

SCC Evaluation of the S/G Tube on the Shapes of Expanded Region

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1. Introduction

The lifetime of steam generator(S/G) tube plays an important role in the lifetime of power plant. Therefore, many researchers have been in study to elongate the lifetime of S/G tube. In elongating the S/G lifetime, there are several methods like as the usage of material with higher SCC (Stress Corrosion Cracking) resistance and the improvement of fabrication processes and maintenance environments.

From the SCC evaluation of S/G tube on the shapes of expanded region and expansion method, we endeavor to elongate S/G lifetime.

2. Methods and Results

To evaluate SCC of the tube on the shapes of expanded region, Alloy 600HTMA was used as the tube material, the expansion methods were applied in explosive and hydraulic expansion. Normal and abnormal expansion methods were used to make the specimens with the shapes of expanded region. We investigated SCC resistance of tube material, residual stress and SCC in the expanded transition region.

2.1 Tube Expansion

Both the explosive and hydraulic expansions were applied to expand the tube in tubesheet blocks. The explosive expansion is a method which uses the blasting pressure of detonation cord. Hydraulic expansion is a method which uses the hydraulic pressure. To change the shapes of expanded region, explosive expansion changed detonation cord length and hydraulic expansion changed the hydraulic pressure.

2.2 Expansion Shapes

The shapes of tube in the expanded region gave an affect to the manufacturing processes. To fabricate other shapes of tubes in the explosive expanded region, normal and abnormal conditions were used. Normal condition was that the detonation cord is same length to tubesheet thickness and abnormal condition was that the detonation cord is 3.5 mm larger than tubesheet thickness. In case of hydraulic expansion, normal condition was that the expansion pressure, 32,000PSI (2250kgf/cm²) was used and abnormal condition was that the expansion pressure, 35,000PSI (2461kgf/cm²) was used. The shapes of expanded region after

expanding were almost not changed with the expansion methods.

2.3 SCC resistance of tube material

The lifetime of steam generator gives an affect to the SCC resistance of tube material. To investigate SCC resistance of the sensitized tube material, c-ring test was performed with ASTM G38. The stresses on the specimen were applied with stress-strain curve from $0.9\sigma_y$ to $1.5\sigma_y$. 0.05M Na₂S₄O₆ solution was used and test durations were 3 hour ~ 120 hour.

The SCC results for Alloy 600HTMA tube showed that the cracks generated in the center line of the outside diameter of tubes. Time to the crack initiation decreased as the applied stress increased.

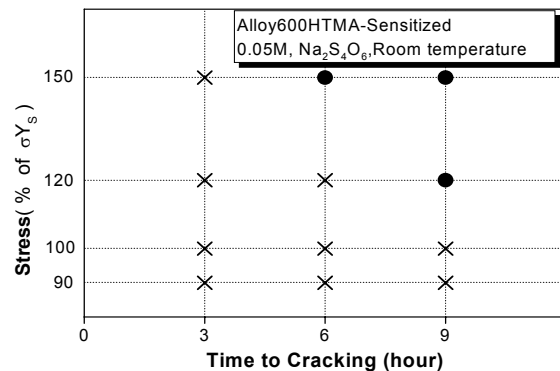


Figure 1. Time to crack initiation with applied stresses in c-ring specimens

2.4 Residual Stress of expanded transition region

The residual stress generated in the manufacturing process of tube affected to the lifetime of the steam generator. The residual stresses to the axial and circumferential directions were measured on the tube expanded transition region. A x-ray diffractometer with Cu(420) target was used to measure the residual stress.

Measured values were similar to one another regardless of the difference of the shapes of expanded region and expansion methods. The circumferential residual stress was higher than the axial one.

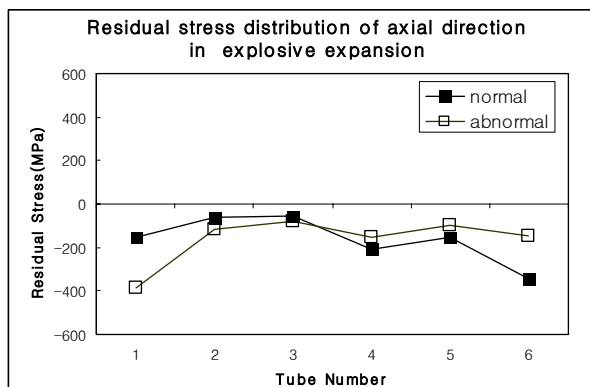


Figure 2. Residual stresses after explosive expanding, under normal and abnormal conditions

2.5 SCC of Expanded Tube

The efficiency of the steam generator would be reduced with the plugging due to the occurrence of crack on the tube and the increase of cracked tube would be reducing lifetime of steam generator with the overdue applied pressure on the each tube.

In the SCC test, 40%NaOH solution was used and saturating vapor pressure of 300°C was applied. During the test, crack on the tube outside diameter didn't occur. This results show that SCC phenomenon is indifferent to the shapes of expanded region. Figure 3 shows the microstructure on tube section of the expansion transition region, no crack is detected.



Figure 3. The microstructure of tube expanding transition region, under abnormal explosive expansion, after 4000 hour duration under 40%NaOH, 300°C.

3. Conclusion

The effects on SCC characteristics according to the shapes of the expanded tube and the expansion methods were investigated

Although the shapes of expanded region and the expansion methods are different, residual stress on the expanded region and time to crack initiation during SCC test have a similar tendency.

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