Ultrasonic Testing Technology Development for Pressure Retaining Ti Alloy-Stainless Steel Dissimilar Metal Joint of SMART Steam Generator

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1. Introduction

The steam generator for the Integral reactor SMART has module feed water (FW) pipe and module steam pipe which consist of Ti-alloy and STS321 called dissimilar metal joint. These brazed joints are classified as a class 1 boundary component being needed in-service inspection according to ASME Sec. XI. But inspecting the thread part of brazed joint is really difficult due to geometrical condition. For this reason, various NDT methods have been investigated. In this paper, the ultrasonic inspection was recommended to evaluate the integrity of brazed dissimilar metal joint, and representative UT results of specimens are presented.

2. Methods and Results

In this section some of the ultrasonic testing techniques used to evaluate the integrity of brazed dissimilar metal joint are described as well as the details of specimens.

2.1 Dissimilar Metal Joint Structure

The module FW pipe plays a role in transferring the secondary side feed water from the nozzle FW header to the module FW header of each cassette. Its boundary is the region between nozzle FW header tube sheet (TS) and module FW header. The module steam pipe plays a role in transferring the secondary side superheated steam from the module steam header of each cassette to the nozzle header and consists of Ti-alloy and STS321 called dissimilar metal joint. The dissimilar metal joint structure of module FW pipe and module steam pipe is shown in Fig. 1[1].

Figure 1. Prepared Dissimilar Metal Joint Specimens for brazing

2.2 Brazed Joint Characteristics

It is well known that fusion welding between Ti-alloy and stainless steel is almost impossible because of brittle inter-metallic compound in its weld metal. So brazing method was selected in order to solve the problem of leakage at the joint area which was designed the thread-type to get proper strength. The joint part is assembled with male part of Ti-alloy and female part of stainless steel as a screw. The joint gap is filled with a filler metal that is BAg-19 and BVAg-30. Fig. 2 shows the cross-sectional view of a specimen that is finished a brazing process.
Fig. 3 shows the typical debonding-like defect that is often at a brazed joint.

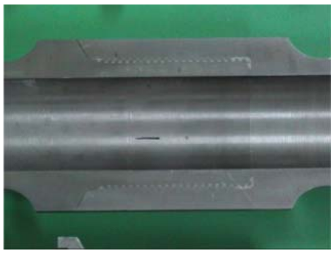

Figure 2. Cross-sectional View of a Brazed Dissimilar Metal Joint Specimen.

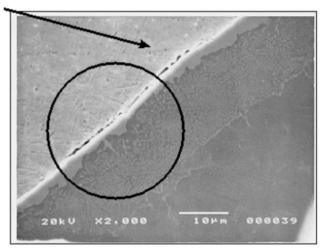

Figure 3. Microscopic View of typical debonding-like defect at the interface between two dissimilar metals.

2.3 Brazed Joint Ultrasonic Testing

Ultrasonic testing is one of the most widely used non-destructive method in which beams of high frequency sound waves are introduced into materials for the detection of surface and subsurface flaws in the material. Most manual ultrasonic inspection is done at frequencies between 1.0 and 5MHz. The major variables that must be considered in ultrasonic testing include both the characteristics of the ultrasonic waves used and the characteristics of the parts being inspected. For this reason, various frequencies and incident angles have been used for selecting the optimum conditions. Especially a brazed joint has a thread, and its geometry causes complicated ultrasonic signal. Fig. 4 shows the angle beam inspection of a brazed thread joint[2,3].

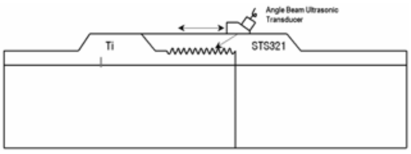

Figure 4. Schematic of pulse-echo technique applied to the testing of thread part.

2.4 Ultrasonic Testing Results

Fig. 5 shows the photo of experimental system setup. The experimental system setup includes Krautkramer USD-15 ultrasonic flaw detector, BNC cable, couplant, wedge, Lecroy 9304 Oscilloscope, and transducers. For our experiment, ten different types of brazed dissimilar metal thread joint specimens, five different frequencies (1.0, 1.5, 2.25, 3.5, and 5.0MHz) of ultrasonic transducers, and three different wedge (45, 60, 70 degrees) for angle beam were prepared. Fig. 6 shows the video mode ultrasonic signal output using 5.0MHz-60degrees transducer. Fig. 7 shows the video mode ultrasonic signal output using 2.25MHz-45degrees transducer.

Figure 5. Photo of Experimental System Setup.

Ultrasonic testing can be useful method for detecting the flaw in the brazed thread joint by two major experimental results. The higher testing frequency we apply, the more clear resolution we can get. On the contrary, the lower testing wedge angle we apply, the stronger signal we can get. Table 1. shows the summary of the above experimental results.

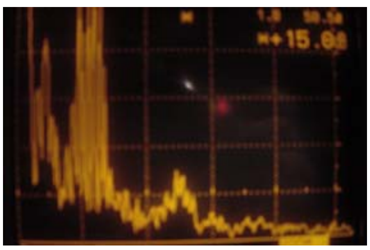

Figure 6. Video Mode Output using 5.0MHz-45degrees Ultrasonic Transducer at Brazed Dissimilar Metal Thread Joint.

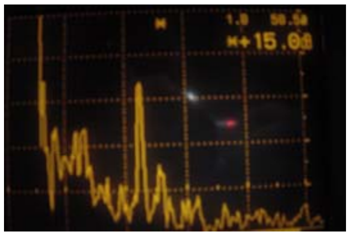

Figure 7. Video Mode Output using 2.25MHz-45degrees Ultrasonic Transducer at Brazed Dissimilar Metal Thread Joint.

Table 1. Qualitative Resolution Comparison between Testing Frequency and Testing Beam Angle (Resolution High : O, Medium : △, Low : X).

Testing Angle(Deg.) / Testing Freq.(MHz)	45°	60°	70°
1.0	△	X	X
1.5	△	△	X
2.25	△	△	X
3.5	O	△	X
5.0	O	O	△

3. Conclusion

In this paper, ultrasonic testing can be useful method for detecting the flaw in the brazed thread joint such as module FW pipe and module steam pipe of SMART steam generator. Especially resolution improved with an increase of testing frequency and sensitivity increased with decrease of testing beam angle. The experimental results indicate that the optimum test frequency and beam angle is 5.0MHz-45Degrees for brazed dissimilar metal thread joint.

Acknowledgement

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