KIGAS Vol. 16, No. 1, February, 2012
(Journal of the Korean Institute of Gas)

Field Inspection of Phase-Array Ultrasonic for PolyEthylene Electrofusion Joints

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(Received October 10, 2011; Revised February 25, 2012; Accepted February 25, 2012)

Abstract - Welding and/or fusion in polyethylene(PE) system made on site is focused on the control of the welding or fusion process to follow proper procedure. The process control is important, but it is not sufficient for the long term reliability of a pipe system. To achieve the rate of failure close to zero, Non Destructive Testing(NDT) is necessary in addition to joining process control. For electrofusion joints several non-destructive testing methods are available. The ultrasonic phased array technique is possible to detect various defects including wire deviations and regions with lack of fusion.

In this studies, testing was carried to detect the defect after electrofusion joining of polyethylene piping is utilized by the ultrasonic phased array technique. From testing data, ultrasonic phased array technique is recommended as a reliable non-destructive testing method.

Key words : polyethylene piping, welding, non destructive testing, electrofusion, llack of fusion, ultrasonic phase array technique

Ⅰ. 서 론

The electrofusion joining is mainly used for welding polyethylene pipes for the water and natural gas utilities. The electrofusion welding process uses a fitting or a coupling socket with resistive wire wound on the inside. We developed a simple and user friendly ultrasonic phased array technique and inspection device for electrofusion welding. With this device it is possible to detect various defects including wire deviations and regions with lack of fusion. Ultrasonic phased array technique uses the ultrasonic array method instead of the traditional ultra sound technique. There are two benefits of the ultrasonic phased array technique over the traditional ultrasound technique. The first one is the capability to control ultrasonic beam in real time by electronics, which enables the ultrasound beam is focused at the desired position in the sound field. As a result of the focusing, the signal to noise ratio and penetration power of the ultrasound through a specimen is dramatically improved. The second benefit is the capability of electronic scanning of the focal point, which means that the position of focal point is controlled in real time. As a result of the electronic scanning of the focal point, real time two-dimensional ultrasonic images are obtained. In test results by using array technology, imperfect fusion joints and soil inclusion are clearly indicated in the images. This paper studies the defect detection case for electrofusion fittings of polyethylene piping is utilized by the ultrasonic phased array technique to obtain ultrasonic images of electrofusion joints.

Ⅱ. Experimental

The testing by ultrasonic phased array technique is carried out for many times to verify the reliability and images of NDT are reliable compared with destructive testing results. The testing is con-

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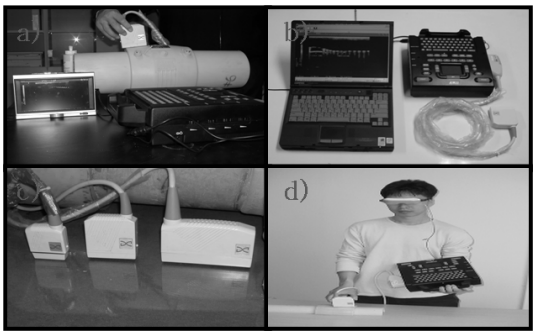

Fig. 1. (a) The inspection device for electrofusion welding (b) the device is played with lab-top computer (c) 7.5MHz, 5MHz, 3.5MHz phase array sensors (d) the device is played with HMD(Head Mount Display) also.

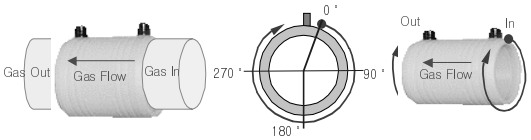

Fig. 2. Inspection direction with the sensor by the ultrasonic phased array technique.

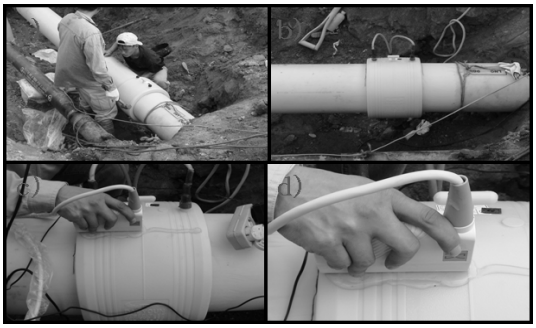

Fig. 3. (a) Insert pipe into coupler before electrofusion (b) during electrofusion joining (c) NDT with 3.5MHz phase array sensor after cooling (d) larger figure of (c).

