Oxidation of Superalloys in Supercritical Water

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The use of supercritical water (SCW) as the working fluid in coal, natural gas and nuclear power plants is a major focus of current research (1, 2). The theoretical efficiency of power generation increases with increasing operating temperature. At the high temperatures and pressures encountered in SCW environments, >400^{0}C and 27MPa, corrosion of materials becomes important to plant reliability and safety (3). Recent advances have facilitated the study of mechanical behavior of the materials under SCW conditions using SCW circulating loops(2). However, the electrochemical behavior was only studied using weight loss measurements. We have recently established a SCW loop facility that allows accelerated corrosion testing in addition to mechanical behavior studies, for the first time.

In situ electrochemical polarization and electrochemical impedance spectroscopy (EIS) were used to characterize the oxidation characteristics of materials during exposure to SCW. The current work focuses on nickel based superalloys due to their superior oxidation resistance in other high temperature environments (4, 5). Specifically Inconel 600, 625, 718, Nimonic 90, and Hastelloy B,C, N, and X alloys were investigated.

Post exposure surface analyses were accomplished using electron microscopy for morphological characterization, and Raman and X-ray photoelectron spectroscopies (XPS) for elucidation of the surface chemistry of the oxide films formed during exposure, respectively. Correlating the electrochemical behavior of materials in SCW to the chemistry of the oxide film formed resulted in a thorough understanding of nickel alloy oxidation characteristics in SCW. A correlation was drawn between varying concentrations of Cr, Mo, and Fe and the stability, thickness, chemical makeup, and chemical bonding of the oxide layer formed.

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