Establishment of Ultrasonic Test Procedure for Dissimilar Metal Weld of PWR Pressurizer Nozzle to Safe-end

Background

In recent years, primary water stress corrosion cracks (PWSCC) have been found in alloy 600 dissimilar metal welds of nozzle to safe-end of PWR Pressurizers (Fig.1). And as the countermeasure, it is planned to apply the outer surface irradiated laser stress improvement process (L-SIP) to these weld joints for reduction of SCC susceptibility. As a premise of L-ship application to the weld joint, it is required to nondestructively confirm the integrity of the weld joint.

Several ultrasonic test (UT) procedures have been developed for these dissimilar weld examinations and verification tests are in progress in the national project (NNW *1). It is also required by the electric power companies to validate the developed UT procedure through validation tests to expedite the application of L-SIP to the PWR pressurizer nozzle.

Objectives

To prove the applicability of the developed UT procedure for detecting PWSCC that through wall depth exceeds 20% of wall thickness, the validation test was carried out. PD Center of CRIEPI participated in this validation test as the reviewer, to confirm the adequacy of the validation test procedure, UT examination process, and the test result.

Principal Results

Technical staff of PD center of CRIEPI reviewed the validation test procedure, UT examination procedure, and the destructive examination procedure to confirm that the validation test is feasible. Technical staff monitored the UT examination process and data evaluation also. The principal results of the verification test are shown below.

(1) Detectability of PWSCC

The following result was drawn from the UT examination and following metallurgical investigation of the PWSCC size.
The validation test using test samples which simulate the diameter and wall thickness of typical pressurizer nozzle to safe-end (Fig.2) verified the detectability of axial and circumferential PWSCC that through wall depth are 12% to 23% (Fig.3). It is noted that if the length of a PWSCC is short and it's through wall depth is less than 20%, detectability will decline.

(2) Data collection and analysis procedure

An automated scanning system was used for the data collection. The data collection pitch along the scan axis was 0.5mm with scan low pitch of 1mm and 3mm. The wave form (A-scope), sectional side view (B-scope), plan view (C-scope) and projected side view (D-scope) were reviewed for the data analysis.

It was confirmed by the validation test that the selected data collection pitch and scan low is appropriate to secure the repeatability and the quality of the flaw image.

(3) Data analysis technique

The ultrasonic scattering in the dissimilar metal weld caused noise and false indications. It was confirmed through the validation test that use of different incident angle transducers, scanning from the opposite side, making a comparison between adjacent area is effective to identify flaw indications from noise and/or false indication.

Future Developments

To facilitate L-SIP application to dissimilar metal weld of nozzle to safe-end of PWR pressurizer, the validation test results are presented to a technical review committee of Japan Society of Maintenology for review. The technical committee comprising members of academic and regulatory background will review the data and conclude it to be adequate.

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Reference

T. Sasahara and T. Jikimoto, 2007, “Validation of Ultrasonic Testing for PWR Pressurizer Dissimilar Metal Weld,” Maintenology, Vol.6, No. 1, pp.21-27 (in Japanese)

*1：NNW: Nondestructive Inspection Technologies on the Ni Alloy Welded Joint

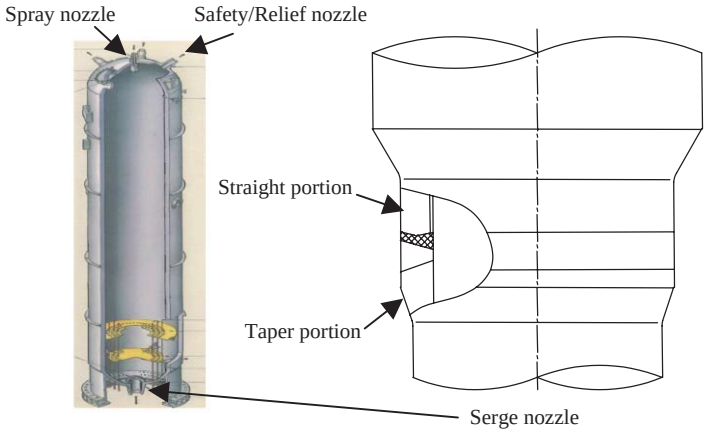
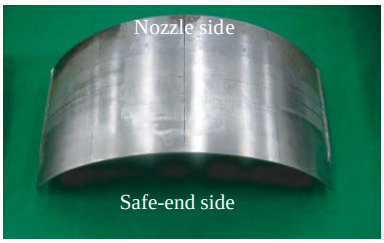
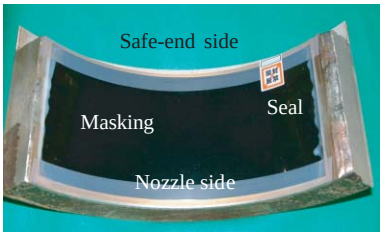


