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Evaluation of Residual Stress on Welds of Spent Fuel Dry Storage Canisters By Peening Technology

Donghee Lee[a]*, Yongdeog Kim, Sungwoo Cho [b]
[a]Central Research Institute, Korean Hydro and Nuclear Power Co. LTD., 1312-70 Yuseong-daero, Yuseong-gu, Daejeon, 34101, Korea
[b]22, Doosan volvo–ro, Seongsan–gu, Changwon–si, Gyeongsangnam–do, 51711, Korea
* E-mail : donghee.lee@khnp.co.kr

:: Introduction

Chloride-induced Stress Corrosion Cracking (CISCC) is known as one of the major material deterioration of dry storage canisters made of stainless steels. Particularly, dry storage canisters installed in coastal regions where salt content in the atmosphere are high are known to be more susceptible to CISCC. Surface Stress Improvement (SSI) Technologies are more widely applied in production of new dry storage canisters in many countries including the U.S. and utilization of other technologies such as cold spraying is also being explored to prevent CISCC even in dry storage canisters that are already in operation. Therefore, residual stress analysis was conducted in this study to examine efficacy in preventing CISCC as well as applicability in dry storage canisters of most widely utilized SSI technologies - laser peening and ultrasonic peening.

:: SSI Technology

1. Objective

- This study is a feasibility study which is aimed to analyze and evaluate CISCC reduction effects of 4 technologies.
- ALP (air laser peening) ALP non-coating / coating, UNSM (ultrasonic nano-crystal surface modification), and USP (ultrasonic shot peening) are the technologies included in the study.
- The purpose is to analyze which of the four technologies is most effective in reducing CISCC in welded stainless steels dry storage canisters.

2. Test Scope & Specimens

Table 1 Entire Test Scope

Classification	Description
Materials	• 304 and 316LN Stainless Steels
Weld Process	• Gas Tungsten Arc Welding (GTAW)
Peening Technologies	• Air Laser Peening Non-Coating • Air Laser Peening Coating • UNSM • USP
Residual Stress Measurement	• Destructive Measurement - Hole Drilling Method: Verification of residual stress depth • Non-destructive Measurement - XRD Method: Verification of surface residual stress

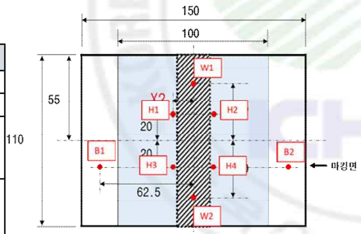

Figure 1 Residual Stress Measurement Locations

- Residual stresses were measured at 2 points on the base material, 2 points on the weld area, and 4 points on the heat affected zones (HAZ)
- The residual stresses have been measured at 8 points shown in the figure 1.

3. Results

● XRD Results

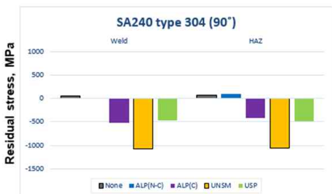

Figure 2 XRD Measurement Results (Avg. Value) Comparison Table (Type 304, 90˚ direction)

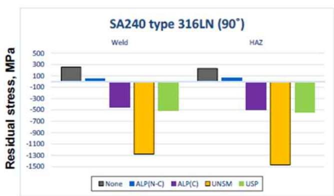

Figure 3 XRD Measurement Results (Avg. Value) Comparison Table (Type 316LN, 90˚ direction)

● Hole-Drilling Results

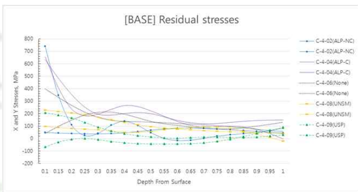

Figure 4 H/D Measurement Results Comparison (Base (Type 304), X-Direction)

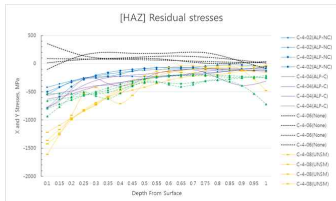

Figure 5 H/D Measurement Results Comparison (HAZ (Type 304), X-Direction)

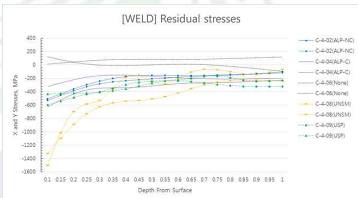

Figure 6 H/D Measurement Results Comparison (Weld (Type 304), X-Direction)

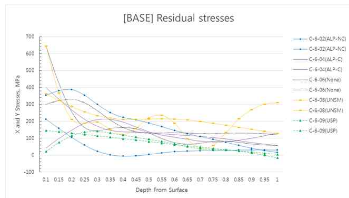

Figure 7 H/D Measurement Results Comparison (Base (Type 316LN), X-Direction)

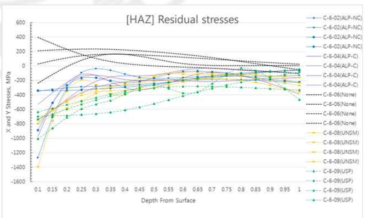

Figure 8 H/D Measurement Results Comparison (HAZ (Type 316LN), X-Direction)

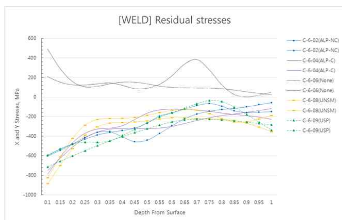

Figure 9 H/D Measurement Results Comparison (Weld (Type 316LN), X-Direction)

- **Base:** The base material area did not display any clear tendency for all specimens, residual stresses were generally measured in a range of 0 to +800 MPa in both 304 and 316LN base materials.
- **HAZ:** HAZ had stress distributions of -300 to +500 MPa, but both 304 and 316LN base materials had compressive stress distributions surface to 1mm depth after application of the peening technologies.
- **Weld:** It was confirmed that the untreated weld areas had stress distributions of -120 to +580 MPa, but both 304 and 316LN base materials had compressive stress distributions surface to 1mm depth after application of the surface stress improvement technologies.

:: Conclusion

➢ Application of four different surface stress improvement technologies, it was able to confirm that compressive stresses were distributed to a depth of 1mm in all treated specimens.

➢ These results are considered to be the basis technology for the aging management of spent fuel dry storage containers in the future.