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IASCC experiment methods using Proton Irradiated Stainless Steel Specimens

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1. Introduction

Under the consideration of a life extension to 60 years or longer, utilities need to set up a degradation management strategy of components. Irradiation-assisted stress corrosion cracking (IASCC) of reactor internals is one of those degradations in a light water reactor (LWR) component [1].

IASCC is a complex phenomenon involving many variables, including materials, environment, stress, and irradiation effect. Complexities of these interactions and the high cost of creating, shipping, handling, and testing neutron irradiated materials make the IASCC research of a LWR component difficult. So, performing experiments using less expensive irradiation techniques like a proton irradiation is attractive.

There are differences in the damage morphology, displacement efficiency and average recoil energy between protons and neutrons. But a intergranular stress corrosion cracking (IGSCC) was observed at a similar dose rate in a normal water chemistry, and a reduced IGSCC propensity has a very good agreement for both conditions in a hydrogen water chemistry [2].

This paper aims to set up IASCC evaluation strategy of stainless steel specimens with a proton irradiation.

2. Experiments

To study the IASCC effect of proton irradiated stainless steel specimens, the microstructure, microchemistry, hardening, and SCC behavior evaluations will be performed.

2.1. Microstructure

Grain size measurements can measured in the transverse direction and in the longitudinal direction on micrographs. And a summary of the particle composition can be measured by EDX. Defect feature will be observed by TEM. Summary of heat/dose conditions for grain boundary compositions can be measured via STEM/EDS.

2.2. Hardness

Hardness changes will be measured after a proton irradiation. The result can be analyzed depending on a dose rate from a microstructure measurement or hardness measurement.

2.3. SCC behavior

For SCC experiments, small size scc samples for proton irradiations were provided as shown in Fig. 1.

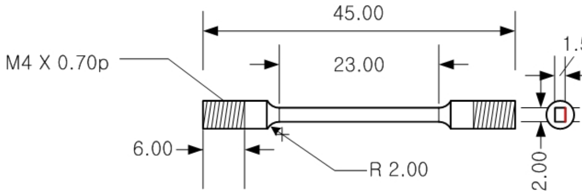

Fig. 1. Schematic of sample for proton irradiations

Samples were fabricated by electric discharge machining then will be proton irradiated at high temperature up to 340℃. SCC test will be carried out by using a primary water simulated water loop. Main environmental variables are dissolved oxygen, dissolved hydrogen, conductivity and pH of the test solution.

Evaluation parameters are dose, water chemistry, strain at failure, ultimate tensile strength, location of failure, and fracture mode. These parameters can be considered at normal water chemistry and at hydrogen water chemistry.

3. Summary

For all the proton irradiations at a high temperature, the main defect feature is reported as dislocation loops. The loops are assumed to be mostly interstitial type, faulted loops. The reason is mostly likely the presence of Si, which is known to suppress a void nucleation and growth.

Hardness of the specimen changes with the dose. According to Higgy and Hammad, the yield strength (Y.S.) change due to an irradiation ($\Delta\sigma_y^{\Delta H(24℃)}$) for 304 stainless steel from a Vickers hardness change using a relation:

$$\Delta\sigma_y^{\Delta H(24℃)} = \Delta H_v^{(24℃)}/0.282$$

The measured change in hardness from the unirradiated condition $\Delta H_v^{(24℃)}$ is independent of the measurement temperature. The change in Y.S. due to irradiation applies at 288℃ as well as at room temperature.

The dose dependence of grain boundary segregation composition profiles can be measured for Fe, Cr, Ni, P, Mo, Mn, Si for 304 stainless steel.

SCC results for the proton irradiated specimen can be analyzed for a stress to strain, a dose dependence to strain to failure, comparison of fracture surface, cracking observation on irradiated surface, inter-granular cracking susceptibility, and correlation between strain to failure and ductile fraction on the fracture surface both of conditions at normal water chemistry and hydrogen water chemistry.

REFERENCES

[1] S. S. Hwang, C. S. Yoo, Y. S. Kim, and W.S. Kim, IASCC of stainless steels in a PWR environment, Transactions of the Korean Nucelar Society Spring Meeting, 2008

[2] G. S. Was, T. R. Allen, Radiation Damage from different particle types, Radiation Effects on Solids, Vol. 235, pp. 65-98, 2007