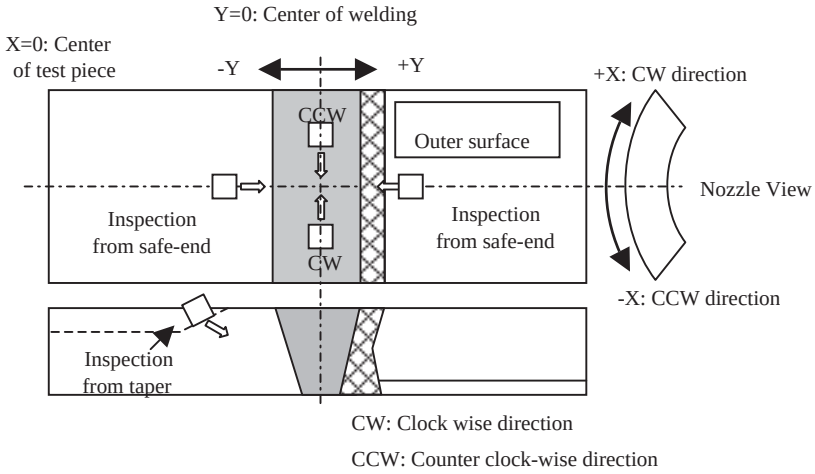
Fig.1 Pressurizer's dissimilar metal weld



(a) Outer surface

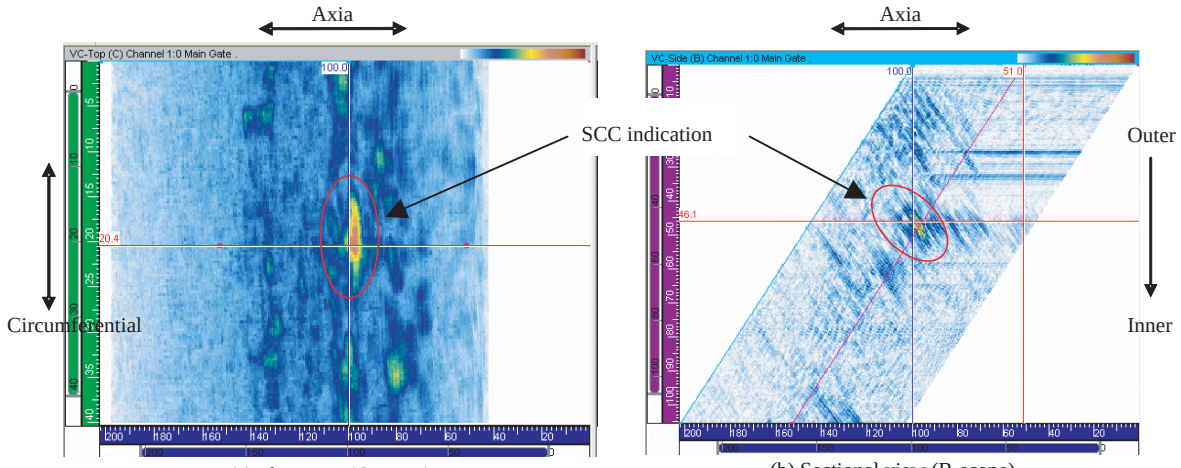


(b) Inner surface



(c) Explanation of UT inspection for SCCs

Fig.2 Example of a test sample used for validation



(a) Plan view (C-scope)

(b) Sectional view (B-scope)

Fig.3 Example of UT examination data: axial scanning from nozzle side to safe-end (Circumferential 18% through wall depth SCC in Serge nozzle)