Effect of Surface Mechanical Attrition Treatment (SMAT) on the Electrochemical Behavior and Oxide Film Composition of Alloy 600.

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Nickel-based Alloy 600 (A600) steam generator (SG) tubing has been shown to be susceptible to stress corrosion cracking (SCC) under normal reactor operating conditions. Replacement alloys, such as Alloy 800 (A800), have been used in nuclear plants around the world. While Alloy 800 has performed better, it is not totally immune, reports having surfaced of SCC under typical operating conditions. This will become a larger issue when higher temperatures and pressures are used to maximize the efficiency of these reactors.

This study investigates the influence of surface modification for preventing SCC using a novel process known as Surface Mechanical Attrition Treatment (S.M.A.T). Smooth, spherical shots are accelerated towards the sample surface using a vibration generator. The resulting impact will induce plastic deformation with a high strain rate, eventually leading to grain refinement on a nanometer scale. The effect of SMAT on the surface oxide properties and corrosion of Alloy 600 in a 0.1 M $Na_2S_2O_3$ solution has been evaluated. The influence of shot composition and treatment time on the development of nanostructured layers has been studied using micro-hardness testing and electron backscatter diffraction (EBSD). Electrochemical techniques were employed to evaluate changes in corrosion behaviour, and analytical surface techniques to determine changes in the passive oxide composition.

Oxide films were grown electrochemically and their properties investigated by electrochemical impedance spectroscopy (EIS). The treated samples show an increase in polarization resistance (R_p) at passivating potentials compared to the untreated alloy, Figure 1. R_P also increased slightly in the transpassive region.

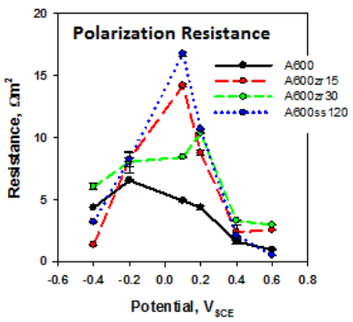

Figure 1. Polarization resistance of SMAT and untreated Alloy 600 samples as a function of applied potential.

Changes in the elemental composition and distribution within the oxide film were studied using X-ray photoelectron spectroscopy (XPS). Cationic fractions for Fe, Ni and Cr were obtained as a function of applied potential from the survey scans, Figure 2.

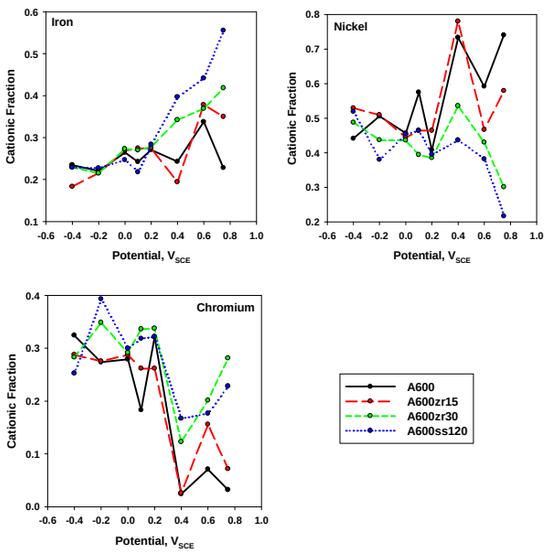

Figure 2. Cationic fractions for Ni, Fe and Cr obtained from XPS survey scans.

Significant changes were observed for all three elements, especially at higher applied potentials. The most significant changes were for Ni and Fe, although it is believed that the role of Cr is most important. This point is emphasized in Figure 3, where the polarization curves for Ni, Fe and Cr are compared to that for the alloy. The comparatively higher current densities for both Ni and Fe indicate these elements have little influence on the passivation of the alloy.

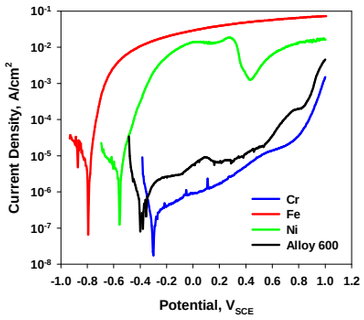

Figure 3. Polarization curves for Cr, Ni, Fe and Alloy 600 in 0.1 M $Na_2S_2O_3$.