Fig. 12. Estimated figure based on results of ultrasonic imaging method of electrofusion joint(figure 11).

Fig. 13. Detailed results of ultrasonic imaging method of electrofusion joint(930mm).

Fig. 14. Estimated figure based on results of ultrasonic imaging method of electrofusion joint(figure 13).

Fig. 15. Cross sectional view of the electrofusion joint.

Fig. 16. Picture of defect (lack of fusion) of electrofusion joint.

2.3. Cutting inspection

Cutting inspection for damaged polyethylene EF joints was performed. And results are shown in the following figure 15. In-appropriate inserting for polyethylene pipes into EF coupling was found. Lack of fusion defect was found at the following figure 16. We can see defects at EF joint, so EF coupling and polyethylene pipes are separated by lack of fusion.

III. Discussion

Non destructive testing(NDT) methods of EF joints of thermoplastics pipes are required for fusion joint safety and for the long term reliability of a pipe system. EF joints, which are joined at the proper fusion process and procedures, may encounter defects due to the difference of ovality between pipes and coupling, improper fusion process or porosity result from EF joining. These defects can cause the failure of

pipeline and by extension, they can be caused the limit to expand the use of plastics pipes.

In this study we found some results.

- This EF process was not appropriate because polyethylene pipes should be inserted parallel to EF coupling, but at this case, misalignment was occurred.

- And appropriate inserting method was not applied. It was estimated that defects occurred at EF joint and would grow depending on the course of time.

- By results of ultrasonic imaging method, we found many defects indication at EF joint especially from 0mm to 470mm to the right on the circumference. and we can see the porosity indication at right.

- By comparing results cutting inspection and ultrasonic imaging method, we found two results were the same.

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