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Small Bore Piping Socket Weld Evaluation System

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1. Introduction

Kori unit 3 had stopped operation due to leakage at Steam Generator drain line socket weld on June 6, 2008.[1]The Cause of socket weld damage was known as a fatigue crack. According to this case, all socket welds located in RCS pressure boundary are carrying out Radiographic Testing. But to inspect socket welds by RT has some problems. The result of EPRI study[2]showed that RT has limitation to find flaws at socket welds. The orientation of flaws has big influence on RT inspection capability and there is not enough space at socket welds for RT, dose problems as well.

Although the gap between coupling and pipe at socket welds must follow up code, surface inspection can't inspect the gap. If there is absence of the gap, socket welds are damaged during operation. The gap should be indentified by RT but the distance of gap can't be measured.

As this paper, the ultrasonic inspection system was introduced to figure out indication and gap in the socket welds.

2. Methods and Results

2.1 Socket Weld Inspection System

2.1.1 Principal of Ultrasonic testing

Figure 1 shows the principal of ultrasonic inspection. It is easy to have welding flaws as incomplete penetration due to socket configuration, and then flaws are growing a fatigue crack by vibration during operation. Therefore, It is important to detect welding flaws. Shear ultrasonic waves are incidence on socket welds on the coupling surface to detect welding flaws. Ultrasonic transducer is designed as dual type. The incidence angle of ultrasonic is 38~42 degree to have the best resolution.

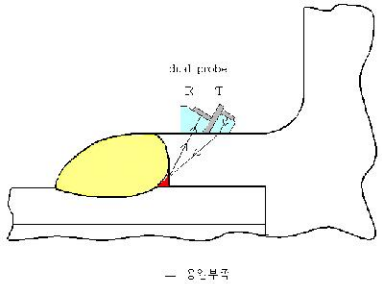

Fig.1. Principal of the Socket Weld Inspection

2.1.2 Inspection System Characteristic

- Inspection is performed automatically
- The process of inspection is imaged with an program to confirm flaws readily at real time
- Collected data is stored easily and quickly at real time
- The result of inspection is easily confirmed by an exclusive program
- Inspection system was optimized for socket welds of 1inch below

2.1.3 Volumetric Inspection System for socket weld

1) Scanner

Scanner was optimized for socket welds of 1inch below. Location is controlled automatically, which leads to reduce installing time. During inspection, scanner is adapted with various surface configurations by pressure spring making pressure on between transducer and coupling.

2) Main System

Main system consists of control panel for motor control, high frequency generator for making ultrasonic waves, pulse & receiver for sending and receiving ultrasonic waves, and control program. Main system is designed for portability and transfer.

2.1.4 Mock-up Testing

To verify inspection system, artificial defects which are EDM notch, incomplete penetration and slag were inserted in socket welds and inspection was performed with four specimens.

All defects were detected but defect sizing was measured with about 25% bigger than real size. Real defect size was 7mm and 4mm but detected defect size was between 3.39mm and 8.73mm

2.2 Socket Weld Gap Measuring System

2.2.1 Principal of Socket Weld Gap Measuring

Figure 3 shows the principal of socket weld gap measuring. Socket welding is fabricated by inserting pipe into coupling and fillet welding. Shear wave

ultrasonic transducer gets Y2s value, and then vertical transducer detects the gap location. X plus Z could be calculated. Distance of gap is measured by difference of two lengths.

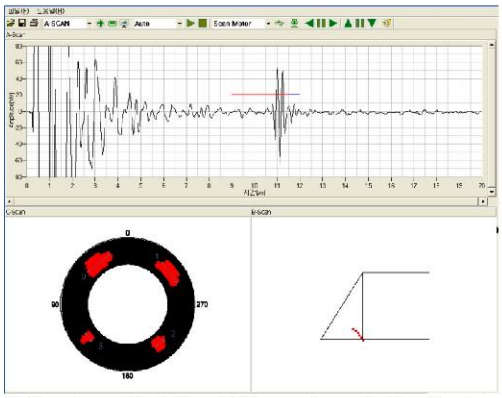

Fig.2. Specimen Test Result(7mm, 4mm; indication length)