ducted at the place of apartment construction. The diameter of 300mm polyethylene pipelines are used for supplying city gas to new apartment and also coupling socket is used for joining two polyethylene pipelines. 3.5MHz phase array sensor is

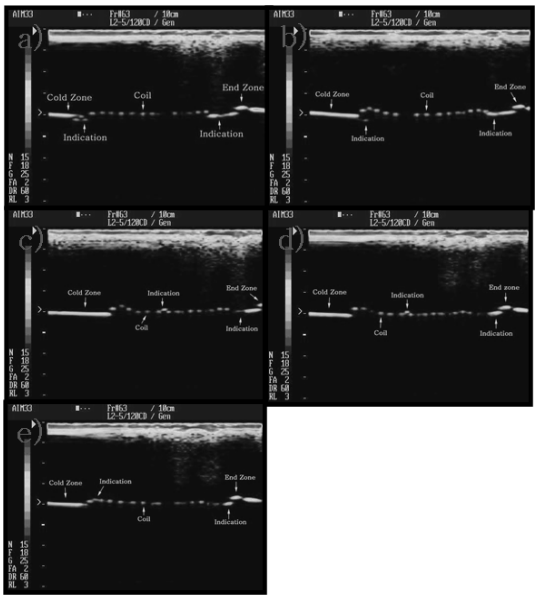

Fig. 4. Image of NDT at each testing angle of gas-in direction (a) at the angle of 0 (b) at the angle of 90 (c) at the angle of 100 (d) at the angle of 180 (e) at the angle of 270.

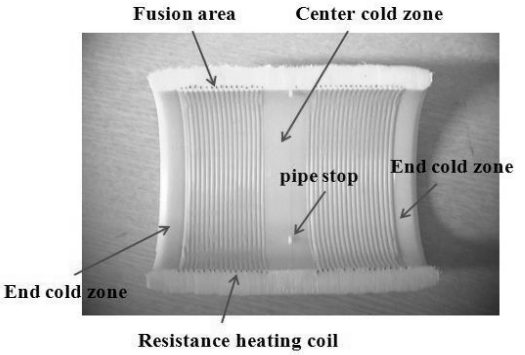

Fig. 5. The figure of cross section of electrofusion coupler.

used to detect the defect of polyethylene electrofusion joint. 3.5MHz phase array sensor can be used for high penetration test purpose. Fig 2 and 3 are figures of testing by the ultrasonic phased array technique.

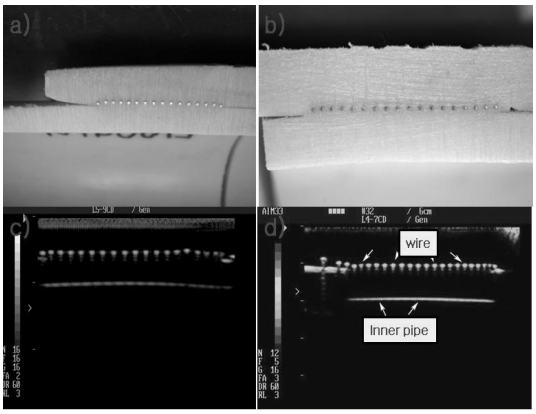

Fig. 6. Image of NDT of specimen made at laboratory (a) good joint(1) before NDT (b) good joint(2) before NDT (c) Image of NDT of (a) (d) Image of NDT of (c).

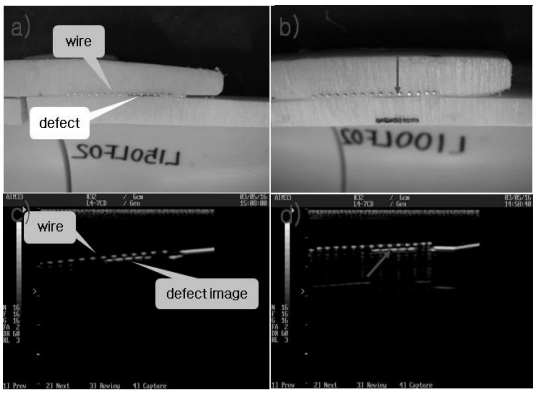

Fig. 7. Image of NDT of specimen made at laboratory (a) lack of fusion specimen(1) (b) lack of fusion specimen(2) (c) Image of NDT of (a) (d) Image of NDT of (c).

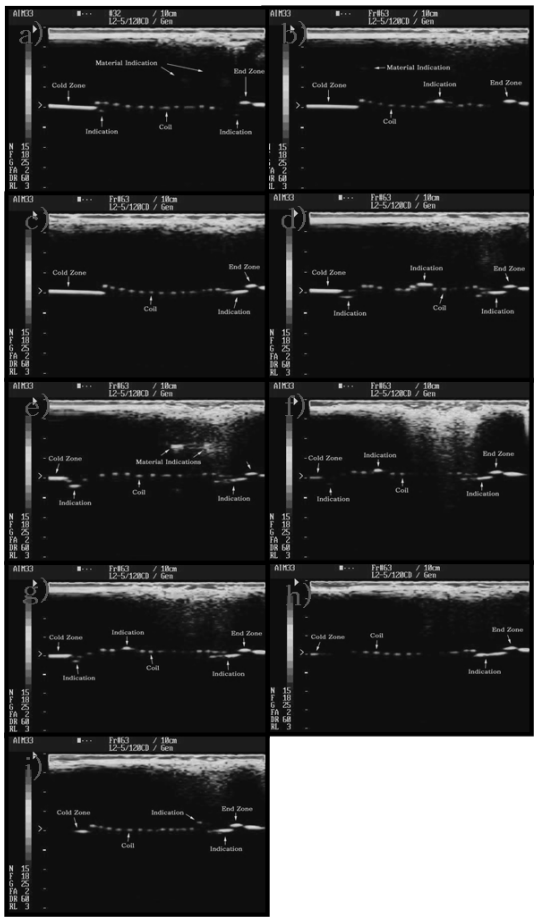

Fig. 8. Image of NDT at each testing angle of gas-out direction (a) at the angle of 0 (b) at the angle of 60 (c) at the angle of 90 (d) at the angle of 120 (e) at the angle of 180 (f) at the angle of 200 (g) at the angle of 220 (h) at the angle of 270 (i) at the angle of 350.

Ⅲ. Results and discussion

Illustrated in figure 4 is the result of testing by this technique. The indications of small porosities are detected at the angle of 100, 180 and 270 of gas-in direction. Particularly, porosity at the angle of 100 and 180 is assumed to be continued spirally from the angle of 100 to the angle of 180 in the middle of wire. At figure 4.(b), indication is found at end cold zone, it is assumed to lack of fusion(Figure 5). These kinds of indications don't exist from laboratory test specimens which are manufactured at laboratory by same process. Illustrated in figure 6 is the testing result of good joint and in figure 7 is partially joined electrofusion interface(lack of fusion). For manufacturing test

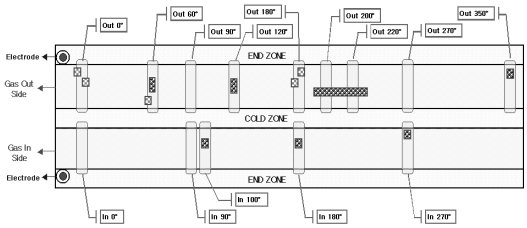

Fig. 9. Drawing of defects after NDT.

specimens which were included artificially made defect in the fusion zone, first defect was designed, second manufactured with paper, third inserted into coupler with made defect, finally electrofusion was conducted and test specimen was completed. After that electrofusion joint was tested by ultrasonic phased array technique

Heating wire reflects ultrasound and the wire signals are indicated in the image of NDT. Ultrasound is transmitted very well when the electrofusion joint is good. That is illustrated in figure 6. Clear indication of partially joined electrofusion interface(lack of fusion) is obtained underneath of wire signal in the image of NDT. Those are illustrated in figure 7 (c), (d). Illustrated in figure 8, indication of single porosity is detected at the angle of 60, 120 and 350. Also, continued porosity at the angle of 200 and 220 of gas-out direction. The indications of defects are detected at the angle of 0, 60 and 180 that are assumed to be the material defects. After NDT, defects which were detected represented graphically shown in figure 9.

Ⅳ. Conclusions

The safety of welding joint of polyethylene depends on welding performance. The ultrasonic imaging test method is possible to detect various defects including wire deviations and regions with lack of fusion. Also it can distinguish defect signals from wire signals and penetrate certain depth of polyethylene. Conventional non destructive inspection techniques detect defects by analysing a one dimensional RF(Radio Frequency) signal, but phase array techniques detect defects by using the two dimensional cross section images so is very convenient. Also because the result of non destructive test is performed with two dimensional cross section images, inspectors get properly educated and trained are capable of detecting defects easily.

Reference

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