Crystallographical Characterization of IGSCC of Alloy600 in Simulated Primary Water Environment of Pressurized Water Reactor

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Susceptibility of intergranular stress corrosion cracking (IGSCC) of Alloy 600 in the primary water environment of pressurized water reactor (PWR) was characterized. A flat Tensile specimen of mill annealed and 10 or 20 % cold rolled Alloy 600 was elongated using a slow strain rate testing (SSRT) apparatus in the simulated PWR primary water at 360 or 340 °C with dissolved hydrogen (DH) of 2.75 or 0.5 ppm. Elongation was terminated at 10 % of straining, then the surface of the specimen was observed using a scanning electron microscopy and an electron-beam back scattering diffraction (EBSD). Quite many IGSCC crack initiations were observed on the surface of the tensile specimen. The crystallographical feature of the initiation of intergranular crack was characterized. The number of grains where IGSCC initiated was statistically analyzed considering misorientation angles, and the angle between load axis and grain boundary. When DH was 2.75 ppm, Alloy 600 tends to exhibit IGSCC along grain boundary with misorientation angle of around 30 degree. Most crack initiate at random grain boundaries. On the other hand, coincidence boundaries, such as Σ3, Σ9, Σ17 exhibited less crack probability with increasing misorientation angle (decreasing Σ value). However, in the solution of DH of 0.5 ppm, cracks initiated at random grain boundaries did not depend on misorientation angle. Therefore, IGSCC might be controlled by DH which may affect stability of grain boundary depending on the misorientation angle.

Susceptibility to IGSCC was also evaluated by a numerical simulation in which the crystalline structure and the morphology of actual test specimen was introduced using the finite element method (FEM). In the numerical analysis, the microscopic stress distribution in each crystal revealed the preferential grain boundaries of IGSCC. The numerical prediction is in fair agreement with the experimental results.

3D characteristics of cracked grain boundaries was also tried using EBSD analysis with layer by layer obsedrvations.

The passive film formed on Alloy600 in the PWR environment was also characterized using X-ray photo electron spectroscopy and the photo electrochemical response. A Cr enriched with duplex structure passive with p-type semiconductor characteristic was observed. The IGSCC susceptibility of Allo600 is discussed correlated with the characteristics of passive film formed in the environment.