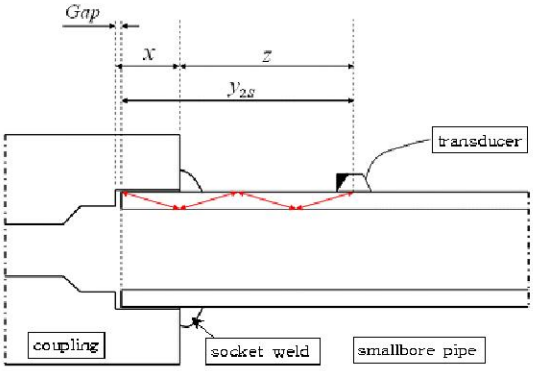

Fig.3. Principal of the Socket Weld Gap Measuring

2.2.2 System Layout

Figure 4 shows system layout of socket welds gap measuring system consisting of scanner and main system. Scanner includes two ultrasonic transducers. One of them is a shear wave transducer to measure pipe distance, another is a transducer to detect the steps located in inside of coupling. The wedge is machined to penetrate ultrasonic waves as 0.5 scabs for measuring distance gap by an inclined detector considering thickness of pipe. If pulse echo is not 0.5 scabs, 1 scab is used.

2.2.3 Mock-up Testing

Figure 5 shows the mock-up used for verifying capability of gap measuring system. The gap is between 1.35mm and 1.36mm at left side on the figure and between 1.04mm and 1.06mm at right side on the figure whose values are used during construction.

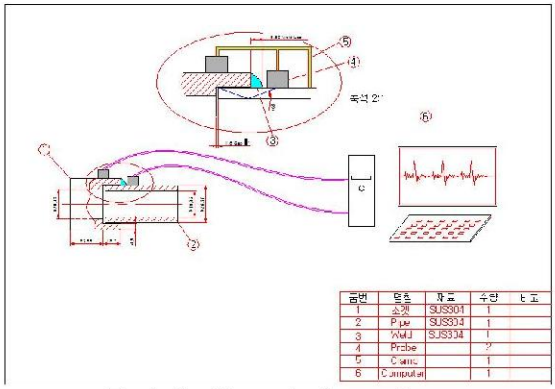

Fig.4 .Gap Measuring System Layout

The result is that left side value is between 1.30mm and 1.33mm and right side value is between 1.00mm and 1.01mm

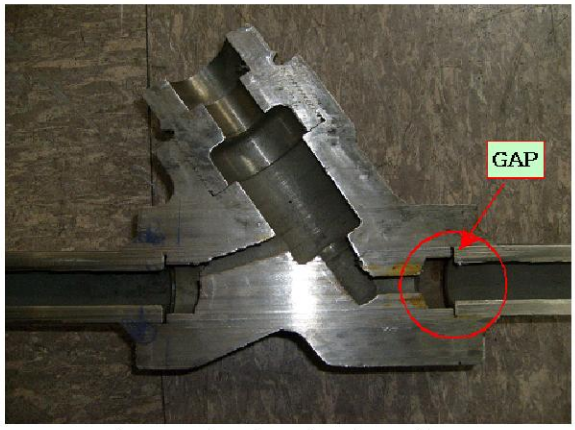

Fig.5. Section view of socket weld gap

3. Conclusions

To have integrity of small bore socket welds, volumetric inspection system was developed to detect flaws during construction and operation. The result of testing this system is that various kinds of flaws were detected. But flaw size tended to be measured with bigger than real flaw size.

Exclusive system for measuring gap in socket welds was also developed. The test result shows that error range of system is 0.03mm ~0.05mm.

It is determined that this systems developed by this study could be used to have integrity of small bore socket welds.

REFERENCES

[1] KINS "Event Report for Nuclear Power Pland" 2008-7(080606K3)

[2] EPRI TR-1016671 "Nondestructive Evaluation : Volumetric Examination of Small-Bore Piping Welds , 2008.12.