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Oxide Film Formation and Corrosion of Stainless Steels in Supercritical and Ultra Supercritical Water

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Introduction

The decreasing supply of fossil fuel sources, coupled with the increasing concentration of green house gases has made it necessary to maximize the efficiency of power generation (1).One method of accomplishing this is by improving the efficiency of power plants by increasing the operating temperature in the coolant loop of the power plant. Nuclear, coal and natural gas power plants can be operated under supercritical water (SCW) and ultra supercritical water (USCW) conditions which would improve power generation efficiency from ~30% to ~40%.

Experimental

Experiments were conducted in the recently established supercritical water loop (SCWL) facility at UNR. This unique facility allows accelerated corrosion testing and mechanical behavior studies to be conducted simultaneously. The environment that will be used for these experiments will be water held at pressures above 27 MPa and temperatures ranging from 425^{0}C up to 600^{0}C. Materials studied include stainless steel alloys 304, 304L, 316 and 316L. A Gamry potentiostat was used for polarization of these samples. The oxide layer that was formed was characterized to determine the corrosion characteristics in this environment. Surface chemistry of the oxide layer was studied using X-ray photoelectron, Raman, and infrared spectroscopies. The corrosion products in the electrolyte were analyzed using inductively coupled plasma atomic emission.

Results

Figure 1 shows the polarization behavior for two stainless steel 304 samples that were polarized in SCW at 450 ^{0}C Figure 2 shows the Raman spectra for this sample with the feature at ~690 wavenumbers being attributed to magnetite (2). Correlation between the oxide film chemistry and the exposure temperature will be discussed.

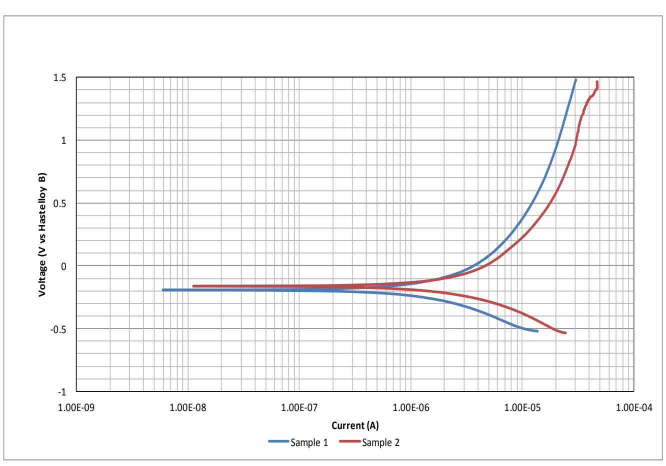

Figure 1: Polarization behavior for two stainless steel 304 samples in SCW at 450 ^{0}C.

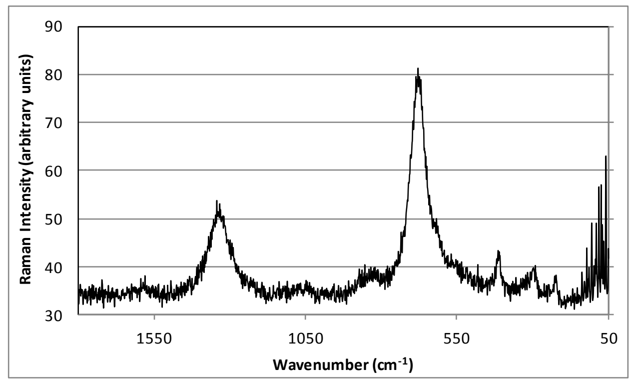

Figure 2: Raman spectra of SS304 sample after polarization in SCW at 450 ^{0}C